Software for selection and dimensioning as well as economic and ecological analysis for bulk material handling systems in surface mining and civil engineering.

For cost efficient and eco-friendly mining.
Software characteristics

- Individual equipment selection for loading and haulage
- Discontinuous and continuous haulage systems
- Technical validation of equipment combinations
- Economic analysis
- Ecological assessment (greenhouse gas emissions)
- Overall-comparison and rating of different bulk material handling systems as a basis for key decisions
- Improvement of economic and ecological feasibility

Key functions

- Selection of various equipment combinations
- Discontinuous and continuous haulage systems
- Calculation of various cost types
- Determination of CO\textsubscript{2}-emissions
- Presentation of results by tables and diagrams

Key applications

- Feasibility studies for green and brown field projects
- Optimization of operating mines and earthmoving projects
- Evaluation of project development dynamics
- Education

Joint development:

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Information and contact

- www.mining-calculator.com
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Project example: copper mine basic data

- 21 Mio. t total ROM
- 3 loading points
  - each 7 Mio. t ROM
- Equipment:
  - 3 Hydraulic shovels, 10 m³ bucket
  - 17 Off-Highway-Trucks, 140 t payload
Project example: copper mine actual status

- **Crusher location actual**
- **Loading points**

- **Mine entry/exit**
- **Belt conveyor to stockpile**
Project example: copper mine actual status – haulage parameters

- **Crusher location actual**
- **Loading points**
- **Mine entry/exit**
  - 2.5 km haulage length
  - 75-105 m vertical height

- 2475 m a.s.l.
- 2450 m a.s.l.
- 2415 m a.s.l.
- 2370 m a.s.l.
- 2385 m a.s.l.
- 2400 m a.s.l.
- 2415 m a.s.l.

Image credit: Google Earth
Project example: copper mine haulage optimization by in-pit crushing and conveying IPCC

- **Crusher location actual**
- **Loading points**
- **Mine entry/exit**
  - 2,5 km haulage length
  - 75-105 m vertical height
- **Crusher location planned**
Project example: copper mine – crusher relocation
in-pit crusher – belt conveying

- **Crusher location actual**
- **Loading points**
- **Crusher location planned**
  - Conveyor belt planned
    - 750 m, 12% inclination
    - 750 m, 2% inclination
    - 500 m, flat
Project example: copper mine – crusher relocation
in-pit crusher – belt conveying

Conveyor belt 1

Crusher feed: 2385 m a.s.l.
Conveyor feed: 2375 m a.s.l.

transfer station: 2460 m a.s.l.

\[ \Delta h: 85 \text{ m} \]

inclination: 12%
Project example: copper mine – crusher relocation
in-pit crusher – belt conveying

conveyor belt 2

transfer station: 2460 m a.s.l.

Belt conveyor discharge: 2475 m a.s.l.

Δh: 15 m

incline: 2 %

Horizontal distance

Vertical height
Simulation of the actual situation
Basic project data

**Project**
- The project can be given a project name, which is taken over to the main folder in the workspace. A project description can be added to clearly describe and identify the project.

**Material characteristics**
- A large variety of different mineral commodities is offered by a Pull-Down-Menu. By choosing the material the associated default parameters for solid density, bulk density and swell factor are displayed.
- The solid density is the volumetric weight of the solid rock before fragmentation, e.g. by blasting. This value can be edited directly. The bulk density of the material can be adjusted by the slide control of the swell factor.
- The angle of repose is the maximum slope angle of bulk material, at which dumped material will stay stable.

**Performance data**
- One important basic value for dimensioning of equipment is the requested annual or hourly production, which usually comprises of production at several loading points. Therefore the calculation methodology of the Mining Calculator is based on the individual performance calculation for each loading point and the following combination of the individual results.
- The total annual production of the project thus results out of addition of individual annual productions at the loading points.
- The scheduled working time is specified as annual operation hours. This is the planned gross working time including all non-productive time, caused by breaks, scheduled and unscheduled maintenance, shift change, etc. and thus without consideration of...
Loading equipment dimensioning and selection

For material loading purpose hydraulic shovels, electric rope shovels and wheel loaders are available. Only one loader type can be applied, a mixture is not possible.

After choosing a loader type a list of machines is shown in the table below. As the software works independent from equipment manufacturers no brand or model name is displayed. Rather, machine classes are used, orientated at the product portfolio of the actual market. The name of each type consists of the abbreviation of the loader type, the machine weight and the standard shovel volume.

