Jean HERAUD | Date

# NOTE TECHNIQUE
# Optimiz Software
# Features and global structure
# IGHEM 2012

D4136/NT/2012-00155-A Indice : A 11 Pages **0** annexe(s) 0 pièce(s) jointe(s)

Entité émettrice : EDF DTG MPSH

Documents associés :

Résumé : This document is the article on Optimiz Software which will be presented at IGHEM 2012.

Intérêt documentaire : Oui

Documentation de référence : Non

Accessibilité : Libre

Direction Production Ingénierie - Division Production Ingénierie Hydraulique
DTG
Direction
21, avenue de l'Europe - B.P. 41 - 38040 GRENOBLE CEDEX 09
**www.edf.com**

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|---|---|---|

## Création - Modifications

| Ind. | Auteur(s) | | | Vérificateur(s) | | | Approbateur | | |
|---|---|---|---|---|---|---|---|---|---|
| | Nom | Visa | Date | Nom | Visa | Date | Nom | Visa | Date |
| A | J HERAUD | | | B REEB | | | M PERSOZ | | |
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## Historique des modifications

| Indice | Date | Paragraphes modifiés / Objet |
|---|---|---|
| A | Avril 2012 | Création of  presentation |

## Diffusion

| Destinataire(s) pour application | Nb | Destinataire(s) pour information | Nb |
|---|---|---|---|
| IGHEM Haradl HULAAS | | Base Perf  Essais hydrauliques | |

**OPTIMIZ software for estimation of hydraulic plants global performances in all their operating configurations**
**Features and global structure**

**Jean HERAUD**
EDF DTG France
Email : jean.heraud@edf.fr

## 1. INTRODUCTION

EDF DTG developped in 2011, a tool called "OptimizV2" which, knowing the intrinsic performances of units (directly taken from site measurements) and losses coefficients in pipes, gives the performance of the plant in all its operating configurations.
(for all heads, all openings of wicket gates/injectors and for any combination of units)

This allows an optimization of the use of the plant :

- Knowledge of the power levels associated with efficiency peaks (whatever units running, whatever head)
- Knowledge of power margins available for contracting system services (A power target value being proposed)

Besides, it allows for major hydraulic plants, a monitoring of power.

This tool version 2 already exists (macros Excel VBA) and version 3 is being at present implemented (intranet server with mathematical part on Matlab)

This version has extended functionalities (monitoring for exemple or comparison of productible)

This issue presents the features, uses and structure of this product.

