
Dept. of Electrical Engineering and Computer Science
(Institut Montefiore)

# user guide of

# ARTERE

# (power flow computation)

Updated February 2014

## 1. Starting ARTERE

A double-click on the ARTERE icon starts the program and opens the windows shown in Fig. 1.

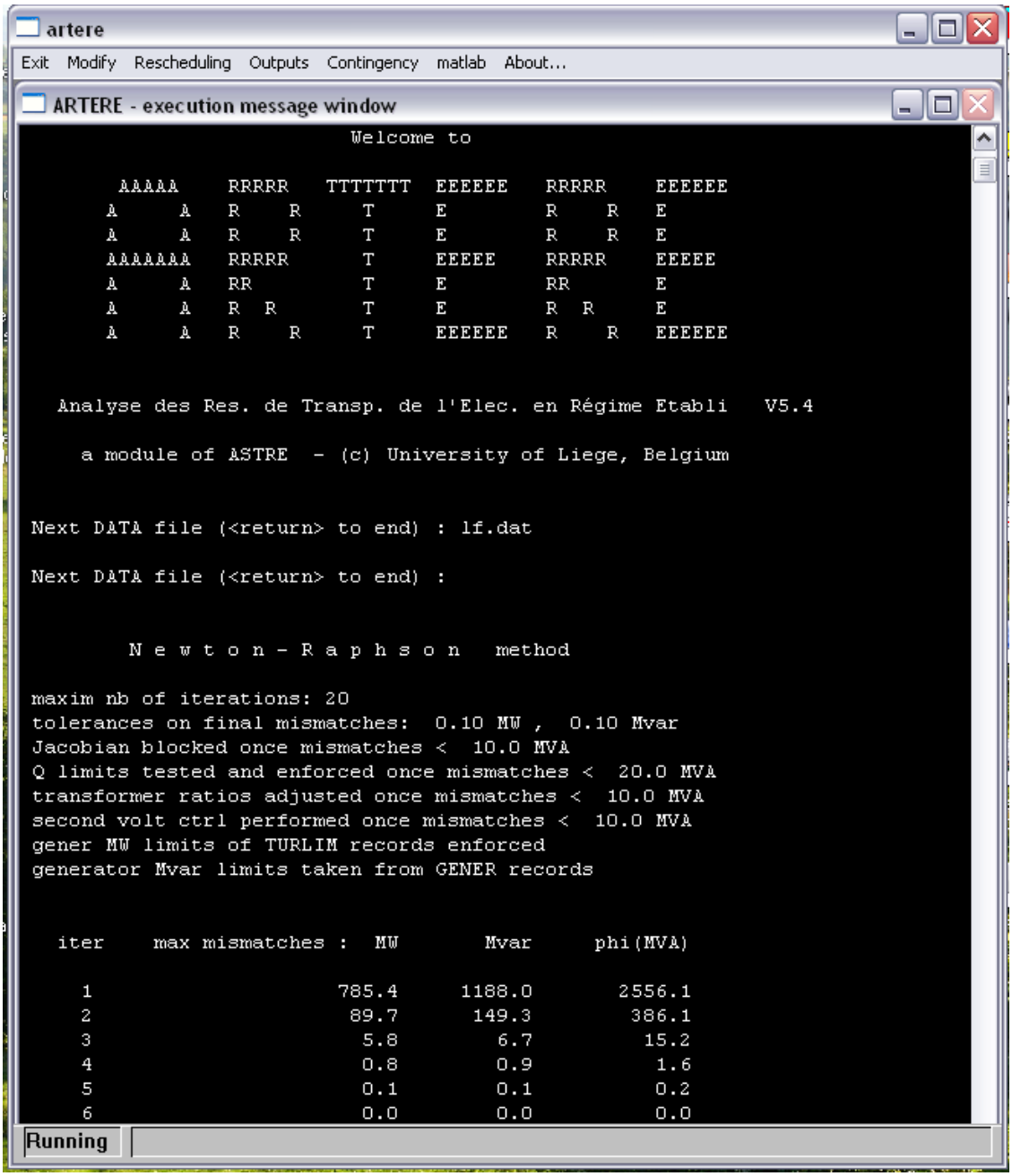


Figure 1. Main window

ARTERE asks the name(s) of the data file(s). The data can be located in one or in several files (please refer to the data description documentation). Enter the names(s) as appropriate and end by pressing « return ».

