

# HIG

## the Hydro unit commitment Instances Generator

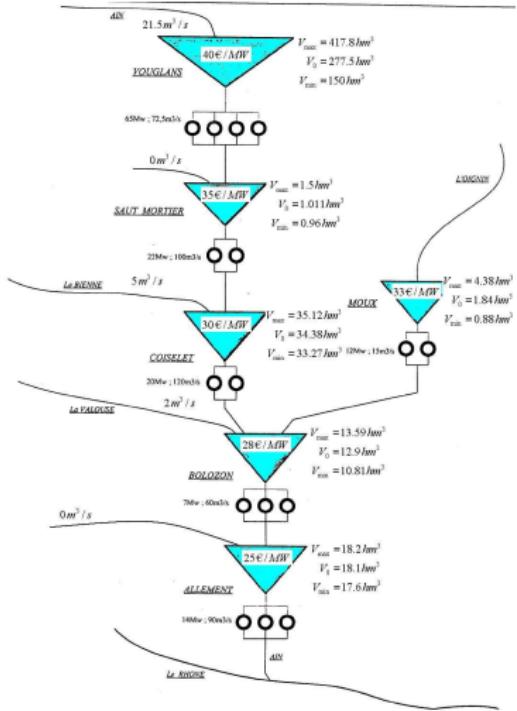
Claudia D'Ambrosio

(joint work with Dimitri Thomopoulos)

CNRS & École Polytechnique, France

PGMO Days 2018

# The Hydro Unit Commitment & Scheduling Problem



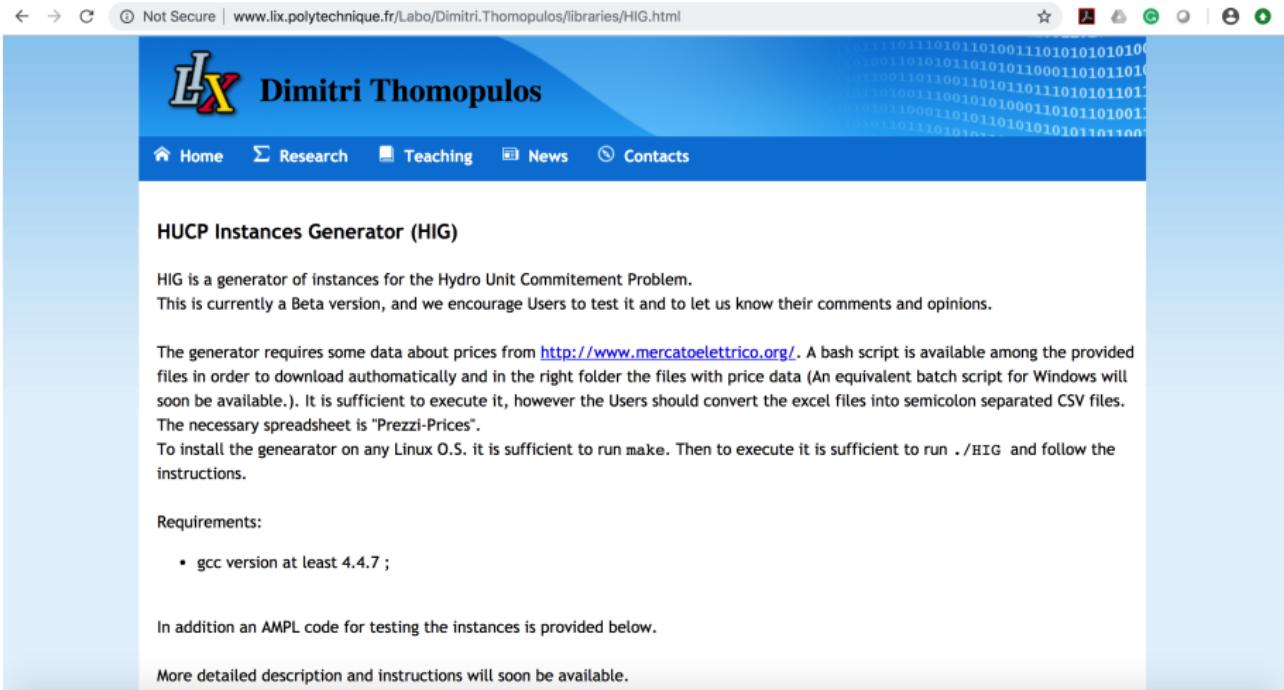
- Find the **optimal scheduling** of several plants with multi-unit pump-storage hydro power station.
- Short term.
- Assumptions:** forecast electricity prices and inflows, price-taker.
- 16.4 %** of the total energy produced worldwide.
- 71 %** of all renewable electricity.

# HIG: Hydro unit commitment Instances Generator

- To the best of our knowledge, no instances testbed available for HUC
- Useful to the community to compare methods
- Open-source code to generate a large number of instances:

<http://www.lix.polytechnique.fr/Labo/Dimitri.Thomopoulos/libraries/HIG.html>

# Where and how to download the HIG code



Not Secure | www.lix.polytechnique.fr/Labo/Dimitri.Thomopoulos/libraries/HIG.html

**LX** Dimitri Thomopoulos

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## HUCP Instances Generator (HIG)

HIG is a generator of instances for the Hydro Unit Commitment Problem.  
This is currently a Beta version, and we encourage Users to test it and to let us know their comments and opinions.

The generator requires some data about prices from <http://www.mercatoelettrico.org/>. A bash script is available among the provided files in order to download automatically and in the right folder the files with price data (An equivalent batch script for Windows will soon be available.). It is sufficient to execute it, however the Users should convert the excel files into semicolon separated CSV files. The necessary spreadsheet is "Prezzi-Prices".  
To install the generator on any Linux O.S. it is sufficient to run `make`. Then to execute it is sufficient to run `./HIG` and follow the instructions.

Requirements:

- gcc version at least 4.4.7 ;

In addition an AMPL code for testing the instances is provided below.

More detailed description and instructions will soon be available.

# Where and how to download the HIG code

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**Codes** (click the name of a code to download it, or to access it through a link).

[HIG \(hg.zip\)](#)

[AMPL\\_model \(math\\_model\\_MILP\\_lin2vars.zip\)](#)



"The best thing one can do when it's raining is to let it rain."