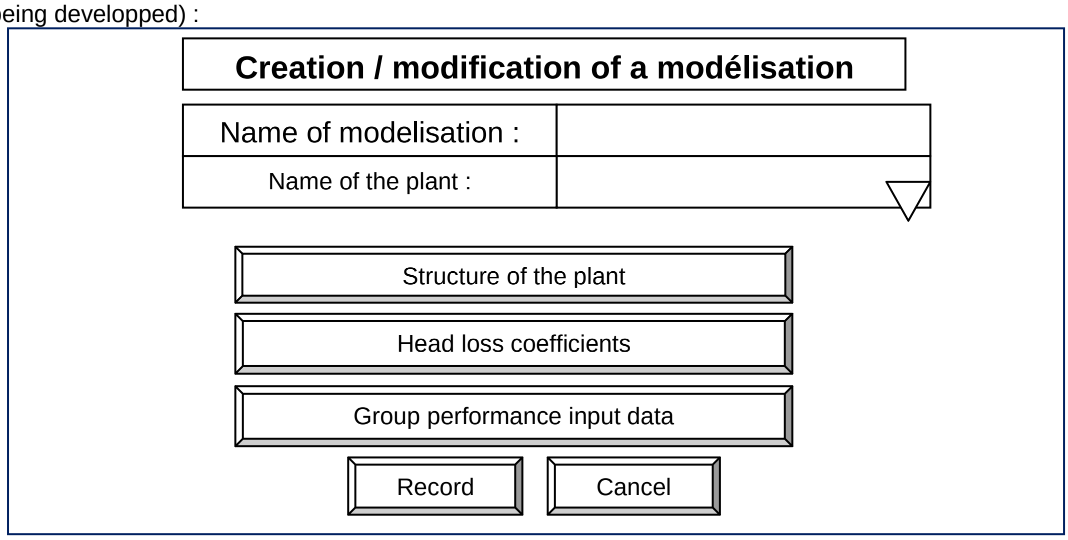
# 2. PRESENTATION OF THE TOOL

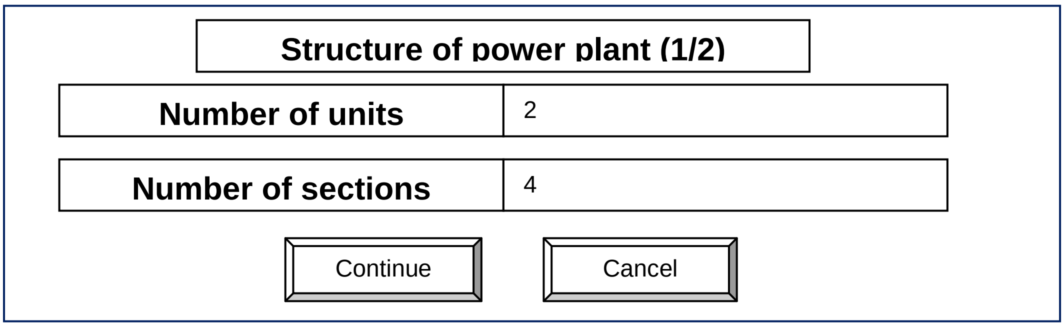
## 2.1. MODELISATION OF A PLANT

The modelisation :

- Describes the structure of the plant
- Precises the head loss coefficients
- Gives unit's performance data (coming from on site performance tests)

OptimizV3 (being developped) :



## Structure of power plant (2/2)

For each group, select the sections involved in their operation

| | G1 | G2 |
|---|---|---|
| Section 1 | ■ | ■ |
| Section 2 | ■ | ■ |
| Section 3 | ■ | □ |
| Section 4 | □ | ■ |

| Intermediate Water intake possible in headrace tunnel | |
|---|---|
| Indicate the section "bypassed" by this input | No |

Record | Cancel

## Head loss coefficients

Enter head loss for each section for a turbine or pump operation (mWC/(m$^3$/s)$^2$)

| | Turbine | Pump |
|---|---|---|
| Section 1 | 0,004642 | |
| Section 2 | 0,002617 | |
| Section 3 | 0,000148 | |
| Section 4 | 0,000148 | |

Record | Cancel

## Unit performance input data

| | Allocation of data sets (turbine) | Injectors altitude (Pelton) | Allocation of data sets (pump) |
|---|---|---|---|
| G1 | St Guill-def | | No |
| G2 | St Guill-def | | No |

Record | Cancel

## Group performance dataset

| Name of dataset | St Guill-def |
|---|---|

### Series of data n°1

| | |
|---|---|
| Net Head = | 234,5 |
| α = | 1,6 |
| β = | 0,5 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Opening | 60,2 | 99,7 | 125 | 150,3 | 164,8 | 176,3 | 196,5 | 217,2 | 220 |
| P (MW) | 10,51 | 20,87 | 28,41 | 35,47 | 38,57 | 40,88 | 44,01 | 46,3 | 46,67 |
| Q (m3/s) | 6,71 | 11,34 | 14,47 | 17,46 | 19,12 | 20,18 | 22,09 | 23,85 | 24,1 |

New operating point

### Series of data n°2

| | |
|---|---|
| Net Head = | 258,5 |
| α = | 1,5 |
| β = | 0,5 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Opening | 81 | 100,5 | 114,5 | 126 | 133 | 149 | 170,5 | 183,5 | 217 |
| P (MW) | 19,62 | 26,31 | 31,52 | 35,10 | 37,76 | 42,60 | 47 ,82 | 50,45 | 55,03 |
| Q (m3/s) | 9,70 | 12,66 | 14,11 | 15,47 | 16,51 | 18,51 | 20,90 | 22,29 | 25,21 |