Note: The shovel volume is not fixed but related to material bulk density in a machine specific range. The effective shovel volume as well as the real payload is displayed in the table of calculated results.

Example: The HS175-10 is a hydraulic shovel with a machine weight of 175 metric tons and a shovel volume of 10 m³. The RS1000-35 is a rope shovel of 1,000 metric ton weight and a standard 35 m³ shovel. The WL100-11 is a wheel loader with a machine weight of 100 metric tons, equipped with a standard shovel volume of 11 m³.

The bucket fill factor specifies the degree of utilization of the shovel volume, expressed as a percentage. Referred to SAE-Standard for heaped capacity a bucket fill factor of 100 % describes a stuck filled shovel plus a heap with an all-side angle of repose of 1 : 2 (27°).

The bucket fill factor is depending on the material properties and ranges
Basic haulage data

**Discontinuous haulage**

- **Truck type**: Off-Highway Truck
- **Availability**: 75%
- **Performance efficiency**: 90%
- **Maneuver time at loader [s]**: 30
- **Maneuver and dump time [s]**: 90

**Continuous haulage**

- **Maximum lump size [mm]**: 250
- **Troughing angle [°]**: 35
- **Mechanical efficiency [%]**: 90%
- **Availability**: 80%
- **Performance efficiency**: 80%
- **Belt speed [m/s]**: auto

**Transport**

The Mining Calculator integrates discontinuous and continuous haulage systems, namely off-highway and articulated trucks as well as belt conveyors.

In principle two different project types can be developed:

- Truck project: discontinuous haulage only
- Belt project: combined discontinuous and continuous haulage

**Note:** A belt-project always comprises one belt conveyor. It is assumed that the belt conveyor is connected in a row with individual parallel belt conveyors from a primary transfer point to a central transfer point. The software does not support the possibility of generating another belt conveyor.

**Discontinuous haulage**

First the hauler type must be selected by a pull-down menu. Off-highway trucks or articulated trucks are available. Within one project only one hauler type can be chosen, a mixture of both types is not possible.

Similarly to the loaders the availability of the haulers has to be entered by the slide control. Availability indicates the percentage of time the trucks are working out of the scheduled gross working time (e.g. annual working hours). The percentage reduction thus includes all non-productive time, caused by breaks, scheduled and unscheduled.
Haul roads

The number of listed haul roads is according to the number of loading points specified as performance data.

Any haul road must be defined either by entering sections or the upload of a pre-defined track.

Entering of sections is assisted by several commands of the path menu. For each section length, grade, rolling resistance and load conditions are mandatory inputs, speed limits and comments are optional.

As haulage normally starts with loaded trucks, pre-setting for the first section is loaded condition. If the row of one section is marked the value of the rolling resistance is adopted for the next added section, which is then inserted directly beneath the marked row respectively section.

To complete a full haulage cycle it is not necessary to edit all sections of the return path but just use the command mirror haul road.

The track profile of the input is instantaneous displayed below the section table, allowing easy control of data input.

Belt conveyor

Working on a belt project, initially one belt conveyor is listed beneath the last haul road. One belt conveyor includes one closed belt and therefore implies no conveyor transfer and thus a more or less straight conveying track. Nevertheless within one track the conveyor may consist of several segments regarding grades.
Equipment combination selection
Haulage performance diagrams
Basic cost and environment data

**Fuel**
- Diesel price [€/l]: 1.10
- CO₂ emission: 700 g/kWh
- CO₂-Emission [g/kWh]: 0
- Exchange price [€/EU]: 0

**Basic data**
- Interest rate [%]: 7
- Insurance rate [%]: 1
- Tax rate [%]: 1
- Salary [€/oh]: 50.00

**Electricity**
- Electricity tariff [€/KWh]: 0.09
- Power consumption rope shovel [KWh/t]: 0.25

**CO₂ emission**
- Power generation type: User defined
- Emission certificates [EU]: 0

*Note: This is also used as the base value for the calculation of labor cost for maintenance and repair.*
Loading machine (hydraulic excavator) - cost data

**Capital costs**
- Purchase price [€/oh]: 1,600,000
- Residual value [€/oh]: 160,000
- Calculatory machine life [h]: 25,000
- Depreciation [€/oh]: 57,60
- Interest expense [€/oh]: 13.91
- Interest rate [%]: 7
- Insurance costs [€/oh]: 1.99
- Insurance rate [%]: 1
- Tax costs [€/oh]: 1.99
- Tax rate [%]: 1

**Operating costs [€/oh]**
- Salary [€/oh]: 50.00
- Fuel consumption (full load) [€/oh]: 95
- Fuel consumption (real) [€/oh]: 76.94
- Fuel costs [€/oh]: 84.63
- Crawler cost base factor [€/oh]: 15.00
- Operational conditions multiplier: 0.9
- Crawler track costs [€/oh]: 13.50
- Consumable costs [€/oh]: 12.09
- Maintenance costs [€/oh]: 38.37

**Costs overview**
- Total capital costs [€/oh]: 79,48

**Loader costs**
Similar to trucks, in case of wheel loaders the purchase price without tires has to be entered as the tires are considered to be wear parts. For hydraulic or electric rope shovels the full purchase price must be entered. Specifying a residual value is optional.