*Henry Wadsworth Longfellow*



# How to compile and run the HIG code

```
[Claudius-MacBook-Pro:Downloads claudio]$ quietReplace existing README file archive file newer
Claudius-MacBook-Pro:Downloads claudio$ unzip hig.zip -d hig
Archive: hig.zip
  creating: hig/Inflows/
  inflating: hig/Inflows/Suviano_2004_2012.csv
  creating: hig/src/
  inflating: hig/src/head.h
  inflating: hig/src/Main.cpp
  inflating: hig/src/read.cpp
  inflating: hig/src/read.h
  inflating: hig/src/write_instance11.JPG
  inflating: hig/src/write_instance.hDisplay.pdf
  inflating: hig/getPrices.sh
  inflating: hig/Makfile
  inflating: hig/Readme.txt
  inflating: hig/README.pdf
(Claudius-MacBook-Pro:Downloads claudio$ cd hig
(Claudius-MacBook-Pro:hig claudio$ chmod +x getPrices.sh
(Claudius-MacBook-Pro:hig claudio$ ./getPrices.sh
./getPrices.sh: line 39: [: =: unary operator expected
./getPrices.sh: line 39: [: =: unary operator expected
./getPrices.sh: line 53: [: =: unary operator expected
./getPrices.sh: line 53: [: =: unary operator expected
./getPrices.sh: line 61: [: =: unary operator expected
./getPrices.sh: line 61: [: =: unary operator expected
-2018-11-16 15:46:59-- http://www.mercatoelettrico.org/En/MenuBiblioteca/Documenti/Anno2004.zip
Resolving www.mercatoelettrico.org... 5.249.130.157
Connecting to www.mercatoelettrico.org[5.249.130.157]:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 2309791 (2.2M) [application/x-zip-compressed]
Saving to: 'Anno2004.zip'  [Vente privée.com.vetrinette] 20181104.pdf

Anno2004.zip  % AgatèMementoCE7.pdf  100%[=]                                     ] 2.20M/s 512KB/s] in 4.4s
2018-11-16 15:47:04 (512 KB/s) - 'Anno2004.zip' saved [2309791/2309791]

--2018-11-16 15:47:04-- http://www.mercatoelettrico.org/En/MenuBiblioteca/Documenti/Anno2005.zip
Resolving www.mercatoelettrico.org... 5.249.130.157
Connecting to www.mercatoelettrico.org[5.249.130.157]:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 10570909 (1.0M) [application/x-zip-compressed]
Saving to: 'Anno2005.zip'  [Vente privée.com.vetrinette] 20181104.pdf

Anno2005.zip  % AgatèMementoCE7.pdf  100%[=]                                     ] 10.08M 1.29M/s] in 12s
Today at 00:10          4.6 MB  PDF document  14Nov2018 at 09:01
Yesterday at 22:09        461 KB  PDF document  Yesterday at 22:09
Yesterday at 22:09        461 KB  PDF document  Yesterday at 22:09
Yesterday at 13:47        2.1 MB  PDF document  Yesterday at 13:47
Yesterday at 12:26        2.3 MB  PDF document  Yesterday at 12:26
14Nov2018 at 21:57       1.6 MB  JPEG image  14Nov2018 at 21:57
14Nov2018 at 21:44       10 KB   PDF document  14Nov2018 at 21:44
14Nov2018 at 08:52       1.4 MB  PDF document  14Nov2018 at 08:52
14Nov2018 at 08:49       1.2 MB  PDF document  14Nov2018 at 08:49
12Nov2018 at 18:19       13.7 MB  PDF document  12Nov2018 at 18:19
10Nov2018 at 17:44       16 KB   PDF document  10Nov2018 at 17:44
10Nov2018 at 17:42       19 KB   PDF document  10Nov2018 at 17:42
8Nov2018 at 10:50      731 KB   PDF document  8Nov2018 at 13:53
7Nov2018 at 22:51      238.7 MB  Disk Image  7Nov2018 at 22:51
7Nov2018 at 14:17      392 bytes Plain Text Document 7Nov2018 at 14:10
5Nov2018 at 14:29       88 KB   PDF document  5Nov2018 at 14:29
5Nov2018 at 12:09      829 KB   PDF document  5Nov2018 at 12:09
5Nov2018 at 11:34      811 KB   PDF document  5Nov2018 at 11:34
4Nov2018 at 20:31      166 KB   PDF document  4Nov2018 at 20:31
4Nov2018 at 13:59      196 KB   PDF document  4Nov2018 at 13:59
31Oct2018 at 21:42      707 bytes Plain Text Document 32Oct2018 at 16:43
31Oct2018 at 21:42      465 bytes Plain Text Document 30Oct2018 at 14:11
30Oct2018 at 17:29      580 KB   PDF document  30Oct2018 at 17:29
30Oct2018 at 16:59      160 KB   PDF document  30Oct2018 at 16:59
29Oct2018 at 21:26      198 KB   PDF document  29Oct2018 at 21:26
29Oct2018 at 21:24      358 KB   PDF document  29Oct2018 at 21:24
29Oct2018 at 21:23      1.4 MB   PDF document  29Oct2018 at 21:23
```

# How to compile and run the HIG code

Name	Downloads	Progress	File Size	Date Modified	Size	Kind	→	Rate	Time Left
Anno2005.zip		100%							
2018-11-16 15:47:16 (888 KB/s) - 'Anno2005.zip' saved [10570909/10570909]									
└── Google Dr...									
└── Anno2005									
└── Anno2005									
--2018-11-16 15:47:16-- http://www.mercatoelettrico.org/En/MenuBiblioteca/Documenti/Anno2006.zip									
Resolving www.mercatoelettrico.org... 5.249.130.157									
Connecting to www.mercatoelettrico.org[5.249.130.157]:80... connected.									
HTTP request sent, awaiting response... 200 OK									
Length: 5781101 (5.5M) [application/x-zip-compressed]									
Saving to: 'Anno2006.zip' [6275.pdf]									
Anno2006.zip									
└── proline_notice									
└── 4295527_NOTCOMP.pdf									
2018-11-16 15:47:24 (707 KB/s) - 'Anno2006.zip' saved [5781101/5781101]									
└── Anno2006									
--2018-11-16 15:47:24-- http://www.mercatoelettrico.org/En/MenuBiblioteca/Documenti/Anno2007.zip									
Resolving www.mercatoelettrico.org... 5.249.130.157									
Connecting to www.mercatoelettrico.org[5.249.130.157]:80... connected.									
HTTP request sent, awaiting response... 200 OK									
Length: 11642528 (11M) [application/x-zip-compressed] off-of-concept.pdf									
Saving to: 'Anno2007.zip'									
└── lecture259703249.pdf									
Anno2007.zip									
└── lecture250693896.pdf									
2018-11-16 15:47:34 (1.18 MB/s) - 'Anno2007.zip' saved [11642528/11642528]									
└── Anno2007									
--2018-11-16 15:47:34-- http://www.mercatoelettrico.org/En/MenuBiblioteca/Documenti/Anno2008.zip									
Resolving www.mercatoelettrico.org... 5.249.130.157									
Connecting to www.mercatoelettrico.org[5.249.130.157]:80... connected.									
HTTP request sent, awaiting response... 200 OK									
Length: 11739011 (11M) [application/x-zip-compressed]									
Saving to: 'Anno2008.zip'									
└── vento-privee_201011104.pdf									
Anno2008.zip									
└── Vente-privee.com_vetrine									
└── AgateMementoCET.pdf									
2018-11-16 15:47:45 (996 KB/s) - 'Anno2008.zip' saved [11790111/11790111]									
└── Anno2008									
--2018-11-16 15:47:45-- http://www.mercatoelettrico.org/En/MenuBiblioteca/Documenti/Anno2009.zip									
Resolving www.mercatoelettrico.org... 5.249.130.157									
Connecting to www.mercatoelettrico.org[5.249.130.157]:80... connected.									
HTTP request sent, awaiting response... 200 OK									
Length: 10378898 (9.9M) [application/x-zip-compressed]									
Saving to: 'Anno2009.zip'									
└── 4221.pdf									
Anno2009.zip									
└── 1A10.000R90.nrf									
2018-11-16 15:47:45 (996 KB/s) - 'Anno2009.zip' saved [10570909/10570909]									
└── Anno2009									



