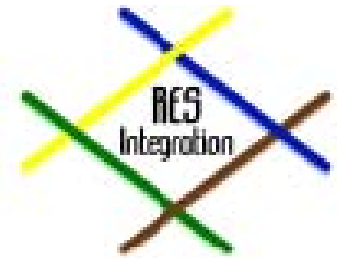

RES – INTEGRATION
FP6 509204 RES Integration

DETERMINING OPTIMUM INTEGRATION OF RENEWABLE ENERGY SOURCES (DOIRES) SOFTWARE

Multi-criteria Analysis Tool

WP 3 – Deliverable 6

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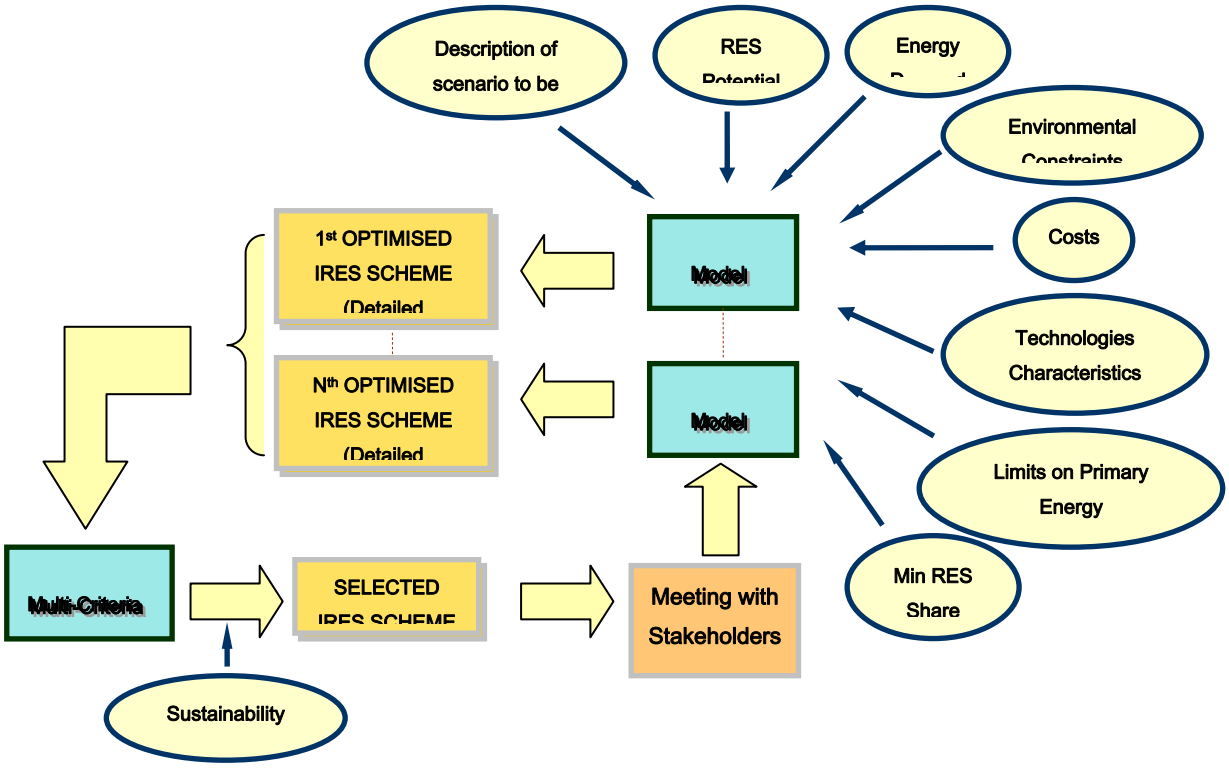
Multi-criteria analysis

Multi-criteria analysis serves as a tool of ranking various optimised alternatives for each case study through suitable sustainability indicators. Optimised alternatives come from the optimisation process of DOIRES, resulting in combination of conventional and RE Technologies. Multi-criteria analysis allows for exploration of the proposed solutions, dialog among decision makers and stakeholders aiming at the best compromise.