ARTERE then runs a power flow computation, displaying the successive values of the mismatches, the generator PV-PQ switchings, the transformer adjustments, etc. At this point, a solution is ready to be displayed. In the sequel, this solution is referred to as the “base case”.

At the end of this computation, several menus appear in the upper bar of the window (see Fig. 1). These main menus of interest are described hereafter.

## 2. The « Outputs » menu

By clicking on « Outputs », the menu shown in Fig. 2 appears, whose items are described hereafter.

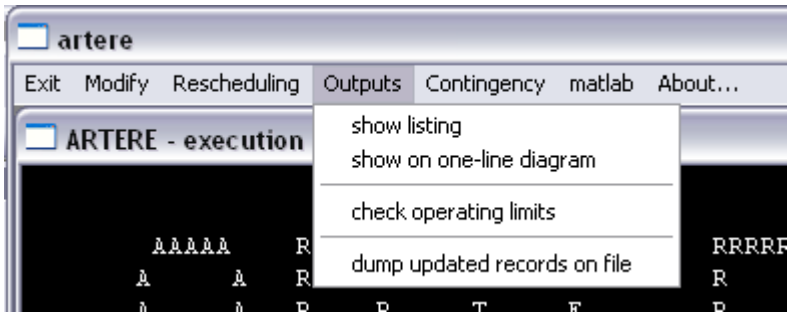


Figure 2. Outputs menu

- **`show listing`** : gives access to various outputs. The output selection box shown in Fig. 3 pops up.

  Click on one or several buttons, as desired, then press « display ». A NOTEPAD windows opens and displays the selected results. The user has access to all NOTEPAD facilities (print, save on file, cut and paste in other documents, etc.).

  By way of example, clicking « global power balance - display » opens the NOTEPAD window shown in Fig. 4 (the window size, the font, etc. depend on the settings of your computer). The window will remain until you close it. If you don't, selecting new outputs and clicking on « display » will open another NOTEPAD window.

  Most of the outputs are self-explanatory. If you are looking for a complete view of the system state, choose « bus overview », « generators », « svcs » (if any in the system), « global power balance » and « adjustable transformers » (if any in the system).