# How to compile and run the HIG code

Name	Size	Last modified	Actions
Anno2009.zip	100%		[>] 9.90M 1.49MB/s in 22s
Favorites			
2018-11-16 15:48:08 (452 KB/s) - 'Anno2009.zip' saved [10378890/10378890]		Today at 16:48	Folder
--2018-11-16 15:48:08-- http://www.mercatoletrico.org... 5.249.130.157 :20081110.pdf		Today at 16:44	ZIP archive
Resolving www.mercatoletrico.org... 5.249.130.157 :20081110.pdf		Today at 00:10	
Connecting to www.mercatoletrico.org[5.249.130.157]:80... connected.		Yesterday at 22:09	PDF document
HTTP request sent, awaiting response... 200 OK		Yesterday at 22:09	
Length: 11216663 (11M) [application/x-zip-compressed]		Yesterday at 22:09	
Saving to: 'Anno2010.zip'		Yesterday at 13:47	
Claudia...			
proline_notice			
Anno2010.zip	100%		[>] 10.79M 1.77MB/s in 9.0s
Favorites			
2018-11-16 15:48:17 (1.19 MB/s) - 'Anno2010.zip' saved [11216663/11216663]		14Nov2018 at 21:57	
--2018-11-16 15:48:17-- http://www.mercatoletrico.org/En/MenuBiblioteca/Documenti/Anno2010.zip		14Nov2018 at 21:44	
Resolving www.mercatoletrico.org... 5.249.130.157		14Nov2018 at 08:52	
Connecting to www.mercatoletrico.org[5.249.130.157]:80... connected.		14Nov2018 at 08:49	
HTTP request sent, awaiting response... 200 OK		12Nov2018 at 10:19	
Length: 11398991 (11M) [application/x-zip-compressed]		10Nov2018 at 17:44	
Saving to: 'Anno2011.zip'		10Nov2018 at 17:42	
Claudia...			
lecture200803800.PDF			
Anno2011.zip	100%		[>] 10.87M 1.50MB/s in 12s
Favorites			
2018-11-16 15:48:29 (906 KB/s) - 'Anno2011.zip' saved [11398991/11398991]		7Nov2018 at 22:51	
--2018-11-16 15:48:29-- http://www.mercatoletrico.org/En/MenuBiblioteca/Documenti/Anno2011.zip		7Nov2018 at 14:17	
Resolving www.mercatoletrico.org... 5.249.130.157		5Nov2018 at 14:29	
Connecting to www.mercatoletrico.org[5.249.130.157]:80... connected.		5Nov2018 at 12:00	
HTTP request sent, awaiting response... 200 OK		5Nov2018 at 11:34	
Length: 6133393 (5.8M) [application/x-zip-compressed]		4Nov2018 at 20:31	
Saving to: 'Anno2012.zip'		4Nov2018 at 13:59	
Claudia...			
Verite-privee.com_verinetta_20181104.pdf			
Anno2012.zip	100%		[>] 5.85M 1.09MB/s in 9.1s
Favorites			
Remote Disc			
20181022_Utter.txt		31Oct2018 at 21:42	Plain Text Document
20181030_D_iCE.txt		31Oct2018 at 21:42	Plain Text Document
Archive: Anno2004.zip	10,1007_s1081-018-9405-6.pdf	30Oct2018 at 17:29	PDF document
Inflating: Prices/Anno_2004.xls		30Oct2018 at 15:59	PDF document
Archive: Anno2005.zip	cacm12.pdf	30Oct2018 at 15:59	PDF document
Inflating: Prices/Anno_2005.xls		29Oct2018 at 21:26	PDF document
Archive: Anno2006.zip	d271.pdf	29Oct2018 at 21:24	PDF document
Inflating: Prices/Anno_2006.xls		29Oct2018 at 21:23	PDF document
Archive: Anno2007.zip	HTI0104690.pdf	29Oct2018 at 21:23	RDF document
Inflating: Prices/Anno_2007.xls			

# How to compile and run the HIG code

```
Archive: Anno2004.zip
inflating: Prices/Anno2004.xls
Archive: Anno2005.zip
inflating: Prices/Anno 2005.xls
Archive: Anno2006.zip
inflating: Prices/Anno 2006.xls
Archive: Anno2007.zip
inflating: Prices/Anno 2007.xls
Archive: Anno2008.zip
inflating: Prices/Anno 2008.xls
Archive: Anno2009.zip
inflating: Prices/Anno 2009.xls
Archive: Anno2010.zip
inflating: Prices/Anno 2010.xls
Archive: Anno2011.zip
inflating: Prices/Anno 2011.xls
Archive: Anno2012.zip
inflating: Prices/Anno 2012.xls
[CLAUDIO]@MacBook-Pro:hig claudio$ make
bla=;
for file in Main.o read.o write_instance.o; do bla="$bla `echo obj/$file`"; done; \
g++ -O3 -pipe -DIL_STD -DNDEBUG -o HIG $bla
Resolving dependencies...
http://www.mercatoelettrico.org/En/MenuBiblioteca/Documenti/Anno2011.zip
Connected to www.mercatoelettrico.org [5.249.130.157]:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 116563 (11M) [application/x-zip-compressed]
Saving... [proline_notice] 4285522_NOTCOMP.pdf 100%[=====] 11216663/11216663
[Image (1).JPG] 100%[=====] 11216663/11216663
[OrigeniDisplay.pdf] 100%[=====] 11216663/11216663
[http://www.mercatoelettrico.org/En/MenuBiblioteca/Documenti/Anno2011.zip] 100%[=====] 11216663/11216663
[11216663/11216663]
```

# How to compile and run the HIG code

```
Claudia-MacBook-Pro:hig claudia$ ./HIG
Instanceinator v0.99

The generator of instances for the HUCP can be used in two possible ways:
  Create a specific instance;
  Create some random instances.

In addition, three possible formats are available:
  0 Single-reservoir instance format with one unique pair of volume bounds;
  1 Multi-reservoir instance format.

Please, select the format of instances you want to create.
An integer value in [0,1] is required. Press enter for the default value { 0 }: 0

Please, select the number of instances you want to create.
An integer value in [1,300] is required. Press enter for the default value { 1 }: 1

Please, select the year of the starting date.
An integer value in [2004,2012] is required. Press enter for the default value { 2004 }:
Default value: 2004

Please, select the month of the starting date.
An integer value in [4,12] is required. Press enter for the default value { 4 }:
Default value: 4

Please, select the day of the starting date.
An integer value in [1,30] is required. Press enter for the default value { 5 }:
Default value: 5

Please, select the number of periods.
An integer value in {24, 48, 72, 96, 120, 144, 168} is required. Press enter for the default value { 24 }: 168

Please, select the number of operational points for turbines.
An integer value in [3,36] is required. Press enter for the default value { 16 }: 3

*** Reading prices
*** [-----] 100% ***
*** Reading prices - Complete ***
*** Reading inflows ***
*** [-----] 100% ***
*** Reading inflows - Complete ***

Please, select the number of volume steps.
An integer value in [1,25] is required. Press enter for the default value { 2 }:
```