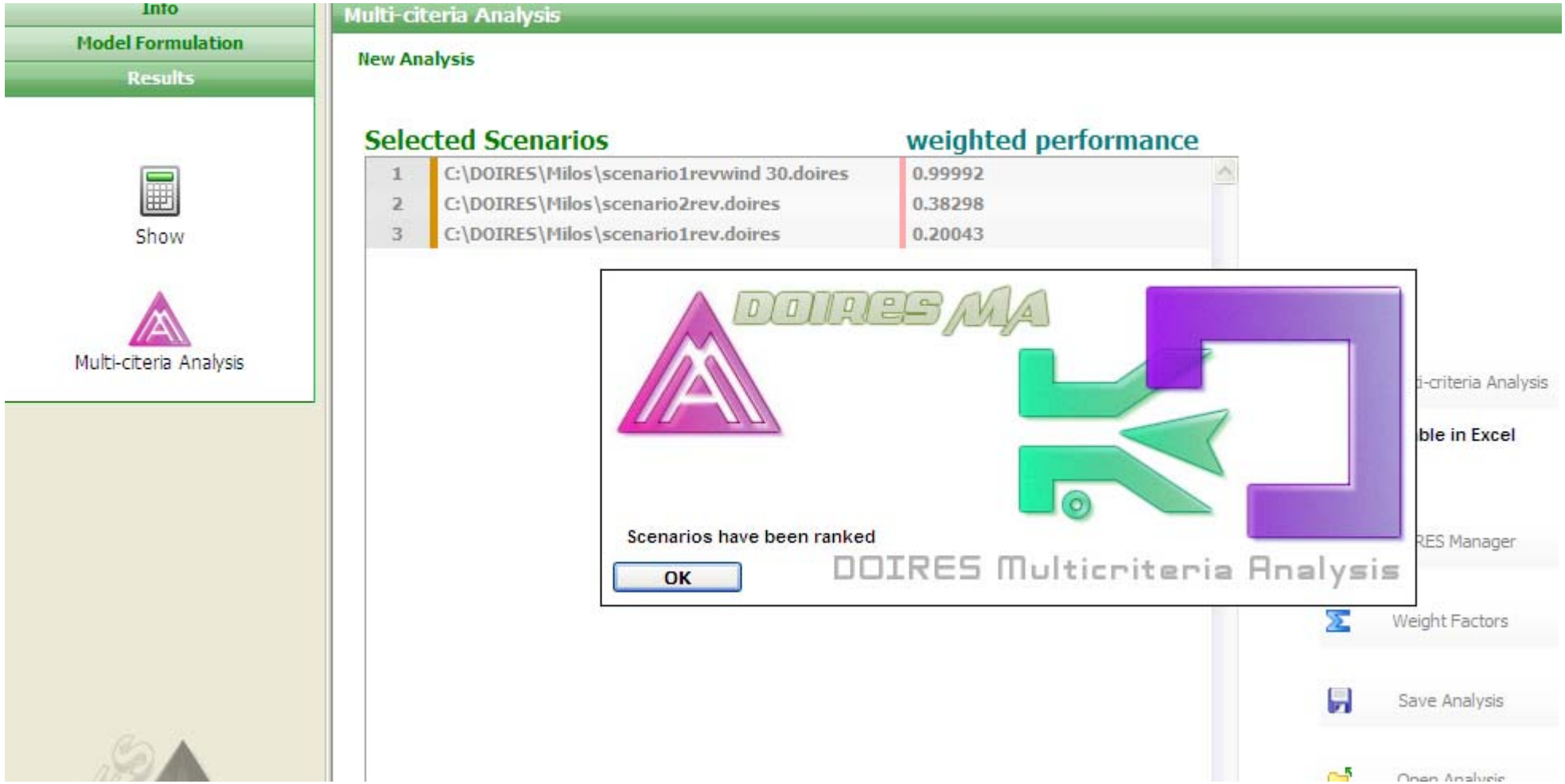
DOIRES allows for optimisation starting from a base of several possible configurations of potential technologies to be exploited for energy production in the target region under study and leads, under suitable constraints and sustainability indicators, set by the user according to the pursued goal, in an edge of best compromise configuration. This procedure could be pictured as a pyramid, its base being the described scenario to be optimised and its edge, the (chosen by DOIRES tool) configuration of technologies in operation for a planning horizon of up to 20 years.