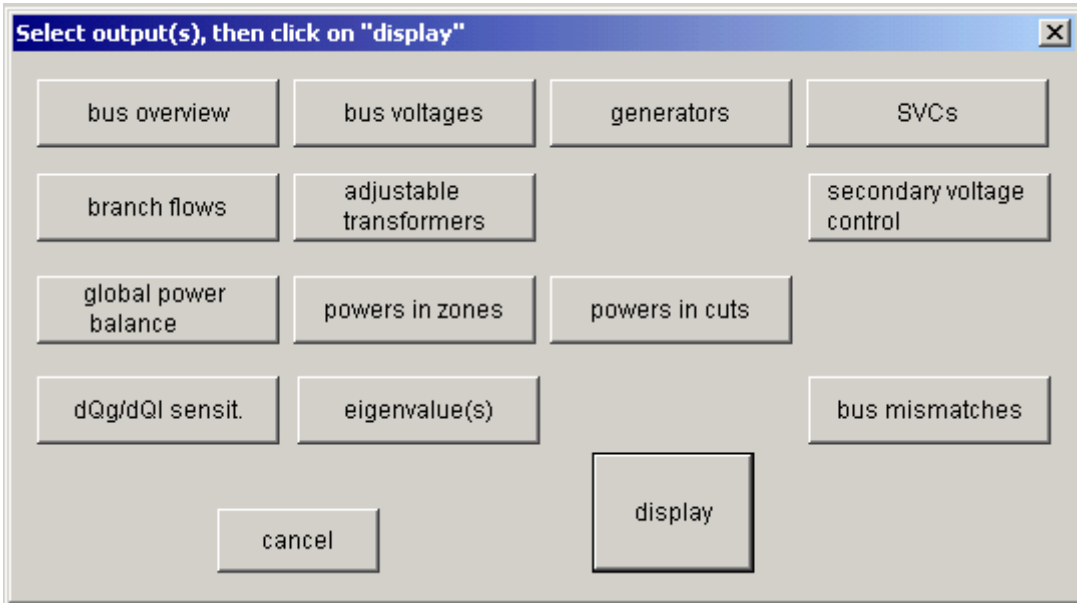


Figure 3. Output selection dialog box

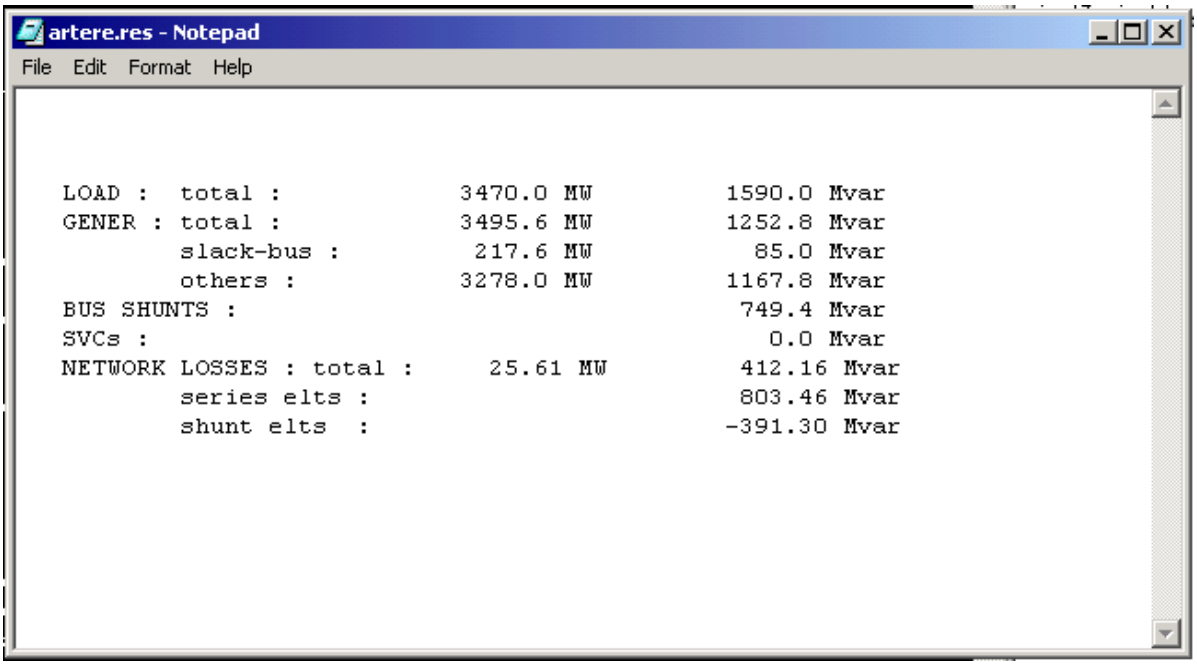


Figure 4. NOTEPAD window showing the selected results

- **`show on one-line diagram`** : results can be displayed on one-line diagrams. These diagrams must be provided in graphic files in SVG format[1]. The file must include special strings of characters which ARTERE replaces by numerical results. The list of codes is given in Appendix 1.

  ARTERE asks the name of the input **`svg`** file and the name of the output **`svg`** file to produce. If you do not provide an output file name, ARTERE uses the default name **`res_name.svg`**

[1] Scalable Vector Graphics. A nice free software producing figures in SVG format is Inkscape (see www.inkscape.org)

where **`name.svg`** is the name of the input file. Once this is done, ARTERE produces the message :

```
Open res_name.svg in your browser
```

The output SVG file can be opened in (hopefully) any browser. An example of display in Google Chrome is shown in Fig. 5.

