Format of ramp-constrained Unit Commitment instances

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Introduction

This document describes a proposed format for instances of the ramp-constrained, hydro-thermal Unit Commitment problem in electric power generation. Randomly generated, "realistic" instances encoded in this format are publicly available, and have been used to test some algorithmic approaches to the problem in several papers, among which

- Frangioni, C. Gentile, F. Lacalandra **"Solving Unit Commitment Problems with General Ramp Contraints"** *International Journal of Electrical Power and Energy Systems*, to appear, 2008
- Frangioni, C. Gentile **"Solving Nonlinear Single-Unit Commitment Problems with Ramping Constraints"** *Operations Research* **54**(4), p. 767 - 775, 2006
- A. Borghetti, A. Frangioni, F. Lacalandra, C.A. Nucci **"Lagrangian Heuristics Based on Disaggregated Bundle Methods for Hydrothermal Unit Commitment"**, *IEEE Transactions on Power Systems* 18(1), pp 313-323, 2003
- A. Borghetti, A. Frangioni, F. Lacalandra, C.A. Nucci, P. Pelacchi, **"Using of a cost-based Unit Commitment algorithm to assist bidding strategy decisions"** *Proceedings IEEE 2003 Powerteck Bologna Conference*, A. Borghetti, C.A. Nucci and M. Paolone editors, Paper n. 547, 2003
- A. Frangioni, C. Gentile **"Perspective Cuts for a class of convex 0-1 Mixed Integer Programs"** *Mathematical Programming* 106(2), p. 225 - 236, 2006

Those papers describe also the model of unit commitment which the instance generator refers to.

File format

To better describe the format, we refer to the following small example instance.

```
ProblemNum      0
HorizonLen      20
NumThermal      2
NumHydro        3
NumCascade      2
LoadCurve
MinSystemCapacity       132.63
MaxSystemCapacity       965.27
MaxThermalCapacity      405.588
Loads   2       10
307.841 309.775 251.72  151.575 151.575  159.417 227.897 288.606 341.329 362.633
151.575 151.575 151.575 151.575 151.575  178.404 232.075 280.024 323.124 372.474
SpinningReserve 10
0.0793793       0.0971151        0.0827699       0.0947514       0.0703931
0.0784057       0.0654399        0.0984396       0.0601816       0.0886065
ThermalSection
0       0.000125959     8.47794 447.838  80.8008 233.187 4       6       6
208.931 192.879 1.00858 5       58940.1  93380.2 167.727
1       0.0485937       7.14811 345.723  51.8293 172.401 1       2       3
239.531 178.164 1.88141 5       40302.3  51170.5 68.5504
```

```
HydroSection
0       1.01484 6.08508 162.173 159.802  225.449 45.6677 421.628
30.4096 34.1051 36.1312 26.7482 26.6108  16.7201 41.1853 21.8502 40.0673 31.246
42.9469 33.5477 26.4026 42.5321 22.4477  30.5453 22.4912 41.0752 26.4598 27.5061
1       1.03721 5.45551 201.851 194.609  298.024 61.7249 559.204
42.4451 34.1532 47.4486 20.6062 41.965   28.1956 44.7556 48.4131 25.2792 45.2077
34.1126 33.1938 24.3282 36.8212 35.3214  36.0302 22.316  47.9132 49.4681 38.1734
2       1.02544 5.19619 195.658 190.804  349.244 70.1036 607.1
21.9377 48.5681 22.1609 29.6121 40.0042  40.8806 35.4053 30.8747 45.5579 33.3071
19.7163 26.2798 47.1741 32.1546 43.7074  31.5493 50.9241 43.1662 34.9967 45.297
HydroCascadeSection
0       CascadeLen      2
0 1.01841       5.21441 216.38  212.469  509.141 149.037 906.007
40.6101 37.0902 49.199  57.2977 31.3688  35.1657 54.8012 48.0506 52.4852 55.0929
38.3713 54.4982 48.7372 23.6957 24.9768  45.6881 36.0201 31.2145 55.1723 25.8256
51.6954 57.3079 44.8995 31.6343
1 1.0315        5.25278 173.814 168.506  400.068 95.5917 698.804
42.0132 43.4855 29.4877 17.3825 36.915   20.3604 42.5424 42.6423 22.496  29.8054
18.7045 37.5917 43.6889 29.251  30.1771  25.8726 31.3146 29.3248 31.266  23.7991
18.5776 23.1008 44.8408 30.2239
1       CascadeLen      4
0 1.03867       6.0367  211.174 203.311  416.222 86.1507 713.983
26.8092 51.9972 55.5023 54.3925 54.651   41.0379 26.4118 38.2636 35.8118 43.8415
55.7944 28.8918 33.9268 54.2318 52.7399  40.2311 54.0559 40.7849 35.7195 48.5681
54.4338 22.7699 33.7433 44.4507
1 1.00422       5.70088 226.024 225.075  479.704 116.11  826.582
35.5126 38.1007 51.7489 42.7875 59.2582  40.524  26.056  40.1177 41.9317 56.2651
30.3894 43.9295 56.4562 60.1321 51.9497  22.933  31.5482 32.7359 41.1431 35.6148
42.9486 37.0621 60.982  23.2792
2 1.02048       5.30606 225.47  220.945  401.813 82.1554 712.193
50.049  44.0475 27.8754 45.4611 41.219   60.5558 48.2483 41.4621 48.0843 59.3605
58.9581 23.9837 25.8246 55.7721 42.8651  54.7408 48.4253 36.4388 52.199  37.1763
51.1582 40.7458 27.2028 33.3684
3 1.01298       6.05599 228.156 225.233  454.513 124.1   775.228
51.5399 59.8688 37.9169 55.1522 51.0587  37.8832 57.8275 48.944  44.6773 40.6595
57.4137 31.7532 56.7713 52.3687 50.2275  45.0141 51.825  51.1609 33.7067 44.5329
61.8139 26.12   41.7722 23.5782
```