# How to compile and run the HIG code

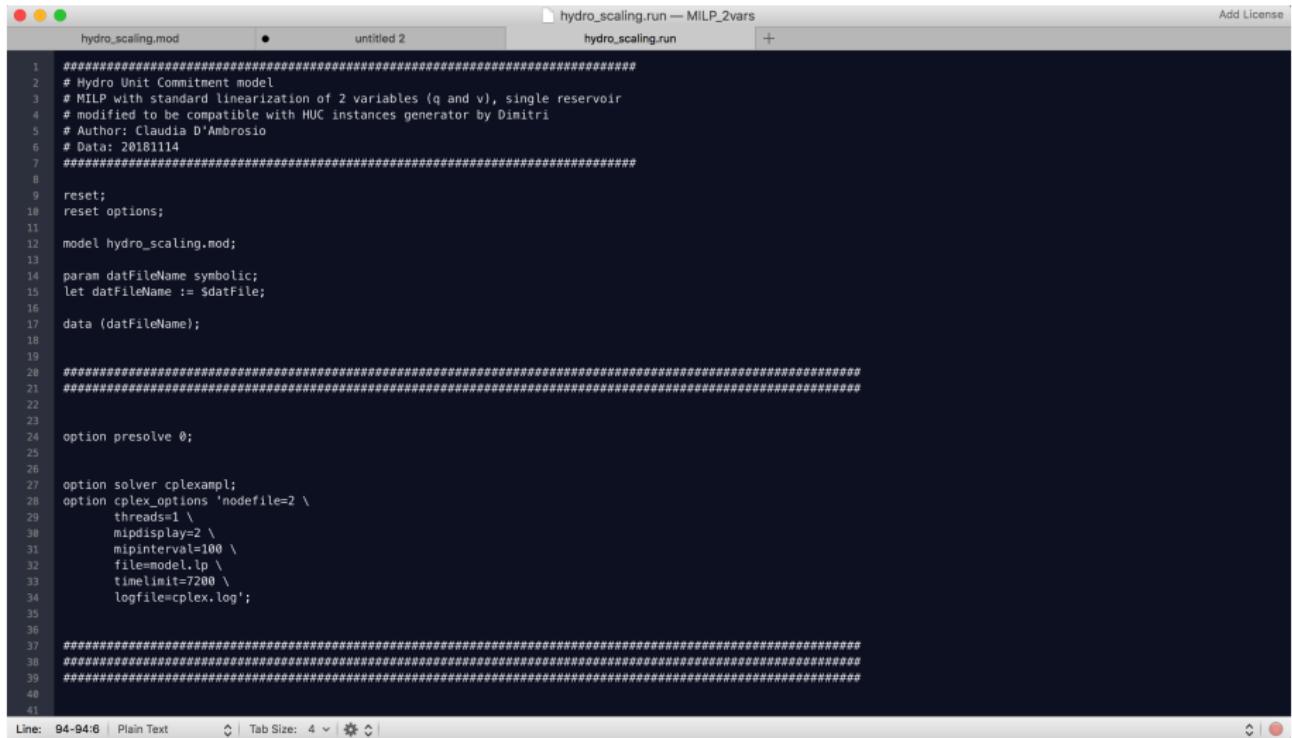
```
Please, select the number of operational points for turbines.  
An integer value in [3,36] is required. Press enter for the default value { 16 }: 3  
*** Reading prices ***  
*** [=====] 100% ***  
*** Reading prices - Complete ***  
  
*** Reading inflows ***  
*** [=====] 100% ***  
*** Reading inflows - Complete ***  
Resolving www.mercatoelettrico.org... 5.249.130.157 or_20181116.pdf  
Please, select the number of volume steps.  
An integer value in [1,25] is required. Press enter for the default value { 2 }:  
Default value: 2  
HTTP request sent, awaiting response... 200 OK  
Please, select the modifier of the LB on the volume.  
An integer value in [0,900] is required. Press enter for the default value { 0 }:  
Default value: 0  
Saving to: 'Anno2010.zip'  
    100%[=====] 4286522 NOTCOMP.pdf 100%[=====]  
Please, select the modifier of the UB on the volume.  
An integer value in [0,900] is required. Press enter for the default value { 0 }:  
Default value: 0  
Anno2010.zip  
Please, select the initial volume.  
An integer value in [0,900] is required. Press enter for the default value { 304 }:  
Default value: 304  
2018-11-16 15:48:17 (1.19 MB/s) - 'Anno2010.zip' saved [11216663/11216663]  
Please, select the target volume.  
An integer value in [0,847] is required. Press enter for the default value { 304 }:  
Default value: 304  
2018-11-16 15:48:17 -- http://www.mercatoelettrico.org/En/MenuBiblioteca/Documenti/Anno2011.zip  
  
Single-reservoir_instances/Suviana_040405_168_3_2_000_000_304_304.dat ... 5.249.130.157  
*** Writing instance ***  
*** [=====] 100% *** mercatoelettrico.org/15.249.130.157:80... connected.  
*** Writing instance - Complete ***  
Claudios-MacBook-Pro:hig claudios$ l  
HIG      Makefile      README.txt      getPrices.sh      src/  
Inflows/  Prices/      Single-reservoir_instances/ obj/  
Claudios-MacBook-Pro:hig claudios$ l Single-reservoir_instances/  
total 24  
drwxr-xr-X  3 claudio  staff   96 Nov 16 15:53 .  
drwxr-xr-X  11 claudio  staff  352 Nov 16 15:53 ..  
-rw-r--r--  1 claudio  staff 10840 Nov 16 15:53 Suviana_040405_168_3_2_000_000_304_304.dat  
Claudios-MacBook-Pro:hig claudios$ ls -l structure260683896.PDF  
drwxr-xr-X  3 claudio  staff   96 Nov 16 15:53 .  
drwxr-xr-X  11 claudio  staff  352 Nov 16 15:53 ..  
-rw-r--r--  1 claudio  staff 10840 Nov 16 15:53 structure260683896.PDF  
Claudios-MacBook-Pro:hig claudios$ ls -l R2.pdf  
drwxr-xr-X  3 claudio  staff   96 Nov 16 15:53 .  
drwxr-xr-X  11 claudio  staff  352 Nov 16 15:53 ..  
-rw-r--r--  1 claudio  staff 10840 Nov 16 15:53 R2.pdf
```

# Instance file name description

For example, Suviana\_040405\_168\_3\_2\_000\_000\_304\_304 stands for:

- Name of the reservoir
- Date considered for the inflows and electricity prices in the format YYMMDD
- Time horizon duration
- Number of operational points of the turbine/pump unit
- Number of levels of water volume considered
- Modification of the default lower bound on the water volume
- Modification of the default upper bound on the water volume
- Modification of the default water volume at time step 0
- Modification of the default target water volume at the last time step