New operating point

### Series of data n°3

| | |
|---|---|
| Net Head = | 292,25 |
| α = | 1,4 |
| β = | 0,5 |

| | | | | |
|---|---|---|---|---|
| Opening | 79,0 | 92,5 | 104 | 118 |
| P (MW) | 25,34 | 31,11 | 35,95 | 42,25 |
| Q (m3/s) | 10,73 | 12,63 | 14,24 | 16,38 |

New operating point

New blank series of data

| **Type of interpolation** (steady net head) | Cubic spline (default) ▽ |
|---|---|

**Limitations associated with the dataset :**

| | |
|---|---|
| MIN limit | Power |
| Value | 15 |

MIN {

| | |
|---|---|
| Type of max limit : | Opening ▽ |
| Value : | 220 |

| | |
|---|---|
| Type of max limit : | Power |
| Value | 45 |

**Visualization of the data set** ▽

| Choice of x-axis | Output ▽ | Choice of y-axis | Power ▽ |
|---|---|---|---|

Efficiency chart

Record    Cancel

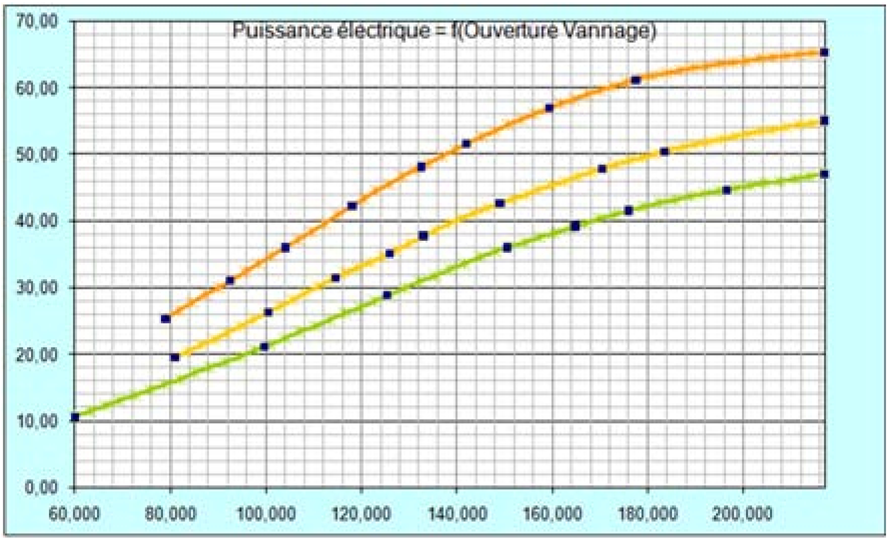
α and β are the coefficients for transposition into net head of power and flow rate.
- In turbine, they worth by default 1.5 and 0.5 (these values do not need to be refined if the simulated net head is framed by net heads of input datas)
- In pump, no default value are proposed. They must be defined at each time

**Graphic validation of input dataValidation**

OptimizV2 allows a visualisation of input data and of the interpolation curves associated.
Il allows to check :

- the quality of interpolation
- the coherence of the data at various net head values …

Many types of curves are proposed among which, the one below (Electric power function of wicket gate opening.)



