Table S1. LCI-based emergy required to produce 1 kg of crude oil.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | **LCI - RAW DATA** |  |  |  |
|  | **INPUTS** | **QUANTITY** | **UEV** | **UNIT** | **EMERGY** |
| 1 | Crude oil | 4,52695E+01 | 9,45E+04 | sej/J | 4,28E+12 |
| 2 | Gas/condensate | 1,50526E+00 | 6,83E+04 | sej/J | 1,03E+11 |
| 3 | Coal | 3,20801E-01 | 5,71E+04 | sej/J | 1,83E+10 |
| 5 | Lignite | 2,76290E-08 | 6,22E+04 | sej/J | 1,72E+03 |
| 6 | Peat | 1,30952E-07 | 3,19E+04 | sej/J | 4,18E+03 |
| 7 | Wood | 1,46879E-09 | 1,04E+04 | sej/J | 1,53E+01 |
| 8 | Hydro | 5,80197E-03 | 1,35E+05 | sej/J | 7,82E+08 |
| 9 | Nuclear | 2,22896E-01 | 3,14E+05 | sej/J | 7,00E+10 |
| 10 | Sulphur | 1,57248E-07 | 2,08E+10 | sej/g | 3,57E+05 |
| 11 | Biomass | 1,67076E-02 | 6,75E+04 | sej/J | 1,13E+09 |
| 12 | Hydrogen | 2,76997E-08 | 1,15E+05 | sej/J | 3,19E+03 |
| 13 | Geothermal | 2,53886E-06 | 4,52E+05 | sej/J | 1,15E+06 |
| 14 | Solar | 9,50301E-09 | 7,93E+04 | sej/J | 7,54E+02 |
| 15 | Wave/tidal | 8,70798E-06 | 2,83E+04 | sej/J | 2,46E+05 |
| 16 | Wind | 7,86566E-04 | 9,90E+04 | sej/J | 7,78E+07 |
| 17 | Air | 3,70152E-01 | 8,67E+07 | sej/g | 3,21E+04 |
| 18 | Barytes | 2,62998E-03 | 1,68E+09 | sej/g | 4,42E+03 |
| 19 | Bauxite | 1,81013E-02 | 1,44E+09 | sej/g | 2,60E+04 |
| 20 | Bentonite | 3,30838E-03 | 4,80E+09 | sej/g | 1,59E+04 |
| 21 | Calcium sulphate (CaSO4) | 2,45548E-05 | 1,68E+09 | sej/g | 4,13E+01 |
| 22 | Chalk (CaCO3) | 4,92569E-29 | 1,13E+07 | sej/g | 5,54E-25 |
| 23 | Clay | 4,42704E-06 | 4,80E+09 | sej/g | 2,13E+01 |
| 24 | Chromium (Cr) | 6,84688E-08 | 1,50E+11 | sej/g | 1,03E+01 |
| 25 | Copper (Cu) | 1,84838E-06 | 9,80E+10 | sej/g | 1,81E+02 |
| 26 | Dolomite | 5,37885E-02 | 1,85E+10 | sej/g | 9,95E+05 |
| 27 | Iron (Fe) | 4,40180E+00 | 1,20E+10 | sej/g | 5,28E+07 |
| 28 | Feldspar | 9,31988E-34 | 1,68E+09 | sej/g | 1,57E-27 |
| 29 | Ferromanganese | 3,99812E-03 | 3,50E+11 | sej/g | 1,40E+06 |
| 30 | Fluorspar | 3,26753E-04 | 8,36E+08 | sej/g | 2,73E+02 |
| 31 | Granite | 3,02114E-10 | 8,40E+08 | sej/g | 2,54E-04 |
| 32 | Gravel | 1,62408E-02 | 8,40E+08 | sej/g | 1,36E+04 |
| 33 | Mercury (Hg) | 4,24591E-08 | 4,20E+13 | sej/g | 1,78E+03 |
| 34 | Limestone | 9,20142E-01 | 1,68E+09 | sej/g | 1,55E+06 |
| 35 | N2 | 3,39154E-01 | 1,17E+10 | sej/g | 3,96E+06 |
| 36 | Nickel (Ni) | 2,95168E-11 | 2,00E+11 | sej/g | 5,90E-03 |
| 37 | Oxygen (O2) | 8,06923E-02 | 8,67E+07 | sej/g | 7,00E+03 |
| 38 | Olivine | 4,12963E-02 | 1,68E+09 | sej/g | 6,94E+04 |
| 39 | Lead (Pb) | 3,38422E-02 | 4,80E+11 | sej/g | 1,62E+07 |
| 40 | Phosphate as P2O5 | 8,37819E-09 | 2,99E+10 | sej/g | 2,50E-01 |
| 41 | Potassium chloride (KCl) | 1,36913E-04 | 4,97E+09 | sej/g | 6,81E+02 |
| 42 | Rutile | 7,07568E-29 | 1,68E+09 | sej/g | 1,19E-22 |
| 43 | Sulphur | 1,70455E-02 | 2,08E+10 | sej/g | 3,55E+05 |
| 44 | Sand (SiO2) | 8,28356E-05 | 1,68E+09 | sej/g | 1,39E+02 |
| 45 | Shale | 6,95354E-05 | 1,68E+09 | sej/g | 1,17E+02 |
| 46 | Sodium chloride (NaCl) | 8,84022E-02 | 1,68E+09 | sej/g | 1,49E+05 |
| 47 | Talc | 5,88669E-23 | 2,80E+10 | sej/g | 1,65E-15 |
| 48 | Zn | 1,23543E-03 | 7,20E+10 | sej/g | 8,90E+04 |
| 49 | Water-Public supply | 7,86334E+01 | 5,51E+05 | sej/J | 1,81E+05 |
| 50 | Water-River canal | 2,11663E-01 | 3,41E+05 | seJ/g | 7,22E+01 |
| 51 | Water-Sea | 2,00494E+01 | 5,36E+04 | seJ/J | 4,50E+03 |
| 52 | Water-Well | 2,06638E-02 | 6,89E+04 | sej/J | 5,96E+00 |
| 53 | Water-Unspecified | 1,56479E+04 | 3,06E+04 | sej/J | 2,00E+06 |
|  |  |  | **Emergy sej/kg** | | **4,472E+12** |
|  |  |  | **UEV sej/g** | | **4,472E+09** |

Table S2. LCI-based emergy required to produce 1 kg of natural gas.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | **LCI - RAW DATA** |  |  |  |
|  | **INPUTS** | **QUANTITY** | **UEV** | **UNIT** | **EMERGY** |
| 1 | Crude oil | 0,276191523 | 94529,02 | sej/J | 2,61E+10 |
| 2 | Gas/condensate | 5,63155E+01 | 6,83E+04 | sej/J | 3,84E+12 |
| 3 | Coal | 9,35411E-01 | 5,71E+04 | sej/J | 5,34E+10 |
| 5 | Lignite | 6,17164E-08 | 6,22E+04 | sej/J | 3836,292 |
| 6 | Peat | 1,17160E-07 | 3,19E+04 | sej/J | 3739,753 |
| 7 | Wood | 3,28091E-09 | 1,04E+04 | sej/J | 34,12434 |
| 8 | Hydro | 1,70886E-02 | 1,35E+05 | sej/J | 2,3E+09 |
| 9 | Nuclear | 6,61175E-01 | 3,14E+05 | sej/J | 2,08E+11 |
| 10 | Sulphur | 3,51254E-07 | 2,08E+10 | sej/g | 797817,6 |
| 11 | Biomass | 4,95686E-02 | 6,75E+04 | sej/J | 3,35E+09 |
| 12 | Hydrogen | 6,18744E-08 | 1,15E+05 | sej/J | 7115,553 |
| 13 | Geothermal | 6,66876E-06 | 4,52E+05 | sej/J | 3013746 |
| 14 | Solar | 2,60784E-08 | 7,93E+04 | sej/J | 2068,017 |
| 15 | Wave/tidal | 2,58125E-05 | 2,83E+04 | sej/J | 730352,3 |
| 16 | Wind | 2,33325E-03 | 9,90E+04 | sej/J | 2,31E+08 |
| 17 | Air | 8,26829E-01 | 8,67E+07 | sej/g | 71676,17 |
| 18 | Barytes | 5,87473E-03 | 1,68E+09 | sej/g | 9869,554 |
| 19 | Bauxite | 4,04340E-02 | 1,44E+09 | sej/g | 58079,36 |
| 20 | Bentonite | 7,39012E-03 | 4,80E+09 | sej/g | 35508,04 |
| 21 | Calcium sulphate (CaSO4) | 5,48493E-05 | 1,68E+09 | sej/g | 92,14688 |
| 22 | Chalk (CaCO3) | 1,10028E-28 | 1,13E+07 | sej/g | 1,24E-24 |
| 23 | Clay | 9,88892E-06 | 4,80E+09 | sej/g | 47,51429 |
| 24 | Chromium (Cr) | 1,52943E-07 | 1,50E+11 | sej/g | 22,94141 |
| 25 | Copper (Cu) | 4,12882E-06 | 9,80E+10 | sej/g | 404,6247 |
| 26 | Dolomite | 1,20150E-01 | 1,85E+10 | sej/g | 2222783 |
| 27 | Iron (Fe) | 9,83256E+00 | 1,20E+10 | sej/g | 1,18E+08 |
| 28 | Feldspar | 2,08183E-33 | 1,68E+09 | sej/g | 3,5E-27 |
| 29 | Ferromanganese | 8,93083E-03 | 3,50E+11 | sej/g | 3125790 |
| 30 | Fluorspar | 7,29887E-04 | 8,36E+08 | sej/g | 610,2491 |
| 31 | Granite | 6,74849E-10 | 8,40E+08 | sej/g | 0,000567 |
| 32 | Gravel | 3,62780E-02 | 8,40E+08 | sej/g | 30473,48 |
| 33 | Mercury (Hg) | 9,48433E-08 | 4,20E+13 | sej/g | 3983,42 |
| 34 | Limestone | 2,05537E+00 | 1,68E+09 | sej/g | 3453026 |
| 35 | N2 | 7,57587E-01 | 1,17E+10 | sej/g | 8841868 |
| 36 | Nickel (Ni) | 6,59334E-11 | 2,00E+11 | sej/g | 0,013187 |
| 37 | Oxygen (O2) | 1,80247E-01 | 8,67E+07 | sej/g | 15625,24 |
| 38 | Olivine | 9,22458E-02 | 1,68E+09 | sej/g | 154973 |
| 39 | Lead (Pb) | 7,55953E-02 | 4,80E+11 | sej/g | 36285737 |
| 40 | Phosphate as P2O5 | 1,87148E-08 | 2,99E+10 | sej/g | 0,55883 |
| 41 | Potassium chloride (KCl) | 3,05831E-04 | 4,97E+09 | sej/g | 1520,837 |
| 42 | Rutile | 1,58053E-28 | 1,68E+09 | sej/g | 2,66E-22 |
| 43 | Sulphur | 3,80755E-02 | 2,08E+10 | sej/g | 792613,2 |
| 44 | Sand (SiO2) | 1,85035E-04 | 1,68E+09 | sej/g | 310,8581 |
| 45 | Shale | 1,55325E-04 | 1,68E+09 | sej/g | 260,9462 |
| 46 | Sodium chloride (NaCl) | 1,97469E-01 | 1,68E+09 | sej/g | 331747,9 |
| 47 | Talc | 4,51913E-23 | 2,80E+10 | sej/g | 1,26E-15 |
| 48 | Zn | 2,75965E-03 | 7,20E+10 | sej/g | 198694,9 |
| 49 | Water-Public supply | 1,75648E+02 | 5,51E+05 | sej/J | 181380,1 |
| 50 | Water-River canal | 4,72803E-01 | 3,41E+05 | seJ/g | 161,2446 |
| 51 | Water-Sea | 4,47855E+01 | 5,36E+04 | seJ/J | 4497,806 |
| 52 | Water-Well | 4,61580E-02 | 6,89E+04 | sej/J | 5,958038 |
| 53 | Water-Unspecified | 3,47824E+04 | 3,06E+04 | sej/J | 2002790 |