# The AMPL files: hydro\_scaling.run



The screenshot shows a code editor window with two tabs open. The left tab is titled "hydro\_scaling.mod" and contains the following code:

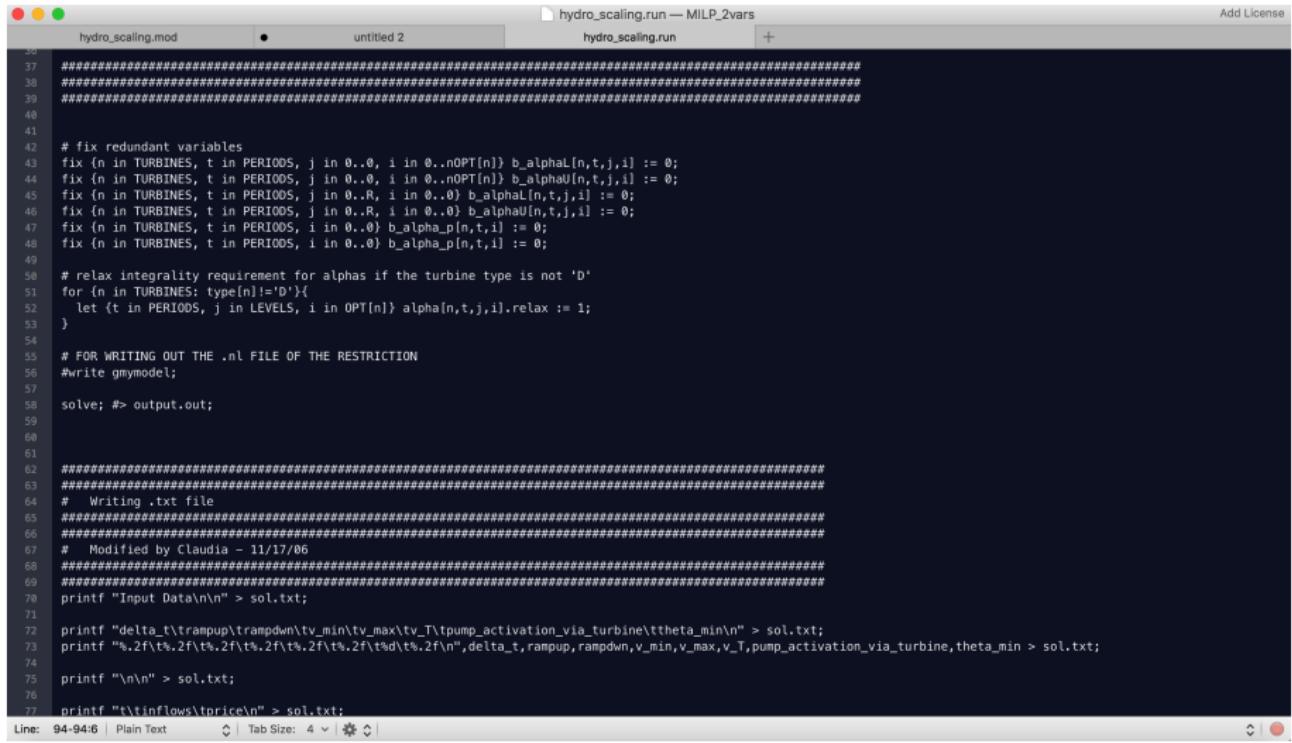
```
1 ##### Hydro Unit Commitment model
2 # MILP with standard linearization of 2 variables (q and v), single reservoir
3 # modified to be compatible with HUC instances generator by Dimitri
4 # Author: Claudia D'Ambrosio
5 # Data: 20181114
6 #####
7
8 reset;
9 reset options;
10
11 model hydro_scaling.mod;
12
13 param datFileName symbolic;
14 let datFileName := $datFile;
15
16 data (datFileName);
17
18
19
20 #####
21 #####
22
23
24 option presolve 0;
25
26
27 option solver cplexampl;
28 option cplex_options 'nodefile=2 \
29     threads=1 \
30     mipdisplay=2 \
31     mipinterval=100 \
32     file=model.lp \
33     timelimit=7200 \
34     logfile=cplex.log';
35
36
37 #####
38 #####
39 #####
40
41 #####
```

The right tab is titled "hydro\_scaling.run" and contains the following code:

```
hydro_scaling.run --- MILP_2vars
```

At the bottom of the editor, there are status bars for "Line: 94-94:6 | Plain Text" and "Tab Size: 4". There are also several navigation icons at the bottom right.

# The AMPL files: hydro\_scaling.run



A screenshot of a code editor window titled "hydro\_scaling.run — MILP\_2vars". The window contains two tabs: "hydro\_scaling.mod" and "hydro\_scaling.run". The "hydro\_scaling.mod" tab shows a portion of an AMPL model file with lines 30 to 58. The "hydro\_scaling.run" tab shows a portion of an AMPL script file with lines 59 to 77. Both files contain comments and declarations related to hydroelectric power generation models.

```
hydro_scaling.mod          hydro_scaling.run
30 #####
31 #####
32 #####
33 #####
34 #####
35 #####
36 #####
37 #####
38 #####
39 #####
40 #####
41 #####
42 # fix redundant variables
43 fix {n in TURBINES, t in PERIODS, j in 0..0, i in 0..nOPT[n]} b_alphaL[n,t,j,i] := 0;
44 fix {n in TURBINES, t in PERIODS, j in 0..0, i in 0..nOPT[n]} b_alphaU[n,t,j,i] := 0;
45 fix {n in TURBINES, t in PERIODS, j in 0..R, i in 0..0} b_alphaL[n,t,j,i] := 0;
46 fix {n in TURBINES, t in PERIODS, j in 0..R, i in 0..0} b_alphaU[n,t,j,i] := 0;
47 fix {n in TURBINES, t in PERIODS, i in 0..0} b_alpha_p[n,t,i] := 0;
48 fix {n in TURBINES, t in PERIODS, i in 0..0} b_alpha_p[n,t,i] := 0;
49
50 # relax integrality requirement for alphas if the turbine type is not 'D'
51 for {n in TURBINES: type[n]!='D'}{
52   let {t in PERIODS, j in LEVELS, i in OPT[n]} alpha[n,t,j,i].relax := 1;
53 }
54
55 # FOR WRITING OUT THE .nl FILE OF THE RESTRICTION
56 #write gmymodel;
57
58 solve; #> output.out;
59
60
61 #####
62 #####
63 #####
64 # Writing .txt file
65 #####
66 #####
67 # Modified by Claudia - 11/17/06
68 #####
69 #####
70 printf "Input Data\n\n" > sol.txt;
71
72 printf "delta_t\trampup\trampdn\tv_min\tv_max\tv_T\tpump_activation_via_turbine\ttheta_min\n" > sol.txt;
73 printf "%.2f\t%.2f\t%.2f\t%.2f\t%.2f\t%.2f\t%.2f\nd\t%.2f\n",delta_t,rampup,rampdn,v_min,v_max,v_T,pump_activation_via_turbine,theta_min > sol.txt;
74
75 printf "\n\n" > sol.txt;
76
77 printf "tinflows\tprice\n" > sol.txt;
```

Line: 94-94:6 | Plain Text | Tab Size: 4 | | | | | |

# The mathematical model: hydro\_scaling.mod

Independent variables:

- For each time step  $t$  and each unit  $j$  (turbine or pump): **water flow** $_{jt}$ ;
- For each time step  $t$ : **spillage** $_t$ ;

Dependent variables:

- For each time step  $t$ : **water volume** $_t$  in the basin;
- For each time step  $t$  and each unit  $j$  (turbine or pump): **power** $_{jt}$  (generated or consumed).