Calculatory machine life can be set up to 60,000 operation hours and influences depreciation. Furthermore machine life has influence on maintenance and repair costs, which are part of the operational costs.

Capital costs are automatically calculated when entering input data.

**Note:** Cost accounting is based on the principle of imputed depreciations in order to achieve results independent from commercial and tax law. Useful life and depreciation period are equated.

**Operating costs**
The hourly wage of the machine operator is copied from the basic parameters.

The position for the slider for the fuel consumption (full load) of diesel-driven loaders correlates to the previously chosen flat setting (min, med or max). The same applies to the specified value. Nevertheless this fuel consumption is achieved only if the loader is fully loaded. If utilization is less, this results in lower fuel consumption in practice. Therefore the fuel consumption (real) is calculated automatically with regard to machine utilization and displayed in a separate output box.

For electric driven rope shovels energy costs are calculated directly from hourly production, specific power consumption and electricity tariff without any additional input.
## Off-Highway-Truck - cost data

### Capital cost [€/oh]

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchase price</td>
<td>1,200,000</td>
</tr>
<tr>
<td>Residual value</td>
<td>120,000</td>
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<tr>
<td>Calculatory machine life [h]</td>
<td>30,000</td>
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<tr>
<td>Depreciation [€/oh]</td>
<td>33,050</td>
</tr>
<tr>
<td>Interest expense [€/oh]</td>
<td>9,52</td>
</tr>
<tr>
<td>Interest rate [%]</td>
<td>7</td>
</tr>
<tr>
<td>Insurance costs [€/oh]</td>
<td>1,18</td>
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<tr>
<td>Insurance rate [%]</td>
<td>1</td>
</tr>
<tr>
<td>Tax costs [€/oh]</td>
<td>1,36</td>
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<tr>
<td>Tax rate [%]</td>
<td>1</td>
</tr>
</tbody>
</table>

### Operating costs [€/oh]

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salary</td>
<td>50,00</td>
</tr>
<tr>
<td>Fuel consumption (full load)</td>
<td>95</td>
</tr>
<tr>
<td>Fuel consumption (real)</td>
<td>84,51</td>
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<tr>
<td>Fuel costs [€/oh]</td>
<td>92,96</td>
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<tr>
<td>Tire set price [€]</td>
<td>75,000,00</td>
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<tr>
<td>Tire life period [oh]</td>
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</tr>
<tr>
<td>Tire costs [€/oh]</td>
<td>16,67</td>
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<tr>
<td>Consumable costs [€/oh]</td>
<td>9,30</td>
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<tr>
<td>Maintenance costs [€/oh]</td>
<td>19,71</td>
</tr>
</tbody>
</table>

### Costs overview

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total capital costs [€]</td>
<td>45,73</td>
</tr>
</tbody>
</table>
Cost overview

The overview lists the specific costs for all equipment within the project. If data input is incomplete, rows are colored red. After requested data is entered, costs are calculated and coloring is repeated.
Calculation results – bar diagrams

A wide variety of bar charts can be created to display calculation results, even by combination of two partial results.

Basis for the allocation of the chart bars are two selection fields. Using the associated slider of selection 1, the value range of the diagram can be adjusted and thus the number of displayed equipment combinations can be reduced.

The bar chart of selection 1 will be grayed out and relates to the upper chart axis and label. The orange bar chart of selection 2 refers to the bottom chart axis.

For transfer of the results e.g. in a presentation or a report the chart window or even the entire program window can be copied to clipboard. (Menu bar: Extras)
Calculation results – bar diagrams

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The bar chart of selection 1 will be grayed out and relates to the upper chart axis and label. The orange bar chart of selection 2 refers to the bottom chart axis.

For transfer of the results e.g. in a presentation or a report the chart window or even the entire program window can be copied to clipboard. (Menu bar Extras)
Calculation results – bar diagram alternatives

A wide variety of bar charts can be created to display calculation results, even by combination of two partial results.