The file is subdivided in different sections, that we now analyze individually.

General information

Contains global information for the overall problem.

`ProblemNum`	Seed used by the generator.
`HorizonLen`	Length of problem temporal horizon (Gg * Breaks).
`NumThermal`	Number of thermal units.
`NumHydro`	Number of hydro units.
NumCascade	Number of cascade hydro units.

Load curve

`MinSystemCapacity`	Sum over minimum power generated by all units.
`MaxSystemCapacity`	Sum over maximum power generated by all units.
`MaxThermalCapacity`	Sum over maximum power generated by all thermal units.
`Loads`	For every day a row will be printed with a load value for each breaks of the day.
`SpinningReserve`	For each breaks of the day will be printed the percentage of loads used as spinning reserve.

Thermal unit description

A row for each unit is printed. The row contains, in this mandatory order:

1. A unit index.
2. The quadratic, linear and constant coefficient used for the calculation of power generation cost.
3. The minimum and maximum power.
4. The initial unit status. A positive integer *t* to indicate that the unit is on by *t* unit times; a negative integer -*t* to indicate that the unit is off by *t* unit times.
5. The minimum up- and down-time of the unit (non-negative integers).
6. The subsequent 6 parameters are used to calculate the start up cost. Let them be denoted as coolAndFuelCost, hotAndFuelCost, tau, tauMax, fixedCost, SUCC:

   6.1 the cool start up cost is equal to coolAndFuelCost * (1-exp(- downTime/tau)) + fixedCost;

   6.2 the hot start up cost is equal to hotAndFuelCost * downTime + fixedCost;

   Note that the last parameter, SUCC, is unused but still present due to compatibility with an old format.
7. The final parameter, P0, is the power that the unit is producing if active prior to the start of the time horizont (i.e., if the initial status is positive, see 4.).

An optional sub-section can then follow with the form

```
RampConstraints    RampUp      RampDown
```

where the two parameters `RampUp` and `RampDown` represents respectively the maximum ranp-up rate and the maximum ramp-down rate of the unit.

Hydro unit description

A hydro unit is described with two rows. In the first row we will find the parameters id, volumeToPower, b_h, maxUsage, maxSpillage, initialFlood, minFlood, maxFlood:

`id`	A unit index.
`volumeToPower`	Liner conversion coefficient from *water* to *power*.
`b_h`	Unused.
`maxUsage`	Maximum amount of water usable for power generation.
`maxSpillage`	Maximum amount of spillable water.
`initialFlood`	Initial amount of water into the basin.
`minFlood`	Minimum amount of water into the basin.
`maxFlood`	Maximum amount of water into the basin.

The second row of hydro unit description contains the amount of water that flows into the basin during the different breaks.

Hydro cascade unit description

Each cascade unit description is made of several rows. The first row contains:

1. The cascade unit index.
2. The token `CascadeLen`.
3. The number of single hydro unit composing the cascade.

Now for each composed hydro unit the description of a simple hydro unit is repeated.