DOIRES model is expected to generate a fair number of alternative configurations. Since these are discrete alternatives' outranking Multicriteria methods are used to rank those alternatives. PROMETHEE methods a special class of outranking method is selected due to its simplicity, clearness and stability. Partial or complete preorder is possible on a finite set of feasible actions. Software facility makes available exploration of the feasible alternatives through changes in preferences and scenarios.

In presence of conflicting objectives, multi-criteria analysis is applied to select a compromise option that enhances sustainability, via suitable sustainability indicators.



DOIRES CHART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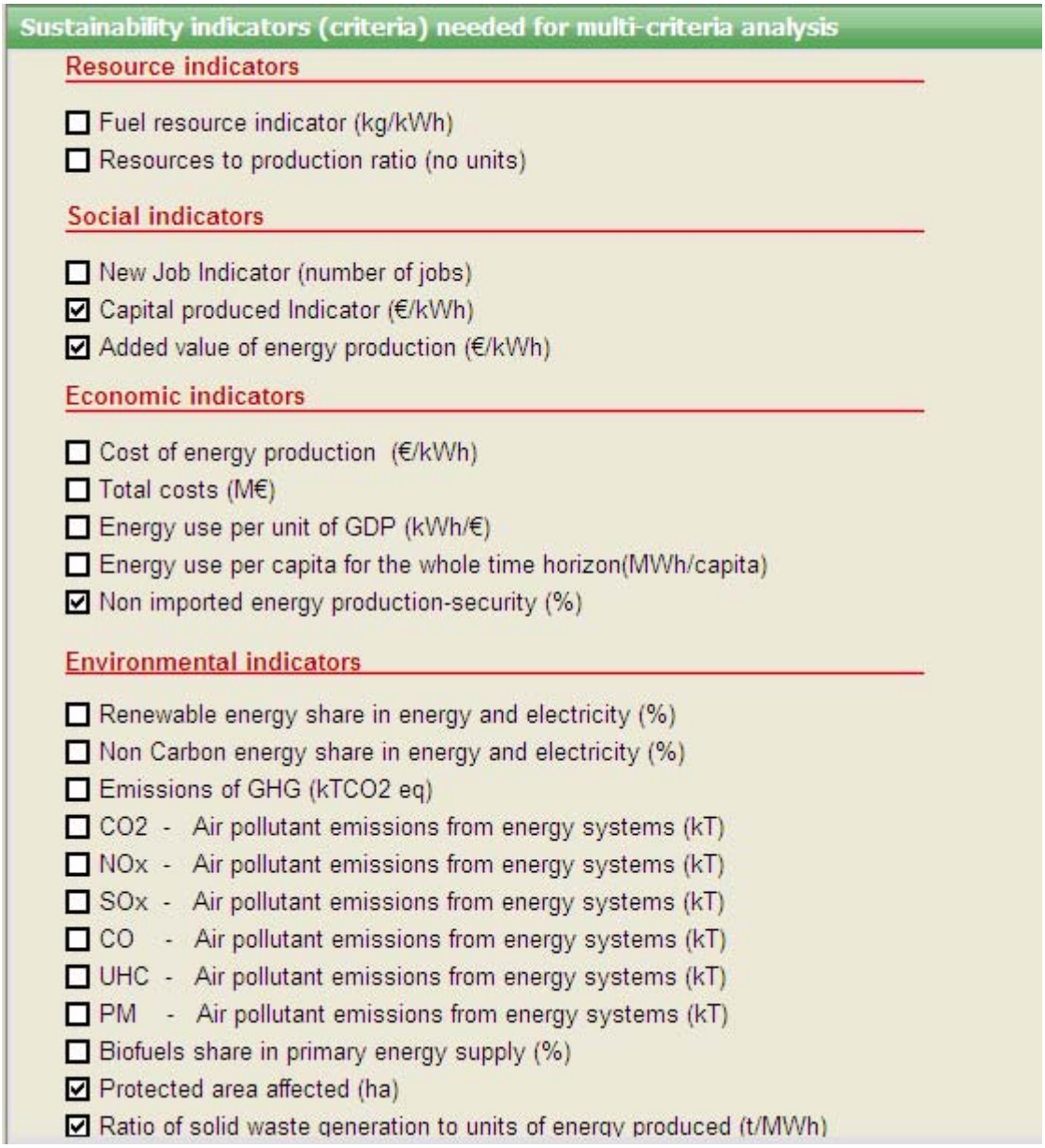
Weight Factors
Save Analysis