Basis for the allocation of the chart bars are two selection fields. Using the associated slider of selection 1, the value range of the diagram can be adjusted and thus the number of displayed equipment combinations can be reduced.

The bar chart of selection 1 will be grayed out and relates to the upper chart axis and label. The orange bar chart of selection 2 refers to the bottom chart axis.

For transfer of the results e.g. in a presentation or a report the chart window or even the entire program window can be copied to clipboard. (Menu bar Extras)
Calculation results – cake diagram of cost structure

Cost distribution

In addition to the bar charts, an individual analysis of the cost structure for a selected project variant can be performed. There is a choice between a simple pie chart showing only the percentage ratio between the capital and operating costs and a detailed view with subcategories for the two types of costs. Furthermore, a direct comparison of two project variants is possible by choosing a second equipment combination.
Creating an IPCC solution
Identical to simulation of actual Situation
IPCC: Loading equipment dimensioning and selection

Identical to simulation of actual Situation

Note: The shovel volume is not fixed but related to material bulk density in a machine specific range. The effective shovel volume as well as the real payload is displayed in the table of calculated results.

Example: The HS175-10 is a hydraulic shovel with a machine weight of 175 metric tons and a shovel volume of 10 m³. The RS1000-35 is a rope shovel of 1,000 metric ton weight and a standard 35 m³ shovel. The WL100-11 is a wheel loader with a machine weight of 100 metric tons, equipped with a standard shovel volume of 11 m³.

The bucket fill factor specifies the degree of utilization of the shovel volume, expressed as a percentage. Referred to SAE-Standard for heaped capacity a bucket fill factor of 100% describes a struck filled shovel plus a heap with an all-side-angle of repose of 1:1 (27°).

The bucket fill factor is depending on the material properties and ranges
Identical to simulation of actual Situation
IPCC: shortened haul roads to Inpit-crusher

The number of listed haul roads is according to the number of loading points specified as performance data.

Any haul road must be defined either by entering sections or the upload of a pre-defined track.

Entering of sections is assisted by several commands of the path menu. For each section length, grade, rolling resistance and load conditions are mandatory inputs. Speed limits and comments are optional.

As haulage normally starts with loaded trucks, presetting for the first section is loaded condition. If the row of one section is marked the value of the rolling resistance is adopted for the next added section, which is then inserted directly beneath the marked row respectively section.

To complete a full haulage cycle it is not necessary to edit all sections of the return path but just use the command mirror haul road.

The track profile of the input is instantaneous displayed below the section table, allowing easy control of data input.

Belt conveyor

Working on a belt project, initially one belt conveyor is listed beneath the first haul road. One belt conveyor includes one closed belt and therefore implies no conveyor transfer and thus a more or less straight conveying track. Nevertheless within one track the conveyor may consist of several segments regarding grades.

Entering of belt sections is identical to the procedure for haul road sections. Main difference is that just values for length and grade are required.
IPCC: new installed belt conveyor 1

Belt conveyor

Working on a belt project, initially one belt conveyor is listed beneath the last haul road. One belt conveyor includes one closed belt and therefore implies no conveyor transfer and thus a more or less straight conveying track. Nevertheless within one track the conveyor may consist of several segments regarding grades.

Entering of belt sections is identical to the procedure for haul road sections. Main difference is that just values for length and grade are required.

The track profile of the belt conveyor is instantaneous displayed below the section table, allowing easy control of data input.

Additional belt conveyors can be added by the associated command of the project menu bar. Similar to haul roads they are numbered. All individual belt conveyors are connected in a row by conveyor transfers and thus have to be considered technical and economic independent.

Note: All belt conveyors within one project solution do have the same belt width and speed, while drive power, belt type or related breaking strength may differ. (see equipment selection, continuous haulage table)
IPCC: new installed belt conveyor 2

Haul roads

The number of listed haul roads is according to the number of loading points specified as performance data.

Any haul road must be defined either by entering sections or the upload of a pre-defined track.

Entering of sections is assisted by several commands of the path menu. For each section length, grade, rolling resistance and load conditions are mandatory inputs. Speed limits and comments are optional.

As haulage normally starts with loaded trucks, presetting for the first section is loaded condition. If the row of one section is marked the value of the rolling resistance is adopted for the next added section, which is then inserted directly beneath the marked row respectively section.

To complete a full haulage cycle it is not necessary to edit all sections of the return path but just use the command mirror haul road.