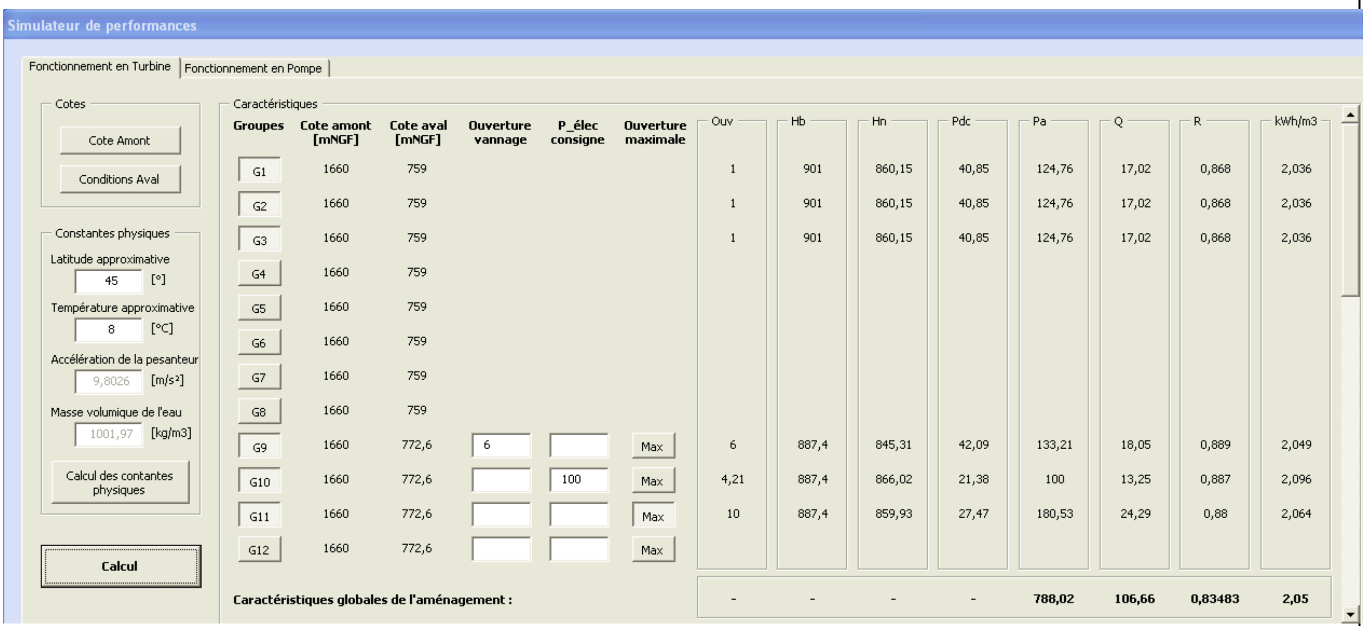

## 2.2. SIMULATOR SCREEN

The screen below is taken from OptimizV2

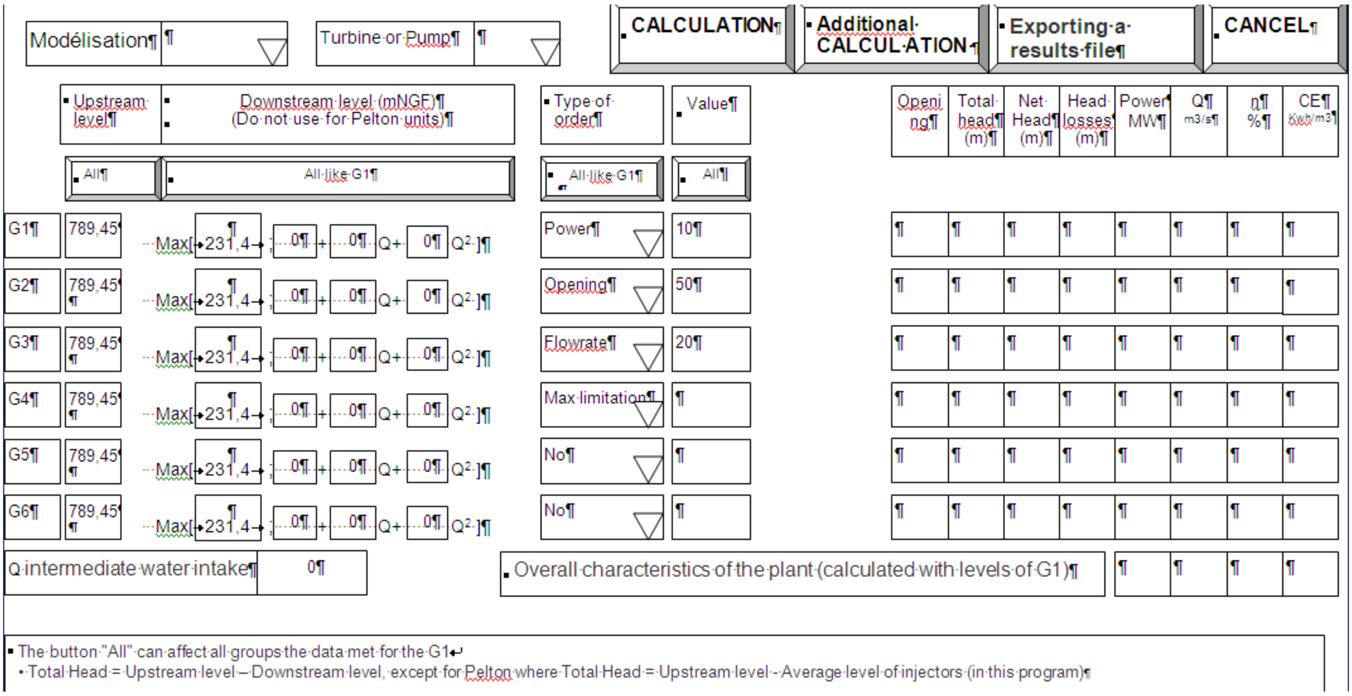
The scalars obtained for each unit are :

- Opening
- Total head
- Net head
- Head losses
- Power
- Flowrate
- Output