|  |  |  |  |  |  |
|  |  |  | **Emergy sej/kg** | | **4,14E+12** |
|  |  |  | **UEV sej/g** | | **4,14E+09** |

Table S3. LCI-based emergy required to produce 1 kg of naphta.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | **LCI - RAW DATA** |  |  |  |
|  | **INPUTS** | **QUANTITY** | **UEV** | **UNIT** | **EMERGY** |
| 1 | Crude oil | 4,80484E+01 | 9,45E+04 | sej/J | 4,54E+12 |
| 2 | Gas/condensate | 1,62489E+00 | 6,83E+04 | sej/J | 1,11E+11 |
| 3 | Coal | 3,56655E-01 | 5,71E+04 | sej/J | 2,04E+10 |
| 5 | Lignite | 6,45137E-08 | 6,22E+04 | sej/J | 4,01E+03 |
| 6 | Peat | 2,55344E-07 | 3,19E+04 | sej/J | 8,15E+03 |
| 7 | Wood | 3,42962E-09 | 1,04E+04 | sej/J | 3,57E+01 |
| 8 | Hydro | 7,16451E-03 | 1,35E+05 | sej/J | 9,65E+08 |
| 9 | Nuclear | 2,35634E-01 | 3,14E+05 | sej/J | 7,40E+10 |
| 10 | Sulphur | 3,67174E-07 | 2,08E+10 | sej/g | 8,34E+05 |
| 11 | Biomass (solid) | 1,77383E-02 | 6,75E+04 | sej/J | 1,20E+09 |
| 12 | Hydrogen | 6,46788E-08 | 1,15E+05 | sej/J | 7,44E+03 |
| 13 | Geothermal | 2,07140E-04 | 4,52E+05 | sej/J | 9,36E+07 |
| 14 | Solar | 8,07139E-07 | 7,93E+04 | sej/J | 6,40E+04 |
| 15 | Wave/tidal | 9,06689E-06 | 2,83E+04 | sej/J | 2,57E+05 |
| 16 | Wind | 8,28011E-04 | 9,90E+04 | sej/J | 8,19E+07 |
| 17 | Air | 8,64305E-01 | 8,67E+07 | sej/g | 7,49E+04 |
| 18 | Barytes | 6,14101E-03 | 1,68E+09 | sej/g | 1,03E+04 |
| 19 | Bauxite | 4,22667E-02 | 1,44E+09 | sej/g | 6,07E+04 |
| 20 | Bentonite | 7,72508E-03 | 4,80E+09 | sej/g | 3,71E+04 |
| 21 | Calcium sulphate (CaSO4) | 5,73354E-05 | 1,68E+09 | sej/g | 9,63E+01 |
| 22 | Chalk (CaCO3) | 1,15015E-28 | 1,13E+07 | sej/g | 1,29E-24 |
| 23 | Clay | 1,03371E-05 | 4,80E+09 | sej/g | 4,97E+01 |
| 24 | Chromium (Cr) | 1,59875E-07 | 1,50E+11 | sej/g | 2,40E+01 |
| 25 | Copper (Cu) | 4,31596E-06 | 9,80E+10 | sej/g | 4,23E+02 |
| 26 | Dolomite | 1,25596E-01 | 1,85E+10 | sej/g | 2,32E+06 |
| 27 | Iron (Fe) | 1,02782E+01 | 1,20E+10 | sej/g | 1,23E+08 |
| 28 | Feldspar | 2,17619E-33 | 1,68E+09 | sej/g | 3,66E-27 |
| 29 | Ferromanganese | 9,33562E-03 | 3,50E+11 | sej/g | 3,27E+06 |
| 30 | Fluorspar | 7,62969E-04 | 8,36E+08 | sej/g | 6,38E+02 |
| 31 | Granite | 7,05437E-10 | 8,40E+08 | sej/g | 5,93E-04 |
| 32 | Gravel | 3,79223E-02 | 8,40E+08 | sej/g | 3,19E+04 |
| 33 | Mercury (Hg) | 9,91421E-08 | 4,20E+13 | sej/g | 4,16E+03 |
| 34 | Limestone | 2,14853E+00 | 1,68E+09 | sej/g | 3,61E+06 |
| 35 | N2 | 7,91925E-01 | 1,17E+10 | sej/g | 9,24E+06 |
| 36 | Nickel (Ni) | 6,89218E-11 | 2,00E+11 | sej/g | 1,38E-02 |
| 37 | Oxygen (O2) | 1,88417E-01 | 8,67E+07 | sej/g | 1,63E+04 |
| 38 | Olivine | 9,64269E-02 | 1,68E+09 | sej/g | 1,62E+05 |
| 39 | Lead (Pb) | 7,90217E-02 | 4,80E+11 | sej/g | 3,79E+07 |
| 40 | Phosphate as P2O5 | 1,95631E-08 | 2,99E+10 | sej/g | 5,84E-01 |
| 41 | Potassium chloride (KCl) | 3,19693E-04 | 4,97E+09 | sej/g | 1,59E+03 |
| 42 | Rutile | 1,65217E-28 | 1,68E+09 | sej/g | 2,78E-22 |
| 43 | Sulphur | 3,98013E-02 | 2,08E+10 | sej/g | 8,29E+05 |
| 44 | Sand (SiO2) | 1,93421E-04 | 1,68E+09 | sej/g | 3,25E+02 |
| 45 | Shale | 1,62365E-04 | 1,68E+09 | sej/g | 2,73E+02 |
| 46 | Sodium chloride (NaCl) | 2,06419E-01 | 1,68E+09 | sej/g | 3,47E+05 |
| 47 | Talc | 6,41106E-23 | 2,80E+10 | sej/g | 1,79E-15 |
| 48 | Zn | 2,88473E-03 | 7,20E+10 | sej/g | 2,08E+05 |
| 49 | Water-Public supply | 1,83609E+02 | 5,51E+05 | sej/J | 4,24E+05 |
| 50 | Water-River canal | 4,94233E-01 | 3,41E+05 | seJ/g | 1,69E+02 |
| 51 | Water-Sea | 4,68154E+01 | 5,36E+04 | seJ/J | 1,05E+04 |
| 52 | Water-Well | 4,82501E-02 | 6,89E+04 | sej/J | 1,39E+01 |
| 53 | Water-Unspecified | 6,15159E+04 | 3,06E+04 | sej/J | 7,87E+06 |
|  |  |  | **Emergy sej/kg** | | **4,52E+12** |
|  |  |  | **UEV sej/g** | | **4,52E+09** |

Table S4. LCI-based emergy required to produce 1 kg of pygas.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | **LCI - RAW DATA** |  |  |  |
|  | **INPUTS** | **QUANTITY** | **UEV** | **UNIT** | **EMERGY** |
| 1 | Energy, gross calorific value, in biomass | 8,05E-2 | 6,75E+04 | seJ/J | 5,44E+9 |
| 3 | Peat, in ground | 1,98E-6 | 3,19E+04 | seJ/J | 6,17E+05 |
| 4 | Wood, primary forest, standing | 9,45E-7 | 1,04E+04 | seJ/J | 1,11E+08 |
| 5 | Carbon dioxide, in air | 2,14E-2 | 8,87E+07 | sej/g | 2,51E+6 |
| 6 | Energy, kinetic (in wind), converted | 2,53E-2 | 9,90E+04 | seJ/J | 2,51E+9 |
| 7 | Energy, solar, converted | 2,20E-3 | 7,93E+04 | seJ/J | 1,74E+8 |
| 8 | Energy, potential (in hydropower reservoir), converted | 9,83E-2 | 1,35E+05 | seJ/J | 1,32E+10 |
| 9 | Aluminium, 24% in bauxite, 11% in crude ore, in ground | 1,43E-5 | 5,40E+09 | seJ/g | 7,70E+7 |
| 10 | Anhydrite, in ground | 7,27E-10 | 1,68E+09 | seJ/g | 1,22E+3 |
| 11 | Barite, 15% in crude ore, in ground | 1,13E-6 | 1,68E+09 | seJ/g | 1,89E+6 |
| 12 | Basalt, in ground | 1,70E-11 | 7,56E+09 | seJ/g | 1,29E+2 |
| 13 | Borax, in ground | 1,45E-10 | 1,68E+09 | seJ/g | 2,43E+2 |
| 14 | Cadmium, 0.30% in sulfide, Cd 0.18%, Pb, Zn, Ag, In, in ground | 7,03E-13 | 3,40E+13 | seJ/g | 2,39E+04 |
| 15 | Calcite, in ground | 1,32E-3 | 1,68E+09 | seJ/g | 2,22E+9 |
| 16 | Carbon, in organic matter, in soil | 8,86E-9 | 2,77E+09 | seJ/g | 2,45E+4 |
| 17 | Cerium, 24% in bastnasite, 2.4% in crude ore, in ground | 1,46E-7 | 1,14E+10 | seJ/g | 1,66E+6 |
| 18 | Chromium, 25.5% in chromite, 11.6% in crude ore, in ground | 2,14E-7 | 1,50E+11 | seJ/g | 3,21E+7 |
| 19 | Chrysotile, in ground | 1,23E-8 | 1,68E+09 | seJ/g | 2,07E+4 |
| 20 | Cinnabar, in ground | 1,15E-9 | 1,68E+09 | seJ/g | 1,93E+3 |
| 21 | Clay, unspecified, in ground | 5,59E-6 | 4,80E+09 | seJ/g | 2,68E+7 |
| 22 | Coal | 3,40E-1 | 5,71E+04 | seJ/J | 1,94E+10 |
| 23 | Cobalt, in ground | 3,06E-7 | 1,30E+11 | seJ/g | 3,98E+7 |
| 24 | Colemanite, in ground | 4,14E-9 | 1,68E+09 | seJ/g | 6,96E+3 |
| 25 | Copper, in ground | 6,10E-8 | 9,80E+10 | seJ/g | 5,98E+6 |
| 26 | Diatomite, in ground | 1,83E-13 | 1,68E+09 | seJ/g | 3,07E-1 |
| 27 | Dolomite, in ground | 8,61E-9 | 1,85E+10 | seJ/g | 1,59E+5 |
| 28 | Energy, geothermal, converted | 4,41E-4 | 4,52E+05 | seJ/J | 1,99E+8 |
| 29 | Europium, 0.06% in bastnasite, 0.006% in crude ore, in ground | 3,65E-10 | 1,68E+09 | seJ/g | 6,13E+2 |
| 30 | Feldspar, in ground | 1,78E-15 | 1,68E+09 | seJ/g | 2,99E-3 |
| 31 | Fluorine, in ground | 9,40E-7 | 1,68E+09 | seJ/g | 1,58E+6 |
| 32 | Fluorspar, 92%, in ground | 1,93E-5 | 8,38E+08 | seJ/g | 1,62E+7 |
| 33 | Gadolinium, 0.15% in bastnasite, 0.015% in crude ore, in ground | 9,11E-10 | 1,68E+09 | seJ/g | 1,53E+3 |
| 34 | Gas, natural, in ground | 1,11E+1 | 6,83E+04 | seJ/J | 7,58E+11 |
| 35 | Gold, in ground | 2,17E-17 | 5,00E+11 | seJ/g | 1,08E-2 |
| 36 | Granite, in ground | 1,53E-15 | 8,40E+08 | seJ/g | 1,29E-3 |
| 37 | Gravel, in ground | 5,88E-5 | 8,40E+08 | seJ/g | 4,94E+7 |
| 38 | Gypsum, in ground | 2,37E-8 | 2,85E+09 | seJ/g | 6,75E+4 |
| 39 | Indium, 0.005% in sulfide, In 0.003%, Pb, Zn, Ag, Cd, in ground | 1,03E-14 | 4,03E+11 | seJ/g | 4,16E+0 |
| 40 | Iron, 46% in ore, 25% in crude ore, in ground | 3,75E-6 | 1,20E+10 | seJ/g | 4,49E+7 |