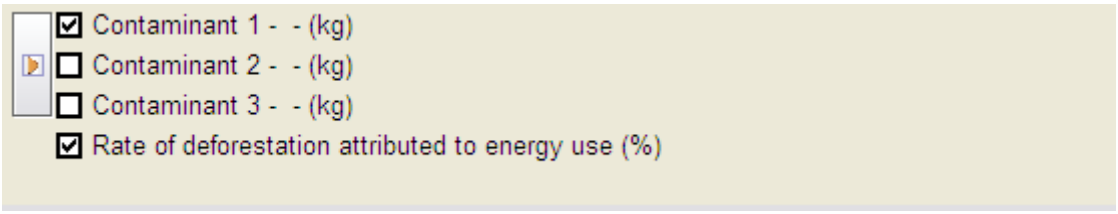
Sustainability indicators (criteria)

Sustainability indicators (criteria) used for the multi-criteria analysis are selected by the user form a list of proposed indicators by the model. The proposed indicators (criteria) have four dimensions: Resource, Social, Economic and Environmental dimensions.

Sustainability indicators are calculated for each scenario to be optimized in each case study. That is why indicators to be used are selected through the optimization process and they have to be common among the different scenarios to be ranked in multi-criteria analysis process.

The list of proposed sustainability indicators by the model has been configured by the consortium of RES INTEGRATION project and is the following:





Resource indicators

Resource indicators take into account the primary energy sources consumption and availability

1. Fuel resource indicator in kg/kWh

   It is calculated by dividing the total fuel consumption throughout the whole energy system and the planning time horizon, by the total energy produced by the system throughout the total planning horizon.

2. Resources to production ratio (no units)

   Ratio of the energy resources remaining at the end of a year to the production of energy in that year. The model asks by the user for the energy resources remaining at the end of the year for each primary energy source and year, is dividing by the annual consumption of this primary energy source and is calculating the total ratio for the whole primary energy sources and the whole time horizon.

Social indicators:

The social indicators reflect the social aspect of the options under consideration.

1. New Job Indicator (number of jobs)

   The job indicator element represents the number of new jobs to be opened corresponding to the respective period. The user is asked to enter the Job creation prospects for technology in jobs/kW. New job indicator is calculated by multiplying job creation prospects with additional capacity to be installed and summing for all technologies and time horizon of the system.

2. Capital produced Indicator (€/kWh)

   It refers to the amount of capital per kWh produced in lifetime. The user is asked to enter the capital produced prospects for technology in €/kWh.

3. Added value of energy production (€/kWh)

Added value of energy production refers to salaries and profit from energy production and supply systems. An estimate of number of employees per unit of

produced energy is asked by the user along with mean salary of the staff. Profits are calculated as margins between cost and selling price, which is asked by the user for electricity and thermal energy.

Economic indicators:

Economic indicators are based on the elements including:

1. Cost of energy production (€/kWh)

   Total cost of the energy system is divided by total energy produced in the whole energy planning time horizon.