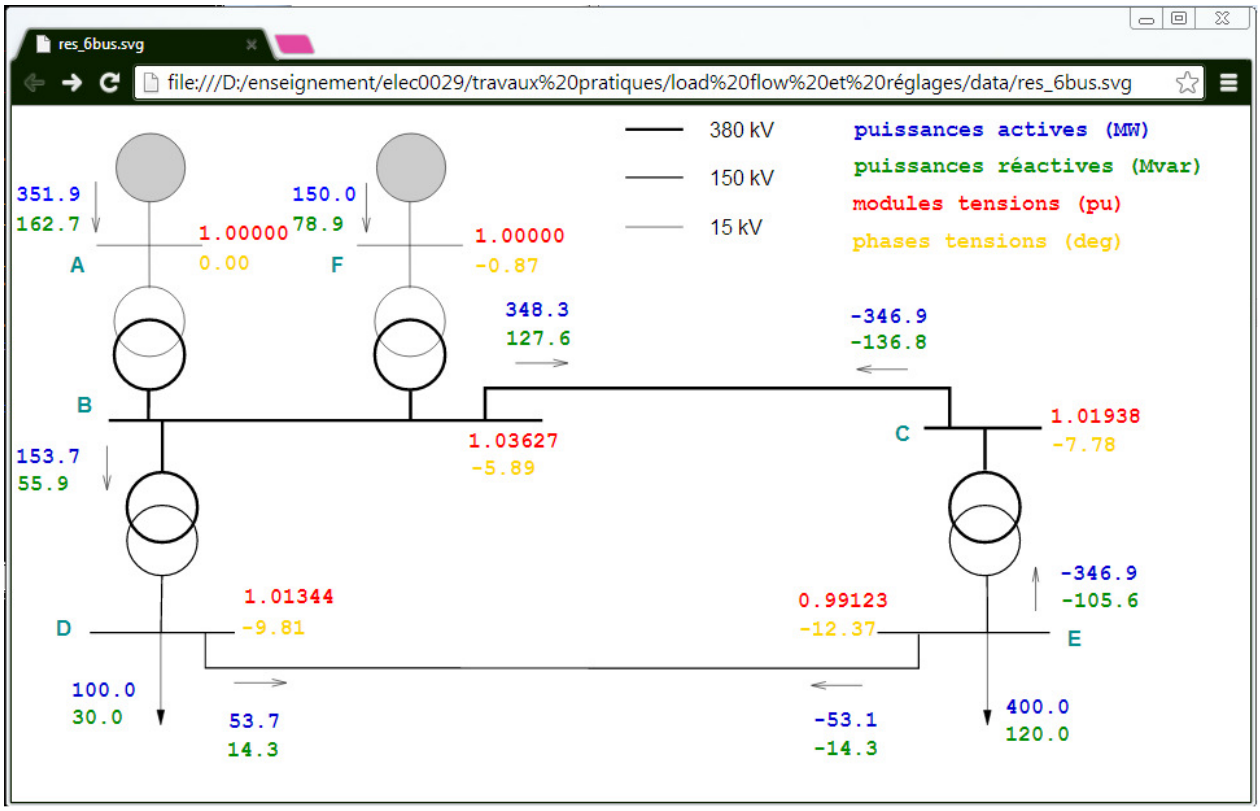


Figure 5. One-line diagram display with Google Chrome

If you ask for another one-line diagram output, you may wish to either replace the previous figure or see it in a separate window, for instance for comparison purposes. In the former case, just click on the refresh button of your Internet browser and the figure will be updated.

- **`check operating limits`** : checks whether each bus voltage is within some interval and each branch current is below the rated value of the branch multiplied by some factor. ARTERE asks for the voltage lower and upper bounds (in per unit) and the factor by which the rated currents must be multiplied.

  A NOTEPAD window opens, showing the violated constraints. The window is empty if all voltages and currents are within limits.

- **`dump updated records on file`** : allows to create a new ARTERE data file corresponding to the present state of the system. All the data are updated as appropriate. In particular, the present values of the voltages are saved as initial values. The program asks for the name of the file to produce.

## 4. The « Modify » menu

By clicking on `modify` , the menu shown in Fig. 6 appears, whose items are described hereafter.