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Working on a belt project, initially one belt conveyor is listed beneath the last haul road. One belt conveyor includes one closed belt and therefore implies no conveyer transfer and thus a more or less straight conveying track. Nevertheless within one track the conveyor may consist of several segments regarding grades.

Entering of belt sections is identical to the procedure for haul road sections. Main difference is that just values for length and grade are required.
IPCC: Equipment combination selection
IPCC: Basic cost and environment data

<table>
<thead>
<tr>
<th>Basic data</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Interest rate (%)</td>
<td>7</td>
</tr>
<tr>
<td>Tax rate (%)</td>
<td>1</td>
</tr>
<tr>
<td>Insurance rate (%)</td>
<td></td>
</tr>
<tr>
<td>Salary (€/h)</td>
<td>50.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fuel</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel price (€/l)</td>
<td>1.10</td>
</tr>
<tr>
<td>Fuel consumption loaders</td>
<td>min</td>
</tr>
<tr>
<td></td>
<td>max</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Electricity</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity tariff (€/kWh)</td>
<td></td>
</tr>
<tr>
<td>Power consumption rope shovel (kWh/t)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CO2 emission</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2-Emission (g/kWh)</td>
<td>720</td>
</tr>
<tr>
<td>Exchange price (€/EU)</td>
<td>0</td>
</tr>
</tbody>
</table>
IPCC: Loading machine (hydraulic excavator) - cost data

Identical to simulation of actual Situation
IPCC: Off-Highway-Truck - cost data

Identical to simulation of actual Situation
IPCC: Belt conveyor 1 – cost data
IPCC: Belt conveyor 2 – cost data
### Costs overview

#### Loaders

<table>
<thead>
<tr>
<th>Type</th>
<th>Capital cost (£/eh)</th>
<th>Operating costs (£/eh)</th>
<th>Overall costs (£/eh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HS175-10</td>
<td>75.48</td>
<td>199.64</td>
<td>275.12</td>
</tr>
</tbody>
</table>

#### Hauler

<table>
<thead>
<tr>
<th>Type</th>
<th>Capital cost (£/eh)</th>
<th>Operating costs (£/eh)</th>
<th>Overall costs (£/eh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T220</td>
<td>67.26</td>
<td>268.41</td>
<td>335.67</td>
</tr>
<tr>
<td>T410</td>
<td>45.73</td>
<td>189.29</td>
<td>235.03</td>
</tr>
</tbody>
</table>

#### Belt conveyors

<table>
<thead>
<tr>
<th>Type</th>
<th>Capital cost (£/eh)</th>
<th>Operating costs (£/eh)</th>
<th>Overall costs (£/eh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-3-1800-S</td>
<td>221.68</td>
<td>331.60</td>
<td>553.28</td>
</tr>
<tr>
<td>B-4-1600-ECO/S</td>
<td>219.89</td>
<td>321.58</td>
<td>541.47</td>
</tr>
</tbody>
</table>
IPCC: additional investments

When implementing an alternative load and transport solution, additional costs can be generated, which are not covered by data input for equipment, for example, the cost of relocation of the primary crusher or extensive earthworks for new tracks. The description is used as the name in the workspace.

Input of the additional investment and the useful life leads directly to the overall cost, calculated as the sum of depreciation and interest.
IPCC: Calculation results – bar diagrams
IPCC: Calculation results – cake diagram of cost structure
Comparison of actual situation and IPCC solution
Project comparison: table (export as EXCEL-file)

<table>
<thead>
<tr>
<th>Project</th>
<th>Count Loading</th>
<th>Count Truck type</th>
<th>Overall costs [€/t]</th>
<th>CO2 emission [g/t]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper Shovel-Truck</td>
<td>3</td>
<td>0</td>
<td>1.16</td>
<td>1.350</td>
</tr>
<tr>
<td>Copper Shovel-Truck</td>
<td>3</td>
<td>0</td>
<td>1.15</td>
<td>1.20</td>
</tr>
<tr>
<td>Copper Shovel-Truck-Belt</td>
<td>3</td>
<td>10</td>
<td>1.15</td>
<td>1.20</td>
</tr>
<tr>
<td>Copper Shovel-Truck-Belt</td>
<td>3</td>
<td>0</td>
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<td>3</td>
<td>10</td>
<td>1.15</td>
<td>1.20</td>
</tr>
</tbody>
</table>

*Filter 1: CO2 emission [g/t] | Show top: 10
Filter 2: Overall costs [€/t] | Show top: 10
Project comparison: bar diagrams
Project comparison: cake diagram of cost structure