Plus auxiliary variables for modeling discontinuities, linearization, etc.

# The mathematical model: hydro\_scaling.mod

Physical constraints:

- Water flow balance equations
- Respect allowed operational points: (dis-)continuous, discrete, turbine/pump related
- Forbid of simultaneous pump and turbine mode
- Power production depending on water flow and head effect
- Minimum number of periods to be spent in a status by the unit (minimum starting up/down times)
- spillage
- ...

# The mathematical model: hydro\_scaling.mod

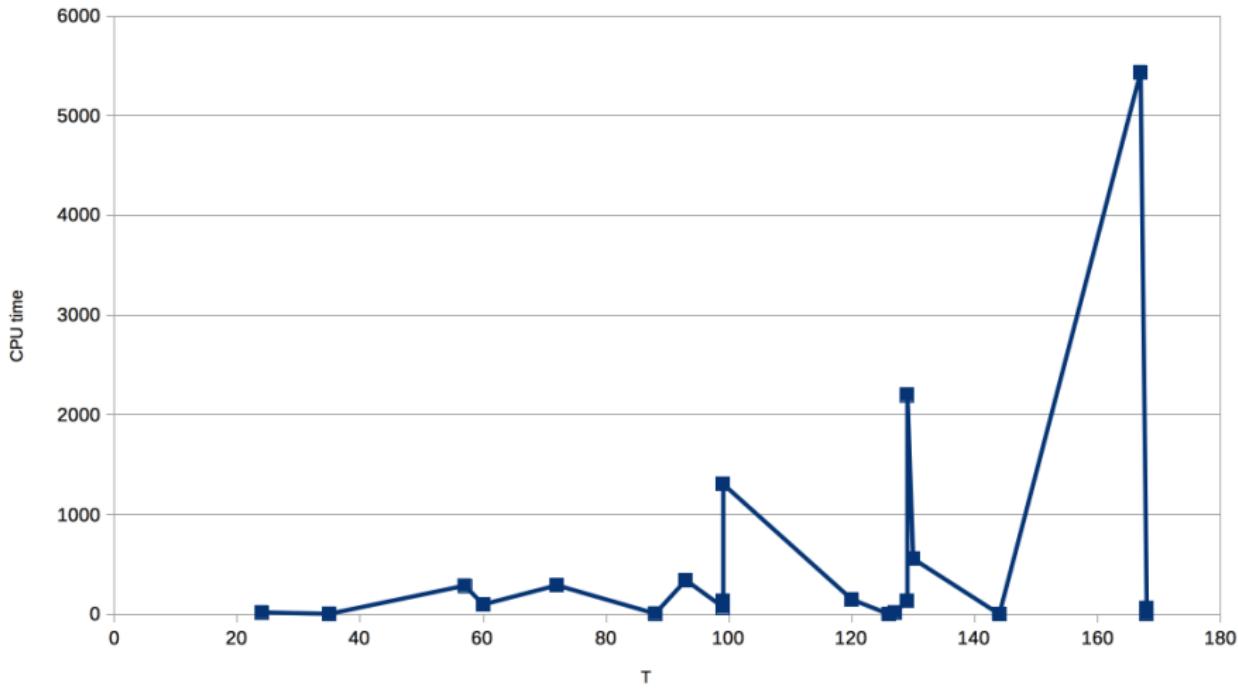
Strategic (soft) constraints:

- Ramp up/down bound constraint
- Load balance equations constraints
- Minimum release of water per period
- Minimum final reservoir level

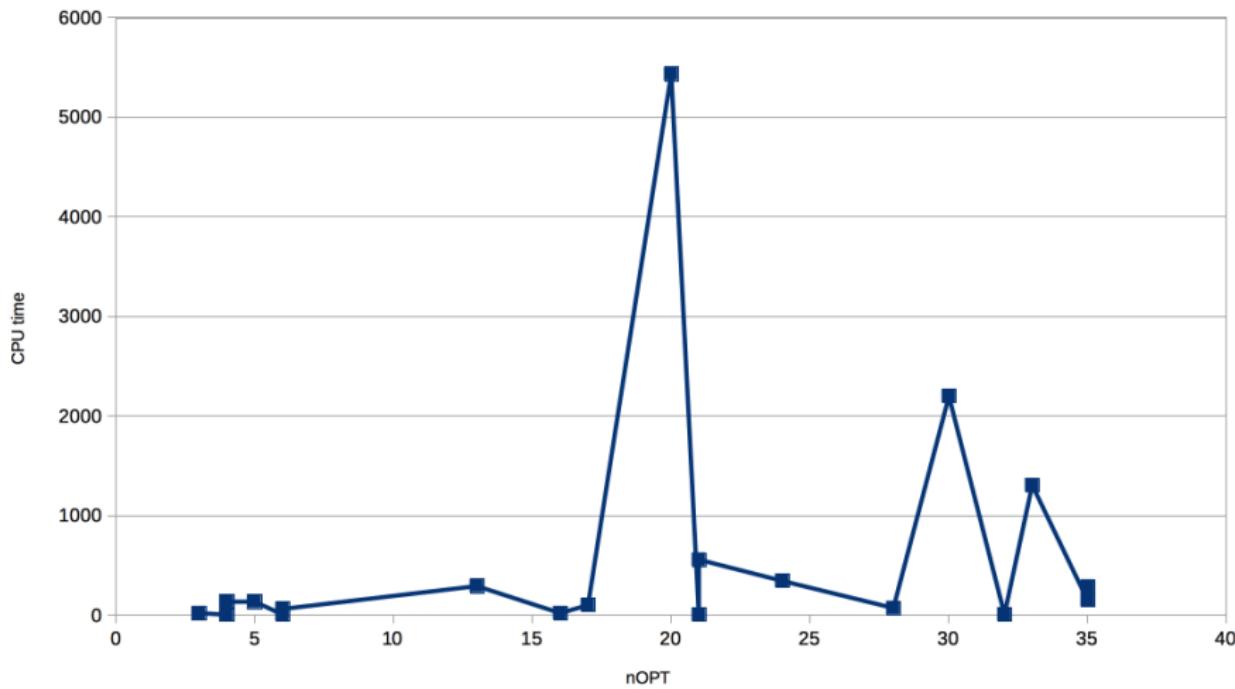
Objective function:

- Maximize the profit

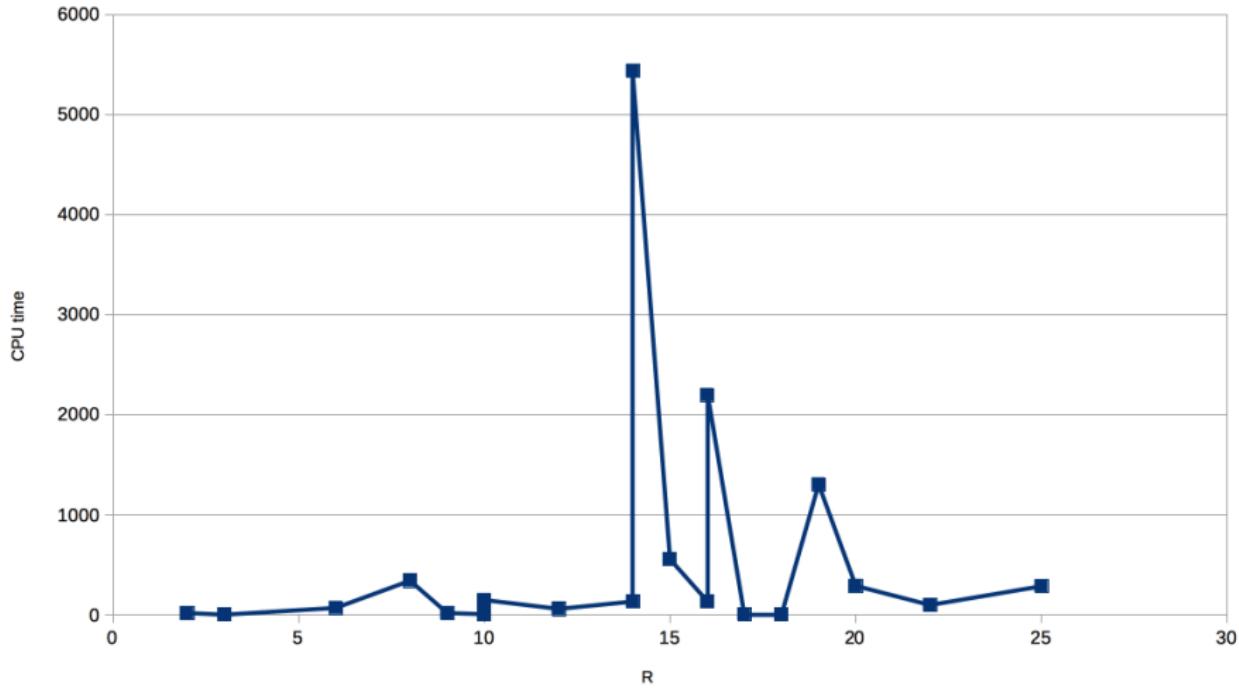
# CPU time as a function of the # of time steps



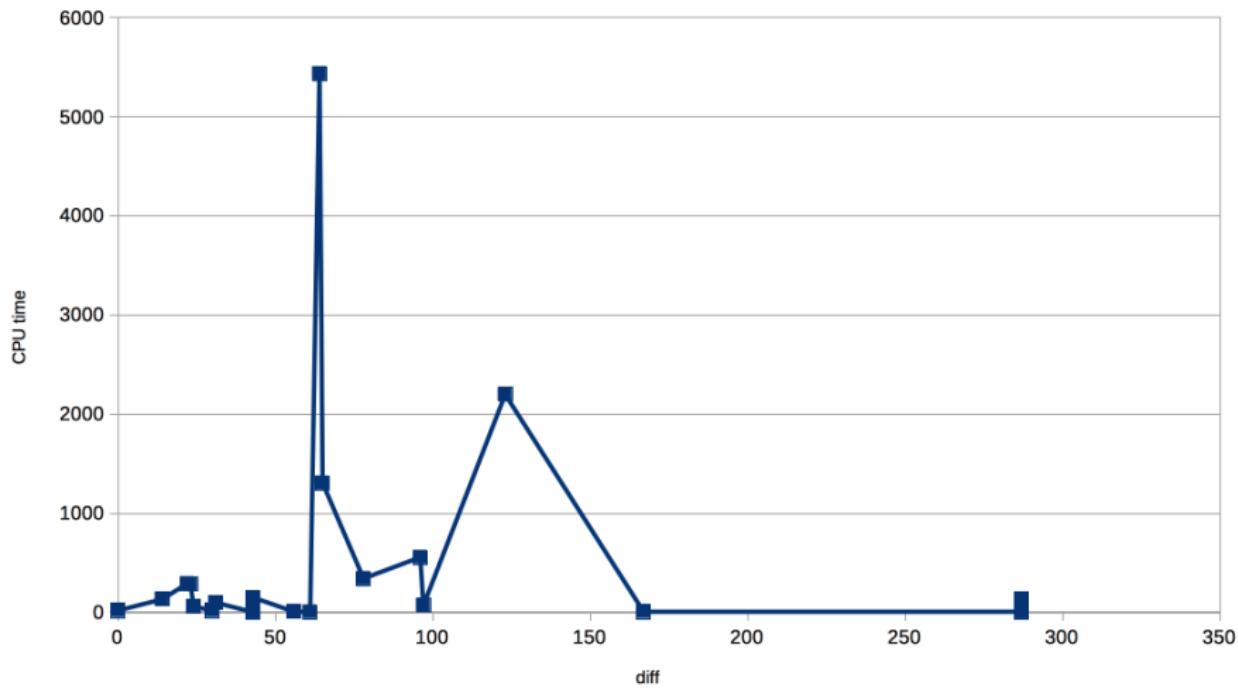
# CPU time as a function of the # of operational points



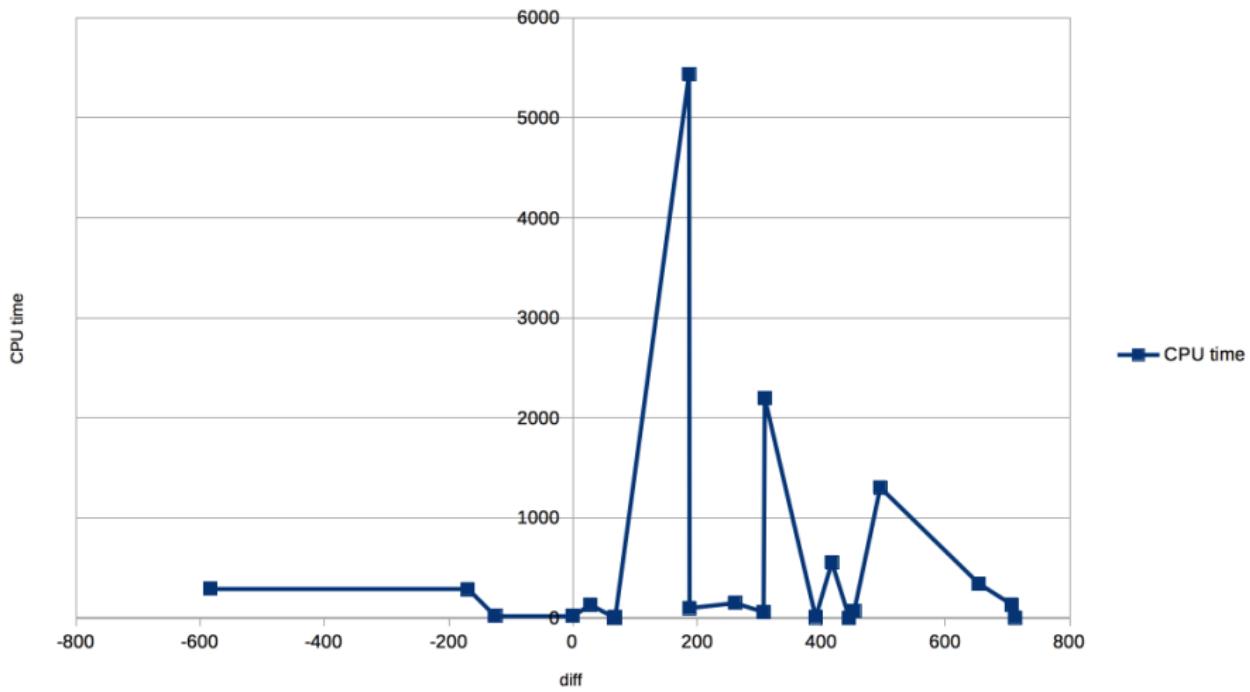
# CPU time as a function of the # of water volume levels