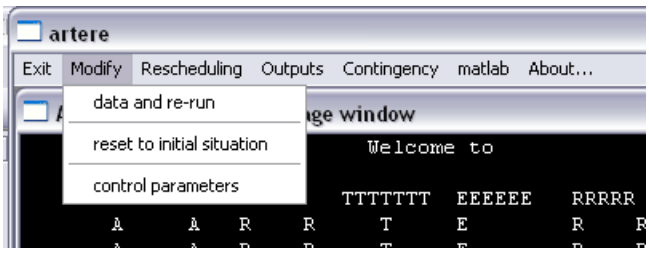


Figure 6. Modify menu

- **`data and re-run`** : allows to modify loads or generations, trip or reconnect equipments, etc. The dialog box shown in Fig. 7 pops up.

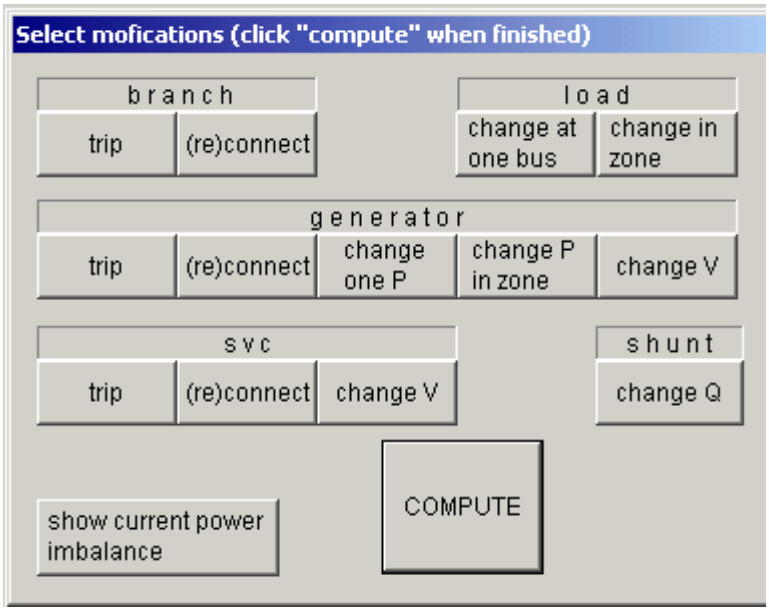


Figure 7. Modification dialog box

All items are self-explanatory. When the user is prompted for the name of an equipment, a scrolling window displays all the valid selections. When all modifications are entered, click on `compute` to trigger a new load flow computation, and obtain the resulting state.

When a branch tripping causes the system to split in two parts (loss of connectivity), only the part containing the slack-bus is considered in the subsequent computations.

As the user modifies generations and/or loads or splits the system, the global power balance is disturbed. By clicking on `show current power imbalance` the active power imbalance is displayed in the main window. Section 6 explains how this power is going to be compensated by the various generators.

Modifications are cumulative. Each load flow computation starts from the last solution.

- **`reset of initial configuration`** : resets the system to the base case. The data as well as the system state are turned back to their base case values. This is useful in particular when load flow divergence has been met.

- **`control parameters`** : allows to specify new control parameters, which replace the ones specified when starting the program.

## 5. The « Contingency » menu

### 5.1. Dialog

The `contingency` menu allows to perform contingency analysis. Through the dialog box shown in Fig. 8, the user specifies the name of the file describing the contingencies (its format is described below) as well as the criteria to be checked on the post-contingency states.