| 41 | Kaolinite, 24% in crude ore, in ground | 3,30E-6 | 1,68E+09 | seJ/g | 5,54E+6 |
| 42 | Kieserite, 25% in crude ore, in ground | 1,16E-10 | 1,68E+09 | seJ/g | 1,94E+2 |
| 43 | Lanthanum, 7.2% in bastnasite, 0.72% in crude ore, in ground | 4,37E-8 | 1,68E+09 | seJ/g | 7,33E+4 |
| 44 | Lead, 5.0% in sulfide, Pb 3.0%, Zn, Ag, Cd, In, in ground | 2,30E-11 | 4,80E+11 | seJ/g | 1,10E+4 |
| 45 | Lithium, 0.15% in brine, in ground | 2,66E-14 | 9,27E+11 | seJ/g | 2,47E+1 |
| 46 | Magnesite, 60% in crude ore, in ground | 1,09E-8 | 1,68E+09 | seJ/g | 1,83E+4 |
| 47 | Manganese, 35.7% in sedimentary deposit, 14.2% in crude ore, in ground | 1,02E-9 | 3,50E+11 | seJ/g | 3,58E+5 |
| 48 | Metamorphous rock, graphite containing, in ground | 2,70E-8 | 1,68E+09 | seJ/g | 4,52E+4 |
| 49 | Molybdenum, 0.025% in sulfide, Mo 8.2E-3% and Cu 0.39% in crude ore, in ground | 6,01E-7 | 7,00E+11 | seJ/g | 4,21E+8 |
| 50 | Neodymium, 4% in bastnasite, 0.4% in crude ore, in ground | 2,40E-8 | 1,68E+09 | seJ/g | 4,03E+4 |
| 51 | Nickel, 1.13% in sulfide, Ni 0.76% and Cu 0.76% in crude ore, in ground | 7,94E-7 | 2,00E+11 | seJ/g | 1,59E+8 |
| 52 | Oil, crude, in ground | 5,25E+1 | 9,45E+04 | seJ/J | 4,96E+12 |
| 53 | Olivine, in ground | 2,49E-10 | 1,68E+09 | seJ/g | 4,18E+2 |
| 54 | Pd,in ground | 1,27E-10 | 1,20E+11 | seJ/g | 1,53E+4 |
| 55 | Phosphorus, 18% in apatite, 12% in crude ore, in ground | 3,76E-6 | 2,07E+10 | seJ/g | 7,77E+7 |
| 56 | Praseodymium, 0.42% in bastnasite, 0.042% in crude ore, in ground | 2,55E-9 | 1,68E+09 | seJ/g | 4,28E+3 |
| 57 | Pt, in ground | 3,94E-12 | 3,70E+11 | seJ/g | 1,46E+3 |
| 58 | Rh, in ground | 3,53E-12 | 1,20E+12 | seJ/g | 4,24E+3 |
| 59 | Rhenium, in crude ore, in ground | 1,05E-12 | 8,93E+12 | seJ/g | 9,40E+3 |
| 60 | Samarium, 0.3% in bastnasite, 0.03% in crude ore, in ground | 1,82E-9 | 1,68E+09 | seJ/g | 3,05E+3 |
| 61 | Sand, unspecified, in ground | 1,39E-8 | 1,68E+09 | seJ/g | 2,34E+4 |
| 62 | Shale, in ground | 2,06E-9 | 1,68E+09 | seJ/g | 3,46E+3 |
| 63 | Silver, in ground | 5,88E-17 | 4,50E+11 | seJ/g | 2,65E-2 |
| 64 | Sodium chloride, in ground | 5,96E-4 | 1,68E+09 | seJ/g | 1,00E+9 |
| 65 | Sodium nitrate, in ground | 7,71E-15 | 1,68E+09 | seJ/g | 1,29E-2 |
| 66 | Sodium sulphate, various forms, in ground | 5,48E-6 | 1,40E+09 | seJ/g | 7,65E+6 |
| 67 | Stibnite, in ground | 1,90E-14 | 1,68E+09 | seJ/g | 3,19E-2 |
| 68 | Sulfur, in ground | 4,28E-6 | 2,08E+10 | seJ/g | 8,92E+7 |
| 69 | Sylvite, 25 % in sylvinite, in ground | 7,20E-9 | 1,68E+09 | seJ/g | 1,21E+4 |
| 70 | Talc, in ground | 3,28E-9 | 2,80E+10 | seJ/g | 9,19E+4 |
| 71 | Tantalum, 81.9% in tantalite, 1.6E-4% in crude ore, in ground | 2,14E-17 | 1,70E+11 | seJ/g | 3,64E-3 |
| 72 | Tellurium, 0.5ppm in sulfide, Te 0.2ppm, Cu and Ag, in crude ore, in ground | 2,86E-18 | 5,04E+13 | seJ/g | 1,44E-1 |
| 73 | Tin, 79% in cassiterite, 0.1% in crude ore, in ground | 2,57E-10 | 1,70E+12 | seJ/g | 4,37E+5 |
| 74 | TiO2, 54% in ilmenite, 2.6% in crude ore, in ground | 1,07E-5 | 3,82E+10 | seJ/g | 4,10E+8 |
| 75 | Ulexite, in ground | 1,09E-17 | 1,68E+09 | seJ/g | 1,83E-5 |
| 76 | Uranium, in ground | 1,10E-6 | 1,60E+11 | seJ/g | 1,76E+8 |
| 77 | Zinc, 9.0% in sulfide, Zn 5.3%, Pb, Ag, Cd, In, in ground | 4,57E-8 | 7,20E+10 | seJ/g | 3,29E+6 |
| 78 | Zirconium, 50% in zircon, 0.39% in crude ore, in ground | 2,94E-17 | 3,18E+10 | seJ/g | 9,36E-4 |
| 79 | Magnesium, 0.13% in water | 3,37E-18 | 1,68E+09 | seJ/g | 5,67E-6 |
| 80 | Water, cooling, unspecified natural origin | 9,60E-3 | 2,70E+05 | seJ/g | 2,60E+9 |
| 81 | Water, lake | 7,77E-7 | 4,52E+05 | seJ/g | 3,51E+5 |
| 82 | Water, process, unspecified natural origin | 5,89E-4 | 6,74E+04 | seJ/J | 1,66E+8 |
| 83 | Water, river | 2,58E-4 | 3,41E+05 | seJ/g | 8,78E+7 |
| 84 | Water, salt, ocean | 4,81E-4 | 5,36E+04 | seJ/J | 1,08E+8 |
| 85 | Water, salt, sole | 9,15E-4 | 5,36E+04 | seJ/J | 2,05E+8 |
| 86 | Water, unspecified natural origin | 2,23E-3 | 3,06E+04 | seJ/J | 2,86E+8 |
| 87 | Water, well, in ground | 1,14E-4 | 6,89E+04 | seJ/J | 3,28E+7 |
|  |  |  | **Emergy sej/kg** | | **5,77E+12** |
|  |  |  | **UEV sej/g** | | **5,77E+09** |

Table S5. LCI-based emergy required to produce 1 kg of xylene.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | | |  |  |  |  |
|  |  | | |  |  |  |  |
| 1 | Energy, gross calorific value, in biomass | | | 2,53E-02 | 6,75E+04 | seJ/J | 1,71E+09 |
| 3 | Peat, in ground | |  | 5,24E-07 | 3,19E+04 | seJ/J | 1,63E+05 |
| 4 | Wood, primary forest, standing | | | 8,63E-07 | 1,04E+04 | seJ/J | 1,01E+08 |
| 5 | Carbon dioxide, in air | |  | 3,79E-03 | 8,87E+07 | sej/g | 9,74E+05 |
| 6 | Energy, kinetic (in wind), converted | | | 9,85E-03 | 9,90E+04 | seJ/J | 9,74E+08 |
| 7 | Energy, solar, converted | | | 5,70E-04 | 7,93E+04 | seJ/J | 4,52E+07 |
| 8 | Energy, potential (in hydropower reservoir), converted | | | 4,69E-02 | 1,35E+05 | seJ/J | 6,32E+09 |
| 9 | Aluminium, 24% in bauxite, 11% in crude ore, in ground | | | 1,69E-05 | 5,40E+09 | seJ/g | 9,14E+07 |
| 10 | Anhydrite, in ground | |  | 7,29E-10 | 1,68E+09 | seJ/g | 1,22E+03 |
| 11 | Barite, 15% in crude ore, in ground | | | 1,21E-06 | 1,68E+09 | seJ/g | 2,03E+06 |
| 12 | Basalt, in ground | |  | 1,64E-11 | 7,56E+09 | seJ/g | 1,24E+02 |
| 13 | Borax, in ground | |  | 1,37E-10 | 1,68E+09 | seJ/g | 2,30E+02 |
| 14 | Cadmium, 0.30% in sulfide, Cd 0.18%, Pb, Zn, Ag, In, in ground | | | 7,85E-13 | 3,40E+13 | seJ/g | 2,67E+04 |
| 15 | Calcite, in ground | |  | 1,25E-03 | 1,68E+09 | seJ/g | 2,10E+09 |
| 16 | Carbon, in organic matter, in soil | | | 8,49E-09 | 2,77E+09 | seJ/g | 2,35E+04 |
| 17 | Cerium, 24% in bastnasite, 2.4% in crude ore, in ground | | | 1,80E-07 | 1,14E+10 | seJ/g | 2,05E+06 |
| 18 | Chromium, 25.5% in chromite, 11.6% in crude ore, in ground | | | 2,07E-07 | 1,50E+11 | seJ/g | 3,10E+07 |
| 19 | Chrysotile, in ground | |  | 1,33E-08 | 1,68E+09 | seJ/g | 2,23E+04 |
| 20 | Cinnabar, in ground | |  | 1,23E-09 | 1,68E+09 | seJ/g | 2,07E+03 |
| 21 | Clay, unspecified, in ground | | | 5,43E-06 | 4,80E+09 | seJ/g | 2,61E+07 |
| 22 | Coal |  |  | 1,80E-01 | 5,71E+04 | seJ/J | 1,03E+10 |
| 23 | Cobalt, in ground | |  | 3,78E-07 | 1,30E+11 | seJ/g | 4,91E+07 |
| 24 | Colemanite, in ground | |  | 3,92E-09 | 1,68E+09 | seJ/g | 6,58E+03 |
| 25 | Copper, in ground | |  | 1,88E-08 | 9,80E+10 | seJ/g | 1,84E+06 |
| 26 | Diatomite, in ground | |  | 1,73E-13 | 1,68E+09 | seJ/g | 2,90E-01 |
| 27 | Dolomite, in ground | |  | 7,04E-09 | 1,85E+10 | seJ/g | 1,30E+05 |
| 28 | Energy, geothermal, converted | | | 1,04E-04 | 4,52E+05 | seJ/J | 4,71E+07 |
| 29 | Europium, 0.06% in bastnasite, 0.006% in crude ore, in ground | | | 4,51E-10 | 1,68E+09 | seJ/g | 7,57E+02 |
| 30 | Feldspar, in ground | |  | 1,71E-15 | 1,68E+09 | seJ/g | 2,88E-03 |
| 31 | Fluorine, in ground | |  | 8,70E-07 | 1,68E+09 | seJ/g | 1,46E+06 |
| 32 | Fluorspar, 92%, in ground | | | 1,79E-05 | 8,38E+08 | seJ/g | 1,50E+07 |
| 33 | Gadolinium, 0.15% in bastnasite, 0.015% in crude ore, in ground | | | 1,12E-09 | 1,68E+09 | seJ/g | 1,89E+03 |
| 34 | Gas, natural, in ground | | | 5,03E+00 | 6,83E+04 | seJ/J | 3,43E+11 |