- kWh/m$^3$

Screen of OptmizV2

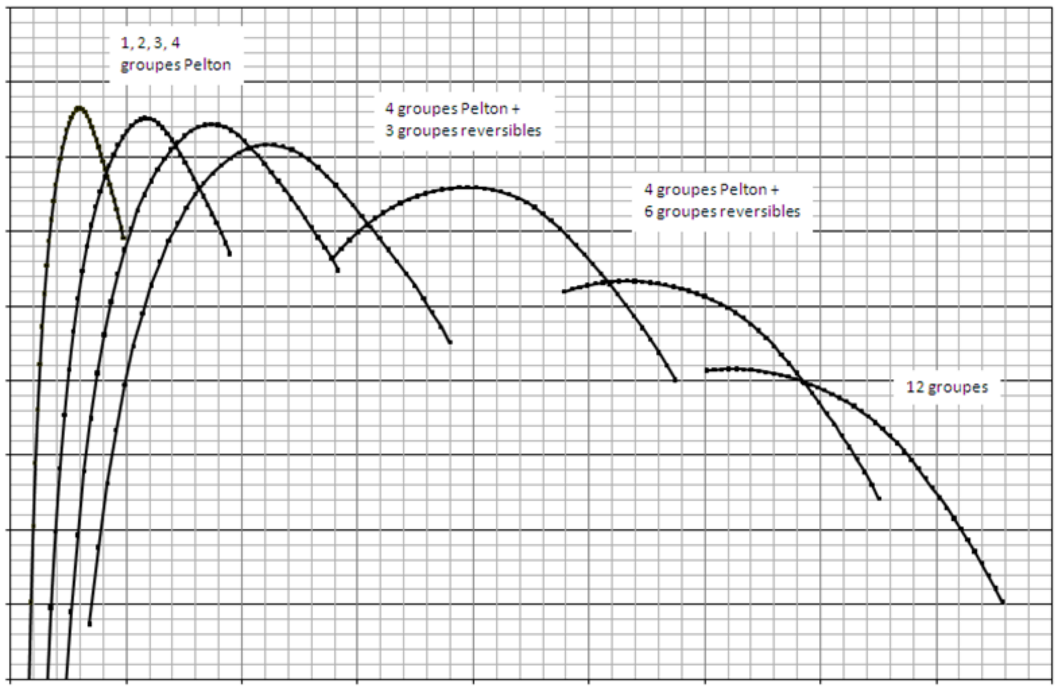



Screen of OptmizV3




## 2.3. GRAPHICS

The tool (V2) is already able to generate curves for variations of load or head.
Superposition of curves are possible (as in the Output/Power drawing below)