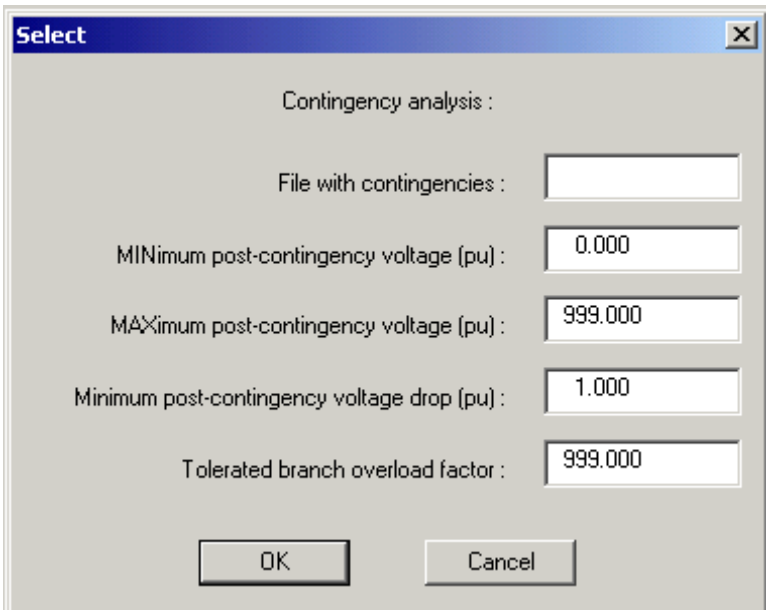


Figure 8. Contingency dialog box

In this box, « voltage drop » refers to difference between the pre- and the post-contingency voltages of a bus. The « branch overload factor » is defined as in the `outputs - check operating limits` menu.

ARTERE simulates each contingency successively, in silent mode. At the end of the analysis, a NOTEPAD window opens and displays the violated constraints for each contingency. Contingencies having led to divergence are also quoted (they *may* correspond to voltage instability).

### 5.2. The contingency specification file

The syntax of the contingency file is as follows. Each contingency is described by:

1. its name (reproduced on output) : a string of at most 40 characters
2. a code describing the disturbance, as listed in the first column of Table 1

3. the name of the involved equipment as indicated in the last column of Table 1
4. in the case of a shunt modification : the increase in nominal reactive power (in Mvar), i.e. the reactive power produced under a 1 per unit voltage
5. the delimiter **`end_contingency`** indicating the end of the contingency definition.

Table 1. Contingency specification

| *code* | *meaning* | *name requested* |
|---|---|---|
| `bt` | branch trip | name of branch |
| `gt` | generator trip | name of generator |
| `st` | SVC trip | name of SVC |
| `hc` | modification of shunt compensation | name of bus |

Each of the items 1 to 5 has to be written on a separate line.

Items 2, 3 and 4 are repeated for each equipment involved in the contingency.

The above sequence is repeated for each contingency.

## 6. The « Rescheduling » menu

This menu allows the user to specify how generation has to be rescheduled when the active power balance will be disturbed. This may result from modifications imposed by the user (menu `modify` : see Section 4) or from contingencies involving generator tripping or system splitting (menu `contingency` : see Section 5).

The dialog box shown in Fig. 9 pops up. The meaning of the options are as follows.

- **`let the slack-bus compensate`** : leaves the compensation of any power imbalance to the slack-bus (specified in the data). All the other generators have constant active power productions;

- **`take participations from GROUP3 and GROUP-PV records`** : reschedules each generation according to the speed droop (or statism) of the corresponding machine, as specified in GROUP3 and/or GROUP-PV records of the data file;

- **`take participation factors from zone :`** generation can be rechduled over the generators of a zone, according to the participation factors specified in the data file. Namely, if $p_i$ is the participation factor of the $i$-th generator of the zone, and $\Delta P_{tot}$ the total power to be distributed over that zone, the active power of this generator is changed by the amount :