| 35 | Gold, in ground | |  | 2,05E-17 | 5,00E+11 | seJ/g | 1,03E-02 |
| 36 | Granite, in ground | |  | 1,48E-15 | 8,40E+08 | seJ/g | 1,24E-03 |
| 37 | Gravel, in ground | |  | 6,51E-05 | 8,40E+08 | seJ/g | 5,47E+07 |
| 38 | Gypsum, in ground | |  | 1,76E-08 | 2,85E+09 | seJ/g | 5,02E+04 |
| 39 | Indium, 0.005% in sulfide, In 0.003%, Pb, Zn, Ag, Cd, in ground |  |  | 1,16E-14 | 4,03E+11 | seJ/g | 4,69E+00 |
| 40 | Iron, 46% in ore, 25% in crude ore, in ground | | | 2,44E-06 | 1,20E+10 | seJ/g | 2,93E+07 |
| 41 | Kaolinite, 24% in crude ore, in ground | | | 4,06E-06 | 1,68E+09 | seJ/g | 6,83E+06 |
| 42 | Kieserite, 25% in crude ore, in ground | | | 1,11E-10 | 1,68E+09 | seJ/g | 1,86E+02 |
| 43 | Lanthanum, 7.2% in bastnasite, 0.72% in crude ore, in ground | | | 5,39E-08 | 1,68E+09 | seJ/g | 9,06E+04 |
| 44 | Lead, 5.0% in sulfide, Pb 3.0%, Zn, Ag, Cd, In, in ground | | | 2,24E-11 | 4,80E+11 | seJ/g | 1,07E+04 |
| 45 | Lithium, 0.15% in brine, in ground | | | 2,58E-14 | 9,27E+11 | seJ/g | 2,39E+01 |
| 46 | Magnesite, 60% in crude ore, in ground | | | 1,06E-08 | 1,68E+09 | seJ/g | 1,79E+04 |
| 47 | Manganese, 35.7% in sedimentary deposit, 14.2% in crude ore, in ground | | | 9,70E-10 | 3,50E+11 | seJ/g | 3,40E+05 |
| 48 | Metamorphous rock, graphite containing, in ground | | | 3,32E-08 | 1,68E+09 | seJ/g | 5,56E+04 |
| 49 | Molybdenum, 0.025% in sulfide, Mo 8.2E-3% and Cu 0.39% in crude ore, in ground | | | 7,18E-07 | 7,00E+11 | seJ/g | 5,02E+08 |
| 50 | Neodymium, 4% in bastnasite, 0.4% in crude ore, in ground | | | 2,97E-08 | 1,68E+09 | seJ/g | 4,98E+04 |
| 51 | Nickel, 1.13% in sulfide, Ni 0.76% and Cu 0.76% in crude ore, in ground | | | 8,43E-07 | 2,00E+11 | seJ/g | 1,69E+08 |
| 52 | Oil, crude, in ground | |  | 5,15E+01 | 9,45E+04 | seJ/J | 4,87E+12 |
| 53 | Olivine, in ground | |  | 2,48E-10 | 1,68E+09 | seJ/g | 4,17E+02 |
| 54 | Pd,in ground | |  | 1,22E-10 | 1,20E+11 | seJ/g | 1,46E+04 |
| 55 | Phosphorus, 18% in apatite, 12% in crude ore, in ground | | | 3,48E-06 | 2,07E+10 | seJ/g | 7,19E+07 |
| 56 | Praseodymium, 0.42% in bastnasite, 0.042% in crude ore, in ground | | | 3,15E-09 | 1,68E+09 | seJ/g | 5,29E+03 |
| 57 | Pt, in ground | |  | 3,78E-12 | 3,70E+11 | seJ/g | 1,40E+03 |
| 58 | Rh, in ground | |  | 3,39E-12 | 1,20E+12 | seJ/g | 4,07E+03 |
| 59 | Rhenium, in crude ore, in ground | | | 1,01E-12 | 8,93E+12 | seJ/g | 9,01E+03 |
| 60 | Samarium, 0.3% in bastnasite, 0.03% in crude ore, in ground | | | 2,25E-09 | 1,68E+09 | seJ/g | 3,77E+03 |
| 61 | Sand, unspecified, in ground | | | 1,21E-08 | 1,68E+09 | seJ/g | 2,03E+04 |
| 62 | Shale, in ground | |  | 2,06E-09 | 1,68E+09 | seJ/g | 3,47E+03 |
| 63 | Silver, in ground | |  | 5,57E-17 | 4,50E+11 | seJ/g | 2,51E-02 |
| 64 | Sodium chloride, in ground | | | 8,11E-04 | 1,68E+09 | seJ/g | 1,36E+09 |
| 65 | Sodium nitrate, in ground | | | 6,98E-15 | 1,68E+09 | seJ/g | 1,17E-02 |
| 66 | Sodium sulphate, various forms, in ground | | | 5,07E-06 | 1,40E+09 | seJ/g | 7,07E+06 |
| 67 | Stibnite, in ground | |  | 1,80E-14 | 1,68E+09 | seJ/g | 3,02E-02 |
| 68 | Sulfur, in ground | |  | 1,01E-06 | 2,08E+10 | seJ/g | 2,11E+07 |
| 69 | Sylvite, 25 % in sylvinite, in ground | | | 6,88E-09 | 1,68E+09 | seJ/g | 1,16E+04 |
| 70 | Talc, in ground | |  | 3,20E-09 | 2,80E+10 | seJ/g | 8,95E+04 |
| 71 | Tantalum, 81.9% in tantalite, 1.6E-4% in crude ore, in ground | | | 2,03E-17 | 1,70E+11 | seJ/g | 3,44E-03 |
| 72 | Tellurium, 0.5ppm in sulfide, Te 0.2ppm, Cu and Ag, in crude ore, in ground | | | 2,70E-18 | 5,04E+13 | seJ/g | 1,36E-01 |
| 73 | Tin, 79% in cassiterite, 0.1% in crude ore, in ground | | | 3,17E-10 | 1,70E+12 | seJ/g | 5,39E+05 |
| 74 | TiO2, 54% in ilmenite, 2.6% in crude ore, in ground | | | 9,92E-06 | 3,82E+10 | seJ/g | 3,79E+08 |
| 75 | Ulexite, in ground | |  | 1,03E-17 | 1,68E+09 | seJ/g | 1,73E-05 |
| 76 | Uranium, in ground | |  | 6,34E-07 | 1,60E+11 | seJ/g | 1,01E+08 |
| 77 | Zinc, 9.0% in sulfide, Zn 5.3%, Pb, Ag, Cd, In, in ground | | | 1,57E-08 | 7,20E+10 | seJ/g | 1,13E+06 |
| 78 | Zirconium, 50% in zircon, 0.39% in crude ore, in ground | | | 2,79E-17 | 3,18E+10 | seJ/g | 8,87E-04 |
| 79 | Magnesium, 0.13% in water | | | 3,19E-18 | 1,68E+09 | seJ/g | 5,37E-06 |
| 80 | Water, cooling, unspecified natural origin | | | 8,34E-03 | 2,70E+05 | seJ/g | 2,26E+09 |
| 81 | Water, lake | |  | 5,89E-07 | 4,52E+05 | seJ/g | 2,66E+05 |
| 82 | Water, process, unspecified natural origin | | | 8,80E-04 | 6,74E+04 | seJ/J | 2,48E+08 |
| 83 | Water, river | |  | 2,44E-04 | 3,41E+05 | seJ/g | 8,31E+07 |
| 84 | Water, salt, ocean | |  | 6,52E-04 | 5,36E+04 | seJ/J | 1,46E+08 |
| 85 | Water, salt, sole | |  | 8,98E-04 | 5,36E+04 | seJ/J | 2,01E+08 |
| 86 | Water, unspecified natural origin | | | 2,19E-03 | 3,06E+04 | seJ/J | 2,81E+08 |
| 87 | Water, well, in ground | |  | 6,65E-05 | 6,89E+04 | seJ/J | 1,92E+07 |
|  |  |  |  |  | **Emergia** | **seJ** | **5,24E+12** |
|  |  |  |  |  | **UEV** | **seJ/g** | **5,24E+09** |

Table S6. LCI-based emergy required to produce 1 kg of ethylene.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | INPUTS |  |  | QUANTIDADE | UEV | UNIDADE | EMERGIA |
| 1 | Energy, gross calorific value, in biomass | 1,30E-01 | | | 6,75E+04 | seJ/J | 8,79E+09 |
| 3 | Peat, in ground | |  | 2,19E-06 | 3,19E+04 | seJ/J | 6,83E+05 |
| 4 | Wood, primary forest, standing | 1,05E-06 | | | 1,04E+04 | seJ/J | 1,23E+08 |
| 5 | Carbon dioxide, in air | |  | 2,14E-02 | 8,87E+07 | sej/g | 3,90E+06 |
| 6 | Energy, kinetic (in wind), converted | 3,94E-02 | | | 9,90E+04 | seJ/J | 3,90E+09 |
| 7 | Energy, solar, converted | 3,66E-03 | | | 7,93E+04 | seJ/J | 2,90E+08 |
| 8 | Energy, potential (in hydropower reservoir), converted | 1,40E-01 | | | 1,35E+05 | seJ/J | 1,89E+10 |
| 9 | Aluminium, 24% in bauxite, 11% in crude ore, in ground | 1,59E-05 | | | 5,40E+09 | seJ/g | 8,59E+07 |
| 10 | Anhydrite, in ground | |  | 8,03E-10 | 1,68E+09 | seJ/g | 1,35E+03 |
| 11 | Barite, 15% in crude ore, in ground | 1,60E-06 | | | 1,68E+09 | seJ/g | 2,68E+06 |
| 12 | Basalt, in ground | |  | 1,89E-11 | 7,56E+09 | seJ/g | 1,43E+02 |
| 13 | Borax, in ground | |  | 1,61E-10 | 1,68E+09 | seJ/g | 2,70E+02 |
| 14 | Cadmium, 0.30% in sulfide, Cd 0.18%, Pb, Zn, Ag, In, in ground | 8,17E-13 | | | 3,40E+13 | seJ/g | 2,78E+04 |
| 15 | Calcite, in ground | |  | 1,85E-03 | 1,68E+09 | seJ/g | 3,11E+09 |
| 16 | Carbon, in organic matter, in soil | 9,78E-09 | | | 2,77E+09 | seJ/g | 2,71E+04 |
| 17 | Cerium, 24% in bastnasite, 2.4% in crude ore, in ground | 1,61E-07 | | | 1,14E+10 | seJ/g | 1,83E+06 |
| 18 | Chromium, 25.5% in chromite, 11.6% in crude ore, in ground | 2,38E-07 | | | 1,50E+11 | seJ/g | 3,57E+07 |
| 19 | Chrysotile, in ground | |  | 1,75E-08 | 1,68E+09 | seJ/g | 2,94E+04 |
| 20 | Cinnabar, in ground | |  | 1,63E-09 | 1,68E+09 | seJ/g | 2,74E+03 |
| 21 | Clay, unspecified, in ground | 6,37E-06 | | | 4,80E+09 | seJ/g | 3,06E+07 |
| 22 | Coal |  |  | 4,90E-01 | 5,71E+04 | seJ/J | 2,80E+10 |
| 23 | Cobalt, in ground | |  | 3,37E-07 | 1,30E+11 | seJ/g | 4,39E+07 |