2. Total costs (M€)

   Total cost of the energy in the whole energy planning time horizon

3. Energy use per unit of GDP (kWh/€)

Total annual energy produced is divided with Gross Domestic Product per year of planning horizon. The ratios are summed for all years of planning horizon.

4. Energy use per capita for the whole time horizon(MWh/capita)

Total annual energy produced is divided with the region's population per year of planning horizon. The ratios are summed for all years of planning horizon.

5. Non imported energy production-security (%)

Energy produced by both technologies that use no primary energy and primary energy that is produced in the system is given as a proportion of total energy produced in the system.

Environmental indicators:

The environmental indicators reflect the environmental aspect of the options under consideration.

1. Renewable energy share in energy and electricity (%)

   Total produced energy by RE technologies is given as a proportion of total produced energy in the system.

2. Non Carbon energy share in energy and electricity (%)

   Energy produced by technologies that use no primary energy and technologies that use biofuels is given as proportion of total produced energy.

3. Emissions of GHG ($kTCO_2$ eq)

Total emissions of various pollutants are expressed as equivalent of CO2 emissions.

4. Air pollutant emissions from energy systems (kT)

Air pollutant emissions from energy systems for the whole time horizon are expressed in kt. Pollutants involved are CO2, NOx, SOx, CO, UHC and PM

5. Biofuels share in primary energy supply (%)

Biofuels consumption throughout the planning horizon is expressed as proportion to tal fuels consumption in the energy system under study.

6. Protected area affected (ha)

The user is asked to give protected area affected by the installation of technologies and primary energy production sources. The figures are given in ha/kW or ha/ha respectively.

7. Ratio of solid waste generation to units of energy produced (t/MWh)

The user inputs to the model the generation of solid waste for each technology in t/ MWh of produced energy.

8. Contaminant discharges in liquid effluents from energy systems (kg)

The purpose of this indicator is to monitor the discharge of harmful pollutants from energy industries into rivers, lakes and marine waters.

An estimate of contaminant discharges is given for liquid effluents from energy systems in kg/MWh of produced energy for each technology.

9. Rate of deforestation attributed to energy use (%)

The purpose of this indicator is to show a change in the area covered by the forest formations of a country over time that could be attributed to using wood for energy needs.
The forest area is calculated as the sum of plantations and natural forest areas with tree crown cover of at least 10%. This calculation is made at given reference years as follows:

The total rate of deforestation (*TRD*) is the compound annual rate in percent from year *P* to year *N*:

$$TRD = 100\left[1 - \left[\frac{\text{Forest area N}}{\text{Forest area P}}\right]^{(1/N-P)}\right]$$