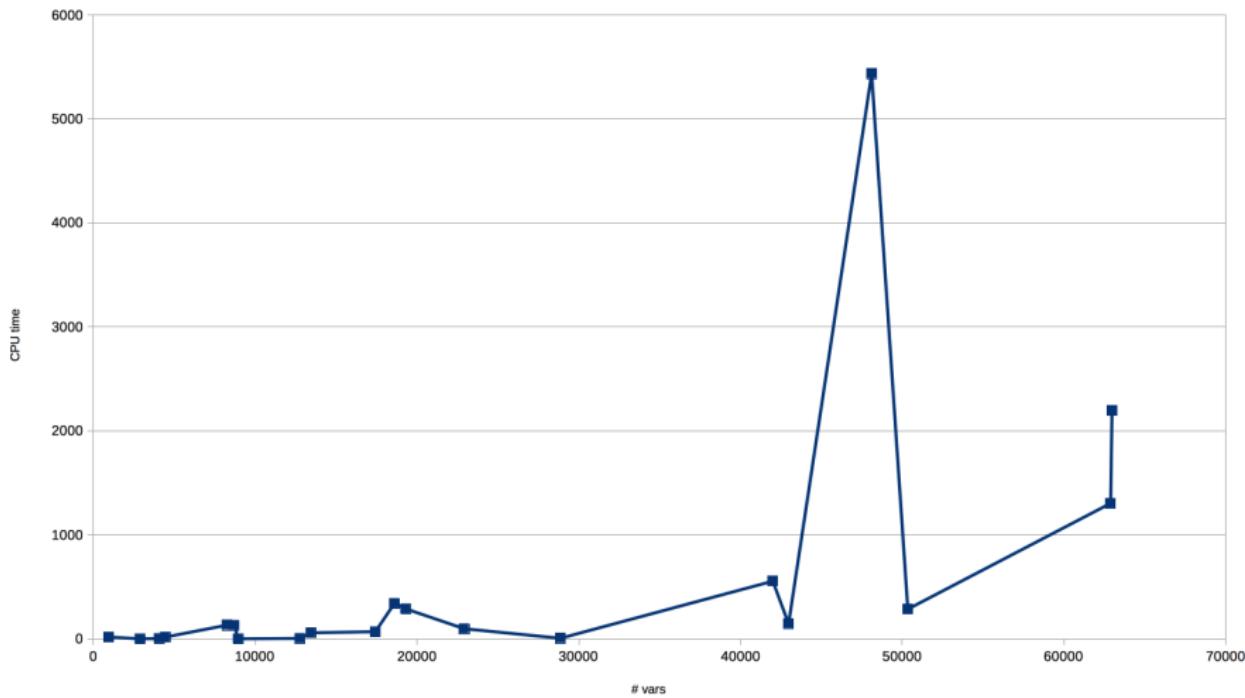
# CPU time as a function of the difference between the initial water volume and the target water volume



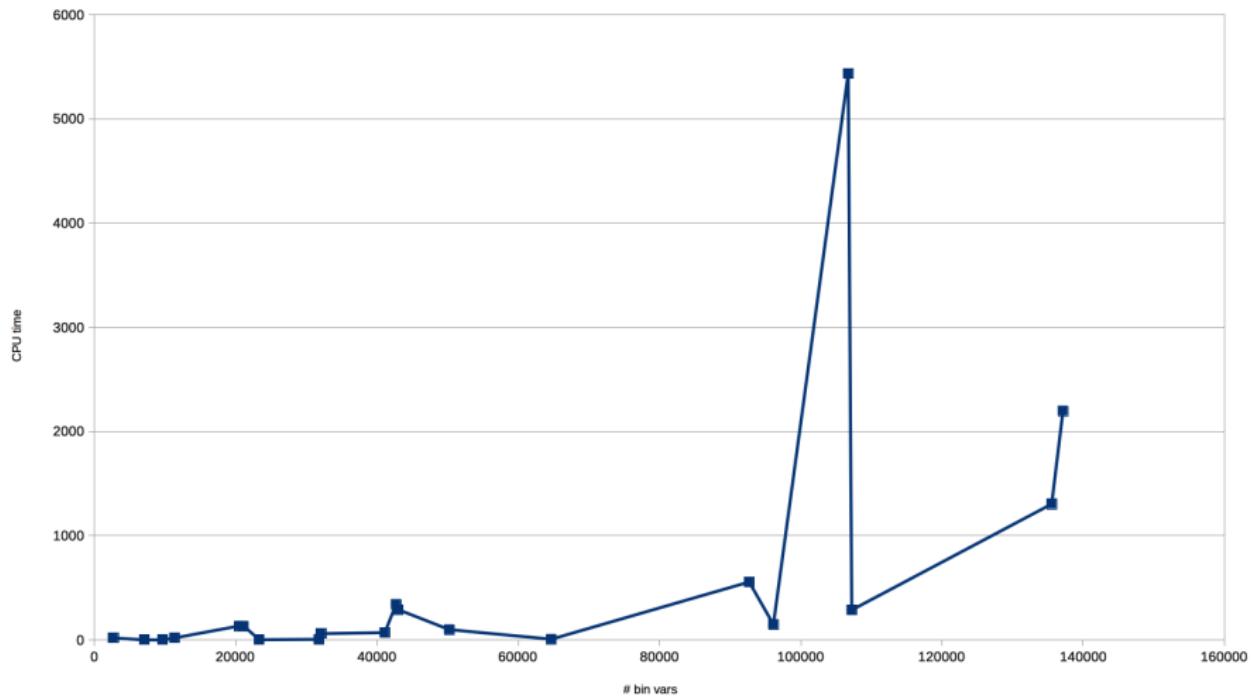
# CPU time as a function of the difference between the upper and the lower bound on the water volume



# CPU time as a function of the # of variables



# CPU time as a function of the # of binary variables



# Conclusions

- Beta version, we hope to have feedback and contributions
- Enrich the variety of potentially generated instances (different valleys, reservoirs, turbines, pumps, etc)
- Enrich the list of available mathematical models (comparison)

Thanks!