| 24 | Colemanite, in ground | |  | 4,59E-09 | 1,68E+09 | seJ/g | 7,71E+03 |
| 25 | Copper, in ground | |  | 9,98E-08 | 9,80E+10 | seJ/g | 9,78E+06 |
| 26 | Diatomite, in ground | |  | 2,03E-13 | 1,68E+09 | seJ/g | 3,40E-01 |
| 27 | Dolomite, in ground | |  | 9,53E-09 | 1,85E+10 | seJ/g | 1,76E+05 |
| 28 | Energy, geothermal, converted | 7,42E-04 | | | 4,52E+05 | seJ/J | 3,35E+08 |
| 29 | Europium, 0.06% in bastnasite, 0.006% in crude ore, in ground | 4,03E-10 | | | 1,68E+09 | seJ/g | 6,76E+02 |
| 30 | Feldspar, in ground | |  | 1,98E-15 | 1,68E+09 | seJ/g | 3,33E-03 |
| 31 | Fluorine, in ground | |  | 1,04E-06 | 1,68E+09 | seJ/g | 1,75E+06 |
| 32 | Fluorspar, 92%, in ground | 2,13E-05 | | | 8,38E+08 | seJ/g | 1,79E+07 |
| 33 | Gadolinium, 0.15% in bastnasite, 0.015% in crude ore, in ground | 1,00E-09 | | | 1,68E+09 | seJ/g | 1,69E+03 |
| 34 | Gas, natural, in ground | 1,24E+01 | | | 6,83E+04 | seJ/J | 8,46E+11 |
| 35 | Gold, in ground | |  | 2,40E-17 | 5,00E+11 | seJ/g | 1,20E-02 |
| 36 | Granite, in ground | |  | 1,70E-15 | 8,40E+08 | seJ/g | 1,43E-03 |
| 37 | Gravel, in ground | |  | 6,56E-05 | 8,40E+08 | seJ/g | 5,51E+07 |
| 38 | Gypsum, in ground | |  | 2,62E-08 | 2,85E+09 | seJ/g | 7,46E+04 |
| 39 | Indium, 0.005% in sulfide, In 0.003%, Pb, Zn, Ag, Cd, in ground |  |  | 1,19E-14 | 4,03E+11 | seJ/g | 4,79E+00 |
| 40 | Iron, 46% in ore, 25% in crude ore, in ground | 4,64E-06 | | | 1,20E+10 | seJ/g | 5,57E+07 |
| 41 | Kaolinite, 24% in crude ore, in ground | 3,64E-06 | | | 1,68E+09 | seJ/g | 6,11E+06 |
| 42 | Kieserite, 25% in crude ore, in ground | 1,28E-10 | | | 1,68E+09 | seJ/g | 2,16E+02 |
| 43 | Lanthanum, 7.2% in bastnasite, 0.72% in crude ore, in ground | 4,82E-08 | | | 1,68E+09 | seJ/g | 8,09E+04 |
| 44 | Lead, 5.0% in sulfide, Pb 3.0%, Zn, Ag, Cd, In, in ground | 2,54E-11 | | | 4,80E+11 | seJ/g | 1,22E+04 |
| 45 | Lithium, 0.15% in brine, in ground | 2,96E-14 | | | 9,27E+11 | seJ/g | 2,75E+01 |
| 46 | Magnesite, 60% in crude ore, in ground | 1,23E-08 | | | 1,68E+09 | seJ/g | 2,06E+04 |
| 47 | Manganese, 35.7% in sedimentary deposit, 14.2% in crude ore, in ground | 1,13E-09 | | | 3,50E+11 | seJ/g | 3,97E+05 |
| 48 | Metamorphous rock, graphite containing, in ground | 2,97E-08 | | | 1,68E+09 | seJ/g | 4,98E+04 |
| 49 | Molybdenum, 0.025% in sulfide, Mo 8.2E-3% and Cu 0.39% in crude ore, in ground | 6,78E-07 | | | 7,00E+11 | seJ/g | 4,75E+08 |
| 50 | Neodymium, 4% in bastnasite, 0.4% in crude ore, in ground | 2,65E-08 | | | 1,68E+09 | seJ/g | 4,45E+04 |
| 51 | Nickel, 1.13% in sulfide, Ni 0.76% and Cu 0.76% in crude ore, in ground | 8,97E-07 | | | 2,00E+11 | seJ/g | 1,79E+08 |
| 52 | Oil, crude, in ground | |  | 5,80E+01 | 9,45E+04 | seJ/J | 5,48E+12 |
| 53 | Olivine, in ground | |  | 2,74E-10 | 1,68E+09 | seJ/g | 4,61E+02 |
| 54 | Pd,in ground | |  | 1,41E-10 | 1,20E+11 | seJ/g | 1,69E+04 |
| 55 | Phosphorus, 18% in apatite, 12% in crude ore, in ground | 4,15E-06 | | | 2,07E+10 | seJ/g | 8,58E+07 |
| 56 | Praseodymium, 0.42% in bastnasite, 0.042% in crude ore, in ground | 2,81E-09 | | | 1,68E+09 | seJ/g | 4,72E+03 |
| 57 | Pt, in ground | |  | 4,36E-12 | 3,70E+11 | seJ/g | 1,61E+03 |
| 58 | Rh, in ground | |  | 3,90E-12 | 1,20E+12 | seJ/g | 4,68E+03 |
| 59 | Rhenium, in crude ore, in ground | 1,16E-12 | | | 8,93E+12 | seJ/g | 1,04E+04 |
| 60 | Samarium, 0.3% in bastnasite, 0.03% in crude ore, in ground | 2,01E-09 | | | 1,68E+09 | seJ/g | 3,37E+03 |
| 61 | Sand, unspecified, in ground | 1,64E-08 | | | 1,68E+09 | seJ/g | 2,76E+04 |
| 62 | Shale, in ground | |  | 2,27E-09 | 1,68E+09 | seJ/g | 3,82E+03 |
| 63 | Silver, in ground | |  | 6,52E-17 | 4,50E+11 | seJ/g | 2,93E-02 |
| 64 | Sodium chloride, in ground | 7,95E-04 | | | 1,68E+09 | seJ/g | 1,34E+09 |
| 65 | Sodium nitrate, in ground | 8,51E-15 | | | 1,68E+09 | seJ/g | 1,43E-02 |
| 66 | Sodium sulphate, various forms, in ground | 6,04E-06 | | | 1,40E+09 | seJ/g | 8,44E+06 |
| 67 | Stibnite, in ground | |  | 2,11E-14 | 1,68E+09 | seJ/g | 3,54E-02 |
| 68 | Sulfur, in ground | |  | 7,21E-06 | 2,08E+10 | seJ/g | 1,50E+08 |
| 69 | Sylvite, 25 % in sylvinite, in ground | 7,96E-09 | | | 1,68E+09 | seJ/g | 1,34E+04 |
| 70 | Talc, in ground | |  | 3,68E-09 | 2,80E+10 | seJ/g | 1,03E+05 |
| 71 | Tantalum, 81.9% in tantalite, 1.6E-4% in crude ore, in ground | 2,37E-17 | | | 1,70E+11 | seJ/g | 4,03E-03 |
| 72 | Tellurium, 0.5ppm in sulfide, Te 0.2ppm, Cu and Ag, in crude ore, in ground | 3,17E-18 | | | 5,04E+13 | seJ/g | 1,60E-01 |
| 73 | Tin, 79% in cassiterite, 0.1% in crude ore, in ground | 2,84E-10 | | | 1,70E+12 | seJ/g | 4,83E+05 |
| 74 | TiO2, 54% in ilmenite, 2.6% in crude ore, in ground | 1,18E-05 | | | 3,82E+10 | seJ/g | 4,52E+08 |
| 75 | Ulexite, in ground | |  | 1,21E-17 | 1,68E+09 | seJ/g | 2,03E-05 |
| 76 | Uranium, in ground | |  | 1,55E-06 | 1,60E+11 | seJ/g | 2,48E+08 |
| 77 | Zinc, 9.0% in sulfide, Zn 5.3%, Pb, Ag, Cd, In, in ground | 7,32E-08 | | | 7,20E+10 | seJ/g | 5,27E+06 |
| 78 | Zirconium, 50% in zircon, 0.39% in crude ore, in ground | 3,26E-17 | | | 3,18E+10 | seJ/g | 1,04E-03 |
| 79 | Magnesium, 0.13% in water | 3,74E-18 | | | 1,68E+09 | seJ/g | 6,29E-06 |
| 80 | Water, cooling, unspecified natural origin | 1,39E-02 | | | 2,70E+05 | seJ/g | 3,76E+09 |
| 81 | Water, lake | |  | 9,85E-07 | 4,52E+05 | seJ/g | 4,45E+05 |
| 82 | Water, process, unspecified natural origin | 7,11E-04 | | | 6,74E+04 | seJ/J | 2,00E+08 |
| 83 | Water, river | |  | 2,86E-04 | 3,41E+05 | seJ/g | 9,74E+07 |
| 84 | Water, salt, ocean | |  | 5,31E-04 | 5,36E+04 | seJ/J | 1,19E+08 |
| 85 | Water, salt, sole | |  | 1,01E-03 | 5,36E+04 | seJ/J | 2,26E+08 |
| 86 | Water, unspecified natural origin | 2,47E-03 | | | 3,06E+04 | seJ/J | 3,16E+08 |
| 87 | Water, well, in ground | |  | 1,60E-04 | 6,89E+04 | seJ/J | 4,60E+07 |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  | Emergia | seJ | 6,40E+12 |
|  |  |  |  |  | UEV | seJ/g | 6,40E+09 |

Table S7. LCI-based emergy required to produce 1 kg of p-xylene.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| INPUTS |  |  | QUANTIDADE | UEV | UNIDADE | EMERGIA |
| Energy, gross calorific value, in biomass | | | 5,86E-02 | 6,75E+04 | seJ/J | 3,96E+09 |
| Peat, in ground | |  | 6,29E-07 | 3,19E+04 | seJ/J | 1,96E+05 |
| Wood, primary forest, standing | | | 1,01E-06 | 1,04E+04 | seJ/J | 1,19E+08 |
| Carbon dioxide, in air | |  | 9,35E-03 | 8,87E+07 | sej/g | 2,16E+06 |
| Energy, kinetic (in wind), converted | | | 2,18E-02 | 9,90E+04 | seJ/J | 2,16E+09 |
| Energy, solar, converted | | | 1,71E-03 | 7,93E+04 | seJ/J | 1,36E+08 |
| Energy, potential (in hydropower reservoir), converted | | | 8,52E-02 | 1,35E+05 | seJ/J | 1,15E+10 |
| Aluminium, 24% in bauxite, 11% in crude ore, in ground | | | 2,05E-05 | 5,40E+09 | seJ/g | 1,11E+08 |
| Anhydrite, in ground | |  | 8,78E-10 | 1,68E+09 | seJ/g | 1,48E+03 |
| Barite, 15% in crude ore, in ground | | | 1,68E-06 | 1,68E+09 | seJ/g | 2,81E+06 |
| Basalt, in ground | |  | 1,94E-11 | 7,56E+09 | seJ/g | 1,46E+02 |
| Borax, in ground | |  | 1,60E-10 | 1,68E+09 | seJ/g | 2,69E+02 |