Then, the rate of deforestation attributed to fuelwood (*RDfw*) is

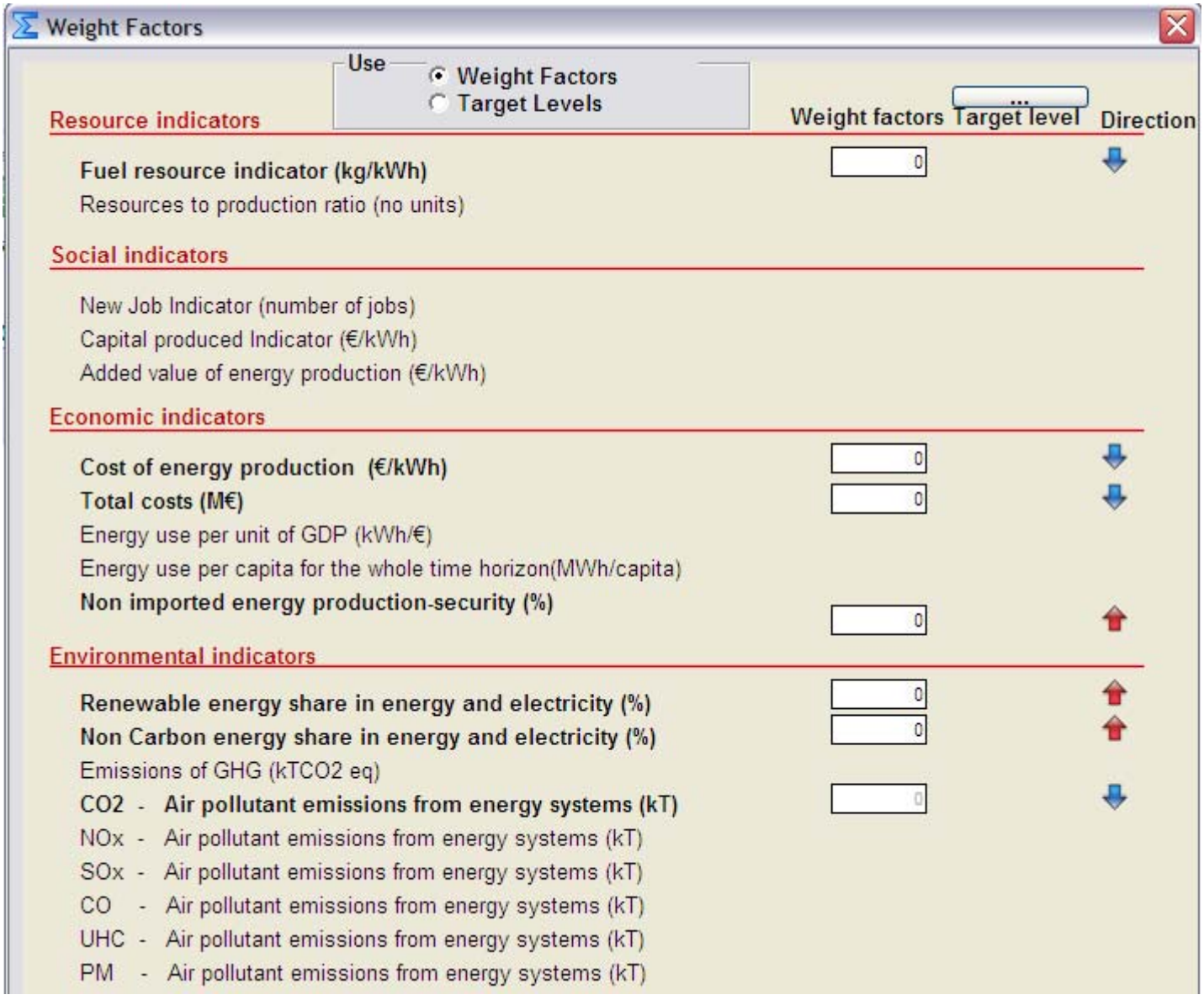
RDfw =TRD (*FWP/ TFF)*

where *FWP* is annual fuelwood production and *TFF* is annual total forest fellings.

The users gives as inputs for Rate of deforestation calculation the annual fuelwood production in t, annual forest fellings in t, forest area in the present year (ha) and forest area in the end year (ha).

Weight factors

During the oprimisation process various scenarios have been optimised for which a number of indicators listed above have been selected. When opening multi-criteria panel the user is asked to insert values to weight factors that give weights to indicators selected. Weight factors take values 0 -1. The sum of weight factors of all indicators selected is 1.



Target level

Alternatively to weight factors the user can give target levels for the indicators selected. This gives direction to multi-criteria model and significance to indicators according to the margin between the value of the indicator and the target level. There is option to select between weights and target level, and complete the corresponding appearing boxes.

Direction

Direction is a reminder to the user to which direction each indicator moves (target minimization or maximization). It is especially useful when completing target levels.

Run Multi-criteria Analysis button

After the scenarios to be ranked have been added to multi-criteria analysis panel and weight factors or target levels have been given, the user presses run multi-criteria analysis button and the scenarios are ranked. Table of values of indicators as long as a diagram of ranking is shown in excel.

Weighted performance gives a fair idea on which of the optmised scenarios is outranked and how its performance differ between the scenarios. The decision lies in local decision makers.

The user can save the analysis to be able to open it in a future instance.