## 2.4. CALCULATION OF PRODUCTIBLE AND ENERGETICAL COEFFICIENT

OptimizV3 will be able to calculate the productible of the plant or the energetical coefficient (kWh/m$^3$) for a monitored period of supervision.
More precisely, with the monitored Power of each group and the upstream and downstreal levels, Optimiz will calculate

- Productible
- Energetical coefficient

This calculation will be made possible by the importation of a monitoring file.

For each line of the file, OptimizV3 will calculate, flowrate, opening, …
Average power, average flowrate, and average levels will allow to calculate average output and average energetical coefficient.

OptimizV3 will be able to simulate what would be productible and the Energetical coefficient with another modelisation.
This is useful when you try to justify the added value of a new shape of turbine for example.

Comparisons can be made :

- At equal power of order for the energetical coefficient
- At power amplificated by a multiplicative factor for comparison of energetical coefficient
- At equal flowrate for comparison of productible or energetical coefficient

## Enegetical coefficient

| | Calcul source | Additional calculation | Additional calculation |
|---|---|---|---|
| imported file | Export Archi.csv | | |
| Modélisation | Sisteron 2011 | Sisteron 2015 | Sisteron 2015 |
| Type of order | Power | Flowrate | Power |
| Multiplicative factor | 1 | 1 | 1,05 |

| | | | |
|---|---|---|---|
| Cumulative time (hours) | | | |
| Average Upstream level | | | |
| Average Downstream level | | | |
| Average POWER (MW) | | | |
| Q moyen ($m^3/s$) | | | |
| η moyen (%) | | | |
| Energy (GWh) | | | |
| **Average energetical coefficient ($kWh/m^3$)** | | | |
| | Calculate | Calculate | Calculate |

Export a result file

Cancel

## 2.1. MONITORING

By monitoring head and openings (of wicked gates or injectors), it is possible to simulate the expected power. Comparison between monitored power and simulated power allows a broad spectrum monitoring which ensures that the power of units is in line with expectations.

This monitoring may allow to :

- Detect technical defects
  - Power measurement defects
  - Opening organs measurement defects
  - Defects in optimization blades / wicket gate of Kaplan/bulb turbines
  - inhomogeneities openings of Pelton turbines injectors
- highlight incidents harmful to the installation:
  - Power losses by obstruction (wood stuck in the wheel, the spiral case, the injector ...)
- highlight performance trends emerged in the long term or after work
  - abnormal loss of performance:
  - significant wear of the wheel and labyrinths
  - poor axial setting of the wheel
  - loss of the tip wheel ...
- detect losses in adductions
  - silting of the gallery
  - Degradation of internal coatings

In this issue, we will not detail the structure of monitoring.

Let's just have a look on the detection of a problem

### Focus on a sample

| | |
|---|---|
| Name of the plant : | XXXXX |
| Name of the modelisation : : | 2011 Modelisation |
| Name of the file of configuration : | XXXX Monitoring |

| | |
|---|---|
| Start date of the sample | 01/02/2013 16:00:00 |
| End date of the sample | 01/02/2013 16:10:00 |

| | Monitored data | | | | | Simulated data | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Opening | Upstream level | Downstream level | Power | Difference (%) | Power | Q | η | kWh /m³ | Total head | Net head | Head losses |
| G9 | 159 | 2000 | 1200 | 80 | -2,5% | 82 | 20 | 90 | 20 | 800 | 760 | 40 |
| G10 | 0 | 2000 | 1200 | 0 | 0% | 0 | 0 | / | 0 | 800 | 800 | 0 |
| G11 | 200 | 2000 | 1200 | 110 | -4,4% | 115 | 25 | 89 | 25 | 800 | 755 | 45 |
| G12 | 200 | 2000 | 1200 | 112 | -2,6 | 115 | 25 | 89 | 25 | 800 | 755 | 45 |

Export result file | Export report | cancel

# 3. STRUCTURE OF THE TOOL

The tool is based on a matricial Newton Raphson iterative resolution.
The aim of the iteration is the convergence of the vector of the total head calculated towards the target value total head.