$$p_i \, . \, \Delta P_{tot} / (\Sigma_j \, p_j)$$

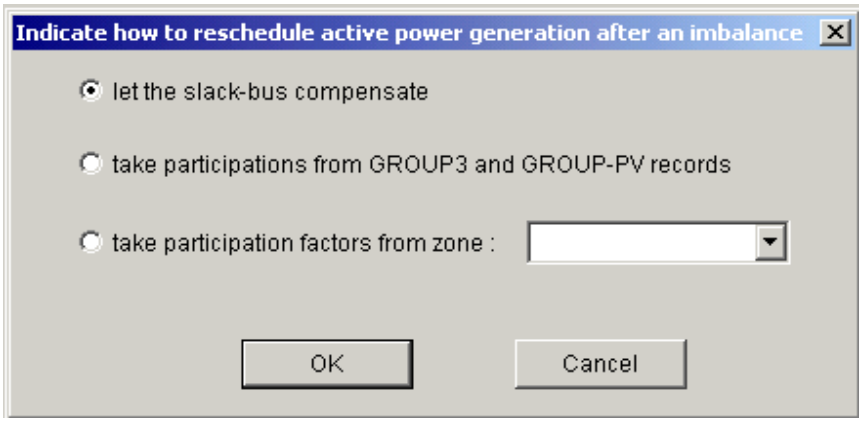


Figure 9. Rescheduling dialog box

where the sum extends over all the generators in service in the zone. ARTERE asks for the name of the zone to be considered.

If generator active power limits are enforced (see Control parameters in Section 8), and the rescheduling would cause a generator to produce more than its upper limit (resp. less than its lower limit), the power in excess (resp. deficit) is distributed over the remaining generators.

Note also that *the various active power generations are rescheduled before a new load flow computation is performed, and are kept constant during this computation*. Hence, the change in losses is still compensated by the slack-bus generator.

## 7. The « matlab » menu

Clicking on the « matlab » menu produces two files :

- **`ini.m`** : MATLAB code defining :
  - a structure named **`opt`** specifying for each bus: the bus name, the bus voltage magnitude (in pu) and phase angle (in radians), the active and reactive power injections (in MW and Mvar, respectively);
  - an array named **`Y0`** which is the admittance matrix of the network. Note that loads and generators admittances are *not* taken into account in this matrix.

- **`net.m`** : not documented here.

These files are used to automatically initialise dynamic simulations performed with SIMULINK. However, the MATLAB code in **`ini.m`** can be easily re-used in computations involving the network admittance matrix, e.g. for the analysis of balanced faults.

## Appendix 1. Codes to insert in SVG file for displaying output results

The codes all start with a %, followed by a single letter that identify the type of output and by one or two equipment names, as described in the following table.

| code to be inserted | meaning | unit |
|---|---|---|
| %AXXX | voltage magnitude at bus XXX | per unit |
| %BXXX | voltage magnitude at bus XXX | kV |
| %CXXX | phase angle of voltage at bus XXX | degrees |
| %DYYYYY,XXX | active power entering branch YYYYY at bus XXX [2] | MW |
| %EYYYYY,XXX | reactive power entering branch YYYYY at bus XXX [3] | Mvar |
| %FYYYYY | ratio of current to nominal current in branch YYYYY | (dimensionless) |
| %GZZZZZ | active power produced by generator ZZZZZ | MW |
| %KZZZZZ | reactive power produced by generator ZZZZZ | Mvar |
| %HXXX | reactive power produced by shunt at bus XXX | Mvar |
| %IXXX | dQgt/dQl sensitivity at bus XXX | (dimensionless) |
| %JYYYYY | position of tap on transformer YYYYY | (dimensionless) |
| %LZZZZZ | reactive power produced by SVC ZZZZZ | Mvar |
| %MWWW | active power generation in zone WWW | MW |
| %NWWW | reactive power production by generators in zone WWW | Mvar |
| %OWWW | active load in zone WWW | MW |
| %PWWW | reactive load in zone WWW | Mvar |
| %QWWW | reactive power by shunts and SVCs in zone WWW | Mvar |
| %RXXX | load active power at bus XXX | MW |
| %SXXX | load reactive power at bus XXX | Mvar |
| %TXXX | breaker status on branch XXXX | (dimensionless) |
| %UXXX | breaker status on generator XXXX | (dimensionless) |

Recall that the names of equipment are limited as follows :

| | | | |
|---|---|---|---|
| bus : | max 8 characters | zones : | max 8 characters |
| generators : | max 20 characters | SVCs : | max 20 characters |
| branches : | max 20 characters | | |

Names which include spaces must be enclosed in quotes. The quotes do not count in the name length.

[2] The comma is mandatory to separate the name of the branch and the name of the bus
[3] Same remark