| Cadmium, 0.30% in sulfide, Cd 0.18%, Pb, Zn, Ag, In, in ground | | | 9,47E-13 | 3,40E+13 | seJ/g | 3,22E+04 |
| Calcite, in ground | |  | 1,92E-03 | 1,68E+09 | seJ/g | 3,22E+09 |
| Carbon, in organic matter, in soil | | | 9,93E-09 | 2,77E+09 | seJ/g | 2,75E+04 |
| Cerium, 24% in bastnasite, 2.4% in crude ore, in ground | | | 2,18E-07 | 1,14E+10 | seJ/g | 2,48E+06 |
| Chromium, 25.5% in chromite, 11.6% in crude ore, in ground | | | 2,43E-07 | 1,50E+11 | seJ/g | 3,64E+07 |
| Chrysotile, in ground | |  | 1,84E-08 | 1,68E+09 | seJ/g | 3,09E+04 |
| Cinnabar, in ground | |  | 1,71E-09 | 1,68E+09 | seJ/g | 2,87E+03 |
| Clay, unspecified, in ground | | | 6,51E-06 | 4,80E+09 | seJ/g | 3,13E+07 |
| Coal |  |  | 3,10E-01 | 5,71E+04 | seJ/J | 1,77E+10 |
| Cobalt, in ground | |  | 4,57E-07 | 1,30E+11 | seJ/g | 5,94E+07 |
| Colemanite, in ground | |  | 4,58E-09 | 1,68E+09 | seJ/g | 7,70E+03 |
| Copper, in ground | |  | 2,18E-08 | 9,80E+10 | seJ/g | 2,14E+06 |
| Diatomite, in ground | |  | 2,02E-13 | 1,68E+09 | seJ/g | 3,39E-01 |
| Dolomite, in ground | |  | 8,26E-09 | 1,85E+10 | seJ/g | 1,53E+05 |
| Energy, geothermal, converted | | | 4,10E-04 | 4,52E+05 | seJ/J | 1,85E+08 |
| Europium, 0.06% in bastnasite, 0.006% in crude ore, in ground | | | 5,45E-10 | 1,68E+09 | seJ/g | 9,16E+02 |
| Feldspar, in ground | |  | 2,01E-15 | 1,68E+09 | seJ/g | 3,38E-03 |
| Fluorine, in ground | |  | 1,01E-06 | 1,68E+09 | seJ/g | 1,71E+06 |
| Fluorspar, 92%, in ground | | | 2,09E-05 | 8,38E+08 | seJ/g | 1,75E+07 |
| Gadolinium, 0.15% in bastnasite, 0.015% in crude ore, in ground | | | 1,36E-09 | 1,68E+09 | seJ/g | 2,29E+03 |
| Gas, natural, in ground | | | 6,11E+00 | 6,83E+04 | seJ/J | 4,17E+11 |
| Gold, in ground | |  | 2,40E-17 | 5,00E+11 | seJ/g | 1,20E-02 |
| Granite, in ground | |  | 1,74E-15 | 8,40E+08 | seJ/g | 1,46E-03 |
| Gravel, in ground | |  | 7,80E-05 | 8,40E+08 | seJ/g | 6,55E+07 |
| Gypsum, in ground | |  | 2,07E-08 | 2,85E+09 | seJ/g | 5,89E+04 |
| Indium, 0.005% in sulfide, In 0.003%, Pb, Zn, Ag, Cd, in ground | IN |  | 1,41E-14 | 4,03E+11 | seJ/g | 5,66E+00 |
| Iron, 46% in ore, 25% in crude ore, in ground | | | 3,26E-06 | 1,20E+10 | seJ/g | 3,91E+07 |
| Kaolinite, 24% in crude ore, in ground | | | 4,91E-06 | 1,68E+09 | seJ/g | 8,26E+06 |
| Kieserite, 25% in crude ore, in ground | | | 1,30E-10 | 1,68E+09 | seJ/g | 2,19E+02 |
| Lanthanum, 7.2% in bastnasite, 0.72% in crude ore, in ground | | | 6,52E-08 | 1,68E+09 | seJ/g | 1,10E+05 |
| Lead, 5.0% in sulfide, Pb 3.0%, Zn, Ag, Cd, In, in ground | | | 2,66E-11 | 4,80E+11 | seJ/g | 1,28E+04 |
| Lithium, 0.15% in brine, in ground | | | 3,04E-14 | 9,27E+11 | seJ/g | 2,82E+01 |
| Magnesite, 60% in crude ore, in ground | | | 1,26E-08 | 1,68E+09 | seJ/g | 2,12E+04 |
| Manganese, 35.7% in sedimentary deposit, 14.2% in crude ore, in ground | | | 1,14E-09 | 3,50E+11 | seJ/g | 3,98E+05 |
| Metamorphous rock, graphite containing, in ground | | | 4,01E-08 | 1,68E+09 | seJ/g | 6,73E+04 |
| Molybdenum, 0.025% in sulfide, Mo 8.2E-3% and Cu 0.39% in crude ore, in ground | | | 8,68E-07 | 7,00E+11 | seJ/g | 6,07E+08 |
| Neodymium, 4% in bastnasite, 0.4% in crude ore, in ground | | | 3,59E-08 | 1,68E+09 | seJ/g | 6,03E+04 |
| Nickel, 1.13% in sulfide, Ni 0.76% and Cu 0.76% in crude ore, in ground | | | 1,01E-06 | 2,00E+11 | seJ/g | 2,01E+08 |
| Oil, crude, in ground | |  | 6,01E+01 | 9,45E+04 | seJ/J | 5,68E+12 |
| Olivine, in ground | |  | 2,99E-10 | 1,68E+09 | seJ/g | 5,02E+02 |
| Pd,in ground | |  | 1,42E-10 | 1,20E+11 | seJ/g | 1,71E+04 |
| Phosphorus, 18% in apatite, 12% in crude ore, in ground | | | 4,06E-06 | 2,07E+10 | seJ/g | 8,38E+07 |
| Praseodymium, 0.42% in bastnasite, 0.042% in crude ore, in ground | | | 3,81E-09 | 1,68E+09 | seJ/g | 6,39E+03 |
| Pt, in ground | |  | 4,41E-12 | 3,70E+11 | seJ/g | 1,63E+03 |
| Rh, in ground | |  | 3,95E-12 | 1,20E+12 | seJ/g | 4,74E+03 |
| Rhenium, in crude ore, in ground | | | 1,18E-12 | 8,93E+12 | seJ/g | 1,05E+04 |
| Samarium, 0.3% in bastnasite, 0.03% in crude ore, in ground | | | 2,72E-09 | 1,68E+09 | seJ/g | 4,56E+03 |
| Sand, unspecified, in ground | | | 1,52E-08 | 1,68E+09 | seJ/g | 2,55E+04 |
| Shale, in ground | |  | 2,49E-09 | 1,68E+09 | seJ/g | 4,18E+03 |
| Silver, in ground | |  | 6,51E-17 | 4,50E+11 | seJ/g | 2,93E-02 |
| Sodium chloride, in ground | | | 1,15E-03 | 1,68E+09 | seJ/g | 1,93E+09 |
| Sodium nitrate, in ground | | | 8,16E-15 | 1,68E+09 | seJ/g | 1,37E-02 |
| Sodium sulphate, various forms, in ground | | | 5,91E-06 | 1,40E+09 | seJ/g | 8,25E+06 |
| Stibnite, in ground | |  | 2,10E-14 | 1,68E+09 | seJ/g | 3,53E-02 |
| Sulfur, in ground | |  | 2,93E-06 | 2,08E+10 | seJ/g | 6,09E+07 |
| Sylvite, 25 % in sylvinite, in ground | | | 8,06E-09 | 1,68E+09 | seJ/g | 1,35E+04 |
| Talc, in ground | |  | 3,80E-09 | 2,80E+10 | seJ/g | 1,06E+05 |
| Tantalum, 81.9% in tantalite, 1.6E-4% in crude ore, in ground | | | 2,37E-17 | 1,70E+11 | seJ/g | 4,03E-03 |
| Tellurium, 0.5ppm in sulfide, Te 0.2ppm, Cu and Ag, in crude ore, in ground | | | 3,16E-18 | 5,04E+13 | seJ/g | 1,59E-01 |
| Tin, 79% in cassiterite, 0.1% in crude ore, in ground | | | 3,83E-10 | 1,70E+12 | seJ/g | 6,52E+05 |
| TiO2, 54% in ilmenite, 2.6% in crude ore, in ground | | | 1,16E-05 | 3,82E+10 | seJ/g | 4,42E+08 |
| Ulexite, in ground | |  | 1,21E-17 | 1,68E+09 | seJ/g | 2,03E-05 |
| Uranium, in ground | |  | 9,75E-07 | 1,60E+11 | seJ/g | 1,56E+08 |
| Zinc, 9.0% in sulfide, Zn 5.3%, Pb, Ag, Cd, In, in ground | | | 1,82E-08 | 7,20E+10 | seJ/g | 1,31E+06 |
| Zirconium, 50% in zircon, 0.39% in crude ore, in ground | | | 3,26E-17 | 3,18E+10 | seJ/g | 1,04E-03 |
| Magnesium, 0.13% in water | | | 3,74E-18 | 1,68E+09 | seJ/g | 6,28E-06 |
| Water, cooling, unspecified natural origin | | | 1,74E-02 | 2,70E+05 | seJ/g | 4,70E+09 |
| Water, lake | |  | 6,90E-07 | 4,52E+05 | seJ/g | 3,12E+05 |
| Water, process, unspecified natural origin | | | 1,30E-03 | 6,74E+04 | seJ/J | 3,66E+08 |
| Water, river | |  | 2,85E-04 | 3,41E+05 | seJ/g | 9,72E+07 |
| Water, salt, ocean | |  | 7,89E-04 | 5,36E+04 | seJ/J | 1,77E+08 |
| Water, salt, sole | |  | 1,05E-03 | 5,36E+04 | seJ/J | 2,35E+08 |
| Water, unspecified natural origin | | | 2,56E-03 | 3,06E+04 | seJ/J | 3,27E+08 |
| Water, well, in ground | |  | 1,10E-04 | 6,89E+04 | seJ/J | 3,18E+07 |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  | Emergia | seJ | 6,15E+12 |
|  |  |  |  | UEV | seJ/g | 6,15E+09 |

Table S8. LCI-based emergy required to produce 1 kg of ethylene oxide.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| INPUTS |  |  | QUANTIDADE | UEV | UNIDADE | EMERGIA |
| Energy, gross calorific value, in biomass | | | 5,72E-01 | 6,75E+04 | seJ/J | 3,86E+10 |
| Peat, in ground | |  | 1,74E-06 | 3,19E+04 | seJ/J | 5,43E+05 |
| Wood, primary forest, standing | | | 8,34E-07 | 1,04E+04 | seJ/J | 9,80E+07 |
| Carbon dioxide, in air | |  | 9,63E-02 | 8,87E+07 | sej/g | 1,60E+07 |
| Energy, kinetic (in wind), converted | | | 1,61E-01 | 9,90E+04 | seJ/J | 1,60E+10 |
| Energy, solar, converted | | | 1,69E-02 | 7,93E+04 | seJ/J | 1,34E+09 |
| Energy, potential (in hydropower reservoir), converted | | | 4,66E-01 | 1,35E+05 | seJ/J | 6,29E+10 |
| Aluminium, 24% in bauxite, 11% in crude ore, in ground | | | 1,37E-05 | 5,40E+09 | seJ/g | 7,39E+07 |
| Anhydrite, in ground | |  | 6,39E-10 | 1,68E+09 | seJ/g | 1,07E+03 |
| Barite, 15% in crude ore, in ground | | | 1,27E-06 | 1,68E+09 | seJ/g | 2,14E+06 |
| Basalt, in ground | |  | 1,51E-11 | 7,56E+09 | seJ/g | 1,14E+02 |
| Borax, in ground | |  | 1,28E-10 | 1,68E+09 | seJ/g | 2,15E+02 |
| Cadmium, 0.30% in sulfide, Cd 0.18%, Pb, Zn, Ag, In, in ground | | | 6,50E-13 | 3,40E+13 | seJ/g | 2,21E+04 |
| Calcite, in ground | |  | 5,41E-03 | 1,68E+09 | seJ/g | 9,08E+09 |
| Carbon, in organic matter, in soil | | | 7,78E-09 | 2,77E+09 | seJ/g | 2,16E+04 |
| Cerium, 24% in bastnasite, 2.4% in crude ore, in ground | | | 1,28E-07 | 1,14E+10 | seJ/g | 1,46E+06 |
| Chromium, 25.5% in chromite, 11.6% in crude ore, in ground | | | 1,90E-07 | 1,50E+11 | seJ/g | 2,85E+07 |
| Chrysotile, in ground | |  | 1,39E-08 | 1,68E+09 | seJ/g | 2,34E+04 |
| Cinnabar, in ground | |  | 1,30E-09 | 1,68E+09 | seJ/g | 2,18E+03 |
| Clay, unspecified, in ground | | | 5,07E-06 | 4,80E+09 | seJ/g | 2,44E+07 |
| Coal |  |  | 1,69E+00 | 5,71E+04 | seJ/J | 9,65E+10 |
| Cobalt, in ground | |  | 2,69E-07 | 1,30E+11 | seJ/g | 3,49E+07 |
| Colemanite, in ground | |  | 3,65E-09 | 1,68E+09 | seJ/g | 6,14E+03 |
| Copper, in ground | |  | 7,94E-08 | 9,80E+10 | seJ/g | 7,78E+06 |
| Diatomite, in ground | |  | 1,61E-13 | 1,68E+09 | seJ/g | 2,71E-01 |
| Dolomite, in ground | |  | 7,59E-09 | 1,85E+10 | seJ/g | 1,40E+05 |
| Energy, geothermal, converted | | | 3,49E-03 | 4,52E+05 | seJ/J | 1,58E+09 |
| Europium, 0.06% in bastnasite, 0.006% in crude ore, in ground | | | 3,20E-10 | 1,68E+09 | seJ/g | 5,38E+02 |
| Feldspar, in ground | |  | 1,58E-15 | 1,68E+09 | seJ/g | 2,65E-03 |
| Fluorine, in ground | |  | 8,26E-07 | 1,68E+09 | seJ/g | 1,39E+06 |
| Fluorspar, 92%, in ground | | | 1,70E-05 | 8,38E+08 | seJ/g | 1,42E+07 |
| Gadolinium, 0.15% in bastnasite, 0.015% in crude ore, in ground | | | 8,00E-10 | 1,68E+09 | seJ/g | 1,34E+03 |
| Gas, natural, in ground | | | 1,11E+01 | 6,83E+04 | seJ/J | 7,54E+11 |
| Gold, in ground | |  | 1,91E-17 | 5,00E+11 | seJ/g | 9,56E-03 |
| Granite, in ground | |  | 1,36E-15 | 8,40E+08 | seJ/g | 1,14E-03 |
| Gravel, in ground | |  | 5,22E-05 | 8,40E+08 | seJ/g | 4,39E+07 |
| Gypsum, in ground | |  | 2,08E-08 | 2,85E+09 | seJ/g | 5,94E+04 |
| Indium, 0.005% in sulfide, In 0.003%, Pb, Zn, Ag, Cd, in ground |  |  | 9,47E-15 | 4,03E+11 | seJ/g | 3,82E+00 |
| Iron, 46% in ore, 25% in crude ore, in ground | | | 9,34E-06 | 1,20E+10 | seJ/g | 1,12E+08 |
| Kaolinite, 24% in crude ore, in ground | | | 2,90E-06 | 1,68E+09 | seJ/g | 4,86E+06 |
| Kieserite, 25% in crude ore, in ground | | | 1,02E-10 | 1,68E+09 | seJ/g | 1,72E+02 |
| Lanthanum, 7.2% in bastnasite, 0.72% in crude ore, in ground | | | 3,83E-08 | 1,68E+09 | seJ/g | 6,44E+04 |
| Lead, 5.0% in sulfide, Pb 3.0%, Zn, Ag, Cd, In, in ground | | | 2,02E-11 | 4,80E+11 | seJ/g | 9,70E+03 |
| Lithium, 0.15% in brine, in ground | | | 2,36E-14 | 9,27E+11 | seJ/g | 2,19E+01 |
| Magnesite, 60% in crude ore, in ground | | | 9,75E-09 | 1,68E+09 | seJ/g | 1,64E+04 |
| Manganese, 35.7% in sedimentary deposit, 14.2% in crude ore, in ground | | | 9,03E-10 | 3,50E+11 | seJ/g | 3,16E+05 |
| Metamorphous rock, graphite containing, in ground | | | 2,37E-08 | 1,68E+09 | seJ/g | 3,97E+04 |
| Molybdenum, 0.025% in sulfide, Mo 8.2E-3% and Cu 0.39% in crude ore, in ground | | | 5,40E-07 | 7,00E+11 | seJ/g | 3,78E+08 |
| Neodymium, 4% in bastnasite, 0.4% in crude ore, in ground | | | 2,11E-08 | 1,68E+09 | seJ/g | 3,54E+04 |
| Nickel, 1.13% in sulfide, Ni 0.76% and Cu 0.76% in crude ore, in ground | | | 7,14E-07 | 2,00E+11 | seJ/g | 1,43E+08 |
| Oil, crude, in ground | |  | 4,66E+01 | 9,45E+04 | seJ/J | 4,40E+12 |
| Olivine, in ground | |  | 2,18E-10 | 1,68E+09 | seJ/g | 3,67E+02 |
| Pd,in ground | |  | 1,12E-10 | 1,20E+11 | seJ/g | 1,34E+04 |
| Phosphorus, 18% in apatite, 12% in crude ore, in ground | | | 3,30E-06 | 2,07E+10 | seJ/g | 6,82E+07 |
| Praseodymium, 0.42% in bastnasite, 0.042% in crude ore, in ground | | | 2,24E-09 | 1,68E+09 | seJ/g | 3,76E+03 |
| Pt, in ground | |  | 3,47E-12 | 3,70E+11 | seJ/g | 1,28E+03 |
| Rh, in ground | |  | 3,10E-12 | 1,20E+12 | seJ/g | 3,73E+03 |
| Rhenium, in crude ore, in ground | | | 9,25E-13 | 8,93E+12 | seJ/g | 8,26E+03 |
| Samarium, 0.3% in bastnasite, 0.03% in crude ore, in ground | | | 1,60E-09 | 1,68E+09 | seJ/g | 2,68E+03 |
| Sand, unspecified, in ground | | | 2,49E-08 | 1,68E+09 | seJ/g | 4,18E+04 |
| Shale, in ground | |  | 1,81E-09 | 1,68E+09 | seJ/g | 3,04E+03 |
| Silver, in ground | |  | 5,19E-17 | 4,50E+11 | seJ/g | 2,34E-02 |
| Sodium chloride, in ground | | | 6,68E-04 | 1,68E+09 | seJ/g | 1,12E+09 |
| Sodium nitrate, in ground | | | 6,77E-15 | 1,68E+09 | seJ/g | 1,14E-02 |
| Sodium sulphate, various forms, in ground | | | 4,81E-06 | 1,40E+09 | seJ/g | 6,72E+06 |
| Stibnite, in ground | |  | 1,68E-14 | 1,68E+09 | seJ/g | 2,82E-02 |
| Sulfur, in ground | |  | 3,38E-05 | 2,08E+10 | seJ/g | 7,04E+08 |
| Sylvite, 25 % in sylvinite, in ground | | | 6,33E-09 | 1,68E+09 | seJ/g | 1,06E+04 |
| Talc, in ground | |  | 2,93E-09 | 2,80E+10 | seJ/g | 8,19E+04 |
| Tantalum, 81.9% in tantalite, 1.6E-4% in crude ore, in ground | | | 1,89E-17 | 1,70E+11 | seJ/g | 3,21E-03 |
| Tellurium, 0.5ppm in sulfide, Te 0.2ppm, Cu and Ag, in crude ore, in ground | | | 2,52E-18 | 5,04E+13 | seJ/g | 1,27E-01 |
| Tin, 79% in cassiterite, 0.1% in crude ore, in ground | | | 2,26E-10 | 1,70E+12 | seJ/g | 3,84E+05 |
| TiO2, 54% in ilmenite, 2.6% in crude ore, in ground | | | 9,41E-06 | 3,82E+10 | seJ/g | 3,60E+08 |
| Ulexite, in ground | |  | 9,63E-18 | 1,68E+09 | seJ/g | 1,62E-05 |
| Uranium, in ground | |  | 5,01E-06 | 1,60E+11 | seJ/g | 8,02E+08 |
| Zinc, 9.0% in sulfide, Zn 5.3%, Pb, Ag, Cd, In, in ground | | | 5,83E-08 | 7,20E+10 | seJ/g | 4,20E+06 |
| Zirconium, 50% in zircon, 0.39% in crude ore, in ground | | | 2,60E-17 | 3,18E+10 | seJ/g | 8,26E-04 |
| Magnesium, 0.13% in water | | | 2,98E-18 | 1,68E+09 | seJ/g | 5,00E-06 |
| Water, cooling, unspecified natural origin | | | 3,35E-02 | 2,70E+05 | seJ/g | 9,07E+09 |
| Water, lake | |  | 7,84E-07 | 4,52E+05 | seJ/g | 3,54E+05 |
| Water, process, unspecified natural origin | | | 1,02E-03 | 6,74E+04 | seJ/J | 2,87E+08 |
| Water, river | |  | 2,27E-04 | 3,41E+05 | seJ/g | 7,76E+07 |
| Water, salt, ocean | |  | 4,23E-04 | 5,36E+04 | seJ/J | 9,48E+07 |
| Water, salt, sole | |  | 8,04E-04 | 5,36E+04 | seJ/J | 1,80E+08 |
| Water, unspecified natural origin | | | 1,98E-03 | 3,06E+04 | seJ/J | 2,54E+08 |
| Water, well, in ground | |  | 5,07E-04 | 6,89E+04 | seJ/J | 1,46E+08 |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  | Emergia | seJ | 5,40E+12 |
|  |  |  |  | UEV | seJ/g | 5,40E+09 |

Table S9. LCI-based emergy required to produce 1 kg of ethylene glycol.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| INPUTS |  |  | QUANTIDADE | UEV | UNIDADE | EMERGIA |
| Energy, gross calorific value, in biomass | | | 6,16E-01 | 6,75E+04 | seJ/J | 4,16E+10 |
| Peat, in ground | |  | 1,24E-06 | 3,19E+04 | seJ/J | 3,88E+05 |
| Wood, primary forest, standing | | | 5,95E-07 | 1,04E+04 | seJ/J | 6,99E+07 |
| Carbon dioxide, in air | |  | 1,04E-01 | 8,87E+07 | sej/g | 1,71E+07 |
| Energy, kinetic (in wind), converted | | | 1,73E-01 | 9,90E+04 | seJ/J | 1,71E+10 |
| Energy, solar, converted | | | 1,82E-02 | 7,93E+04 | seJ/J | 1,45E+09 |
| Energy, potential (in hydropower reservoir), converted | | | 4,90E-01 | 1,35E+05 | seJ/J | 6,61E+10 |
| Aluminium, 24% in bauxite, 11% in crude ore, in ground | | | 1,02E-05 | 5,40E+09 | seJ/g | 5,51E+07 |
| Anhydrite, in ground | |  | 4,56E-10 | 1,68E+09 | seJ/g | 7,66E+02 |
| Barite, 15% in crude ore, in ground | | | 9,07E-07 | 1,68E+09 | seJ/g | 1,52E+06 |
| Basalt, in ground | |  | 1,07E-11 | 7,56E+09 | seJ/g | 8,12E+01 |
| Borax, in ground | |  | 9,12E-11 | 1,68E+09 | seJ/g | 1,53E+02 |
| Cadmium, 0.30% in sulfide, Cd 0.18%, Pb, Zn, Ag, In, in ground | | | 4,64E-13 | 3,40E+13 | seJ/g | 1,58E+04 |
| Calcite, in ground | |  | 5,61E-03 | 1,68E+09 | seJ/g | 9,42E+09 |
| Carbon, in organic matter, in soil | | | 5,55E-09 | 2,77E+09 | seJ/g | 1,54E+04 |
| Cerium, 24% in bastnasite, 2.4% in crude ore, in ground | | | 9,12E-08 | 1,14E+10 | seJ/g | 1,04E+06 |
| Chromium, 25.5% in chromite, 11.6% in crude ore, in ground | | | 1,36E-07 | 1,50E+11 | seJ/g | 2,04E+07 |
| Chrysotile, in ground | |  | 9,92E-09 | 1,68E+09 | seJ/g | 1,67E+04 |
| Cinnabar, in ground | |  | 9,26E-10 | 1,68E+09 | seJ/g | 1,56E+03 |
| Clay, unspecified, in ground | | | 3,62E-06 | 4,80E+09 | seJ/g | 1,74E+07 |
| Coal |  |  | 1,79E+00 | 5,71E+04 | seJ/J | 1,02E+11 |
| Cobalt, in ground | |  | 1,92E-07 | 1,30E+11 | seJ/g | 2,49E+07 |
| Colemanite, in ground | |  | 2,61E-09 | 1,68E+09 | seJ/g | 4,38E+03 |
| Copper, in ground | |  | 5,67E-08 | 9,80E+10 | seJ/g | 5,55E+06 |
| Diatomite, in ground | |  | 1,15E-13 | 1,68E+09 | seJ/g | 1,93E-01 |
| Dolomite, in ground | |  | 5,41E-09 | 1,85E+10 | seJ/g | 1,00E+05 |
| Energy, geothermal, converted | | | 3,77E-03 | 4,52E+05 | seJ/J | 1,70E+09 |
| Europium, 0.06% in bastnasite, 0.006% in crude ore, in ground | | | 2,29E-10 | 1,68E+09 | seJ/g | 3,84E+02 |
| Feldspar, in ground | |  | 1,12E-15 | 1,68E+09 | seJ/g | 1,89E-03 |
| Fluorine, in ground | |  | 5,89E-07 | 1,68E+09 | seJ/g | 9,90E+05 |
| Fluorspar, 92%, in ground | | | 1,21E-05 | 8,38E+08 | seJ/g | 1,01E+07 |
| Gadolinium, 0.15% in bastnasite, 0.015% in crude ore, in ground | | | 5,71E-10 | 1,68E+09 | seJ/g | 9,59E+02 |
| Gas, natural, in ground | | | 8,41E+00 | 6,83E+04 | seJ/J | 5,74E+11 |
| Gold, in ground | |  | 1,36E-17 | 5,00E+11 | seJ/g | 6,82E-03 |
| Granite, in ground | |  | 9,68E-16 | 8,40E+08 | seJ/g | 8,13E-04 |
| Gravel, in ground | |  | 3,73E-05 | 8,40E+08 | seJ/g | 3,13E+07 |
| Gypsum, in ground | |  | 1,49E-08 | 2,85E+09 | seJ/g | 4,24E+04 |
| Indium, 0.005% in sulfide, In 0.003%, Pb, Zn, Ag, Cd, in ground | IN |  | 6,76E-15 | 4,03E+11 | seJ/g | 2,72E+00 |
| Iron, 46% in ore, 25% in crude ore, in ground | | | 9,17E-06 | 1,20E+10 | seJ/g | 1,10E+08 |
| Kaolinite, 24% in crude ore, in ground | | | 2,07E-06 | 1,68E+09 | seJ/g | 3,47E+06 |
| Kieserite, 25% in crude ore, in ground | | | 7,29E-11 | 1,68E+09 | seJ/g | 1,22E+02 |
| Lanthanum, 7.2% in bastnasite, 0.72% in crude ore, in ground | | | 2,74E-08 | 1,68E+09 | seJ/g | 4,60E+04 |
| Lead, 5.0% in sulfide, Pb 3.0%, Zn, Ag, Cd, In, in ground | | | 1,44E-11 | 4,80E+11 | seJ/g | 6,92E+03 |
| Lithium, 0.15% in brine, in ground | | | 1,68E-14 | 9,27E+11 | seJ/g | 1,56E+01 |
| Magnesite, 60% in crude ore, in ground | | | 6,96E-09 | 1,68E+09 | seJ/g | 1,17E+04 |
| Manganese, 35.7% in sedimentary deposit, 14.2% in crude ore, in ground | | | 6,44E-10 | 3,50E+11 | seJ/g | 2,25E+05 |
| Metamorphous rock, graphite containing, in ground | | | 1,69E-08 | 1,68E+09 | seJ/g | 2,83E+04 |
| Molybdenum, 0.025% in sulfide, Mo 8.2E-3% and Cu 0.39% in crude ore, in ground | | | 3,85E-07 | 7,00E+11 | seJ/g | 2,70E+08 |
| Neodymium, 4% in bastnasite, 0.4% in crude ore, in ground | | | 1,50E-08 | 1,68E+09 | seJ/g | 2,53E+04 |
| Nickel, 1.13% in sulfide, Ni 0.76% and Cu 0.76% in crude ore, in ground | | | 5,10E-07 | 2,00E+11 | seJ/g | 1,02E+08 |
| Oil, crude, in ground | |  | 3,34E+01 | 9,45E+04 | seJ/J | 3,16E+12 |
| Olivine, in ground | |  | 1,56E-10 | 1,68E+09 | seJ/g | 2,62E+02 |
| Pd,in ground | |  | 7,98E-11 | 1,20E+11 | seJ/g | 9,58E+03 |
| Phosphorus, 18% in apatite, 12% in crude ore, in ground | | | 2,36E-06 | 2,07E+10 | seJ/g | 4,87E+07 |
| Praseodymium, 0.42% in bastnasite, 0.042% in crude ore, in ground | | | 1,60E-09 | 1,68E+09 | seJ/g | 2,68E+03 |
| Pt, in ground | |  | 2,47E-12 | 3,70E+11 | seJ/g | 9,16E+02 |
| Rh, in ground | |  | 2,22E-12 | 1,20E+12 | seJ/g | 2,66E+03 |
| Rhenium, in crude ore, in ground | | | 6,60E-13 | 8,93E+12 | seJ/g | 5,90E+03 |
| Samarium, 0.3% in bastnasite, 0.03% in crude ore, in ground | | | 1,14E-09 | 1,68E+09 | seJ/g | 1,91E+03 |
| Sand, unspecified, in ground | | | 2,30E-08 | 1,68E+09 | seJ/g | 3,87E+04 |
| Shale, in ground | |  | 1,29E-09 | 1,68E+09 | seJ/g | 2,17E+03 |
| Silver, in ground | |  | 3,70E-17 | 4,50E+11 | seJ/g | 1,67E-02 |
| Sodium chloride, in ground | | | 4,92E-04 | 1,68E+09 | seJ/g | 8,26E+08 |
| Sodium nitrate, in ground | | | 4,83E-15 | 1,68E+09 | seJ/g | 8,12E-03 |
| Sodium sulphate, various forms, in ground | | | 3,43E-06 | 1,40E+09 | seJ/g | 4,79E+06 |
| Stibnite, in ground | |  | 1,20E-14 | 1,68E+09 | seJ/g | 2,01E-02 |
| Sulfur, in ground | |  | 3,66E-05 | 2,08E+10 | seJ/g | 7,62E+08 |
| Sylvite, 25 % in sylvinite, in ground | | | 4,52E-09 | 1,68E+09 | seJ/g | 7,59E+03 |
| Talc, in ground | |  | 2,09E-09 | 2,80E+10 | seJ/g | 5,85E+04 |
| Tantalum, 81.9% in tantalite, 1.6E-4% in crude ore, in ground | | | 1,35E-17 | 1,70E+11 | seJ/g | 2,29E-03 |
| Tellurium, 0.5ppm in sulfide, Te 0.2ppm, Cu and Ag, in crude ore, in ground | | | 1,80E-18 | 5,04E+13 | seJ/g | 9,06E-02 |
| Tin, 79% in cassiterite, 0.1% in crude ore, in ground | | | 1,61E-10 | 1,70E+12 | seJ/g | 2,74E+05 |
| TiO2, 54% in ilmenite, 2.6% in crude ore, in ground | | | 6,72E-06 | 3,82E+10 | seJ/g | 2,57E+08 |
| Ulexite, in ground | |  | 6,87E-18 | 1,68E+09 | seJ/g | 1,15E-05 |
| Uranium, in ground | |  | 5,25E-06 | 1,60E+11 | seJ/g | 8,41E+08 |
| Zinc, 9.0% in sulfide, Zn 5.3%, Pb, Ag, Cd, In, in ground | | | 4,16E-08 | 7,20E+10 | seJ/g | 2,99E+06 |
| Zirconium, 50% in zircon, 0.39% in crude ore, in ground | | | 1,85E-17 | 3,18E+10 | seJ/g | 5,89E-04 |
| Magnesium, 0.13% in water | | | 2,13E-18 | 1,68E+09 | seJ/g | 3,57E-06 |
| Water, cooling, unspecified natural origin | | | 3,35E-02 | 2,70E+05 | seJ/g | 9,06E+09 |
| Water, lake | |  | 5,59E-07 | 4,52E+05 | seJ/g | 2,53E+05 |
| Water, process, unspecified natural origin | | | 6,69E-03 | 6,74E+04 | seJ/J | 1,89E+09 |
| Water, river | |  | 1,62E-04 | 3,41E+05 | seJ/g | 5,53E+07 |
| Water, salt, ocean | |  | 3,02E-04 | 5,36E+04 | seJ/J | 6,76E+07 |
| Water, salt, sole | |  | 5,74E-04 | 5,36E+04 | seJ/J | 1,29E+08 |
| Water, unspecified natural origin | | | 1,42E-