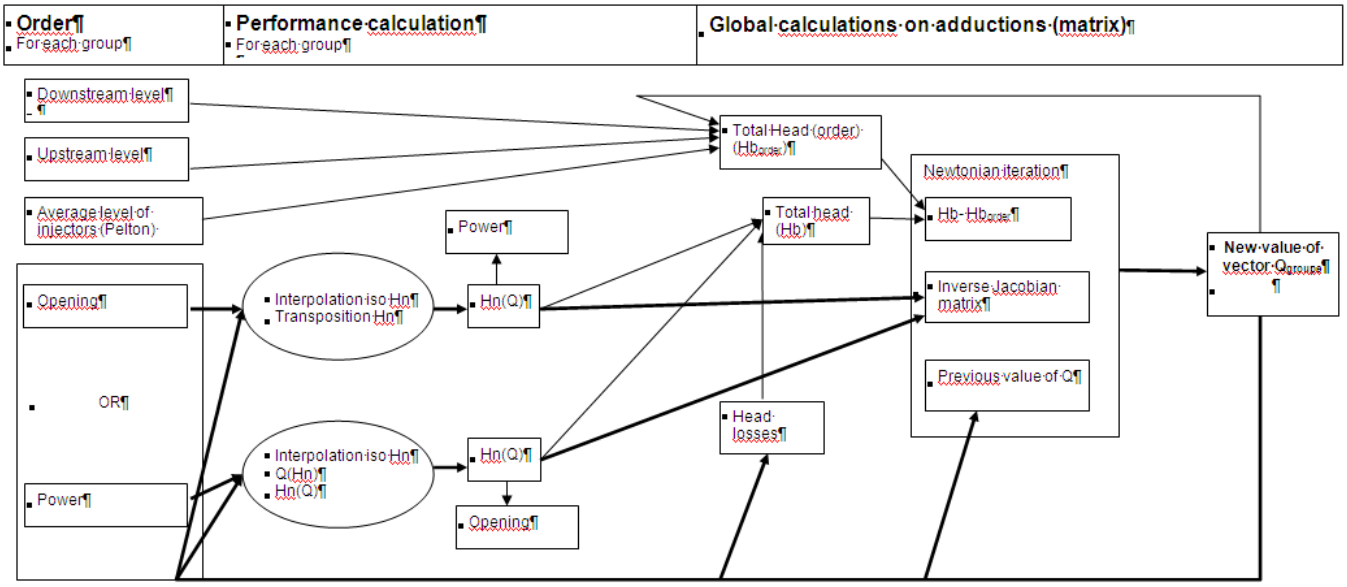
To transpose Power and Flowrate at different net head values, α et β coefficient are used, defined as :

$$P(Hn) = P(Hn_{ref}) \times \left( \frac{Hn}{Hn_{ref}} \right)^{\alpha}$$

$$Q(Hn) = Q(Hn_{ref}) \times \left( \frac{Hn}{Hn_{ref}} \right)^{\beta}$$

If net head values of the input performance datasets frame the net head of transposition, weighted average is realised between the transpositions from various sources.

OptimizV2 allows simulations with target value openings or target value power.
OptimizV3 will allow also target value flowrate.




# 4. CONCLUSION

The need of a tool like Optimiz is universal for operating units at their best and manipulating easily the results of performance measurements.
The aim of this presentation is to present EDF approach and also to exchange among IGHEM group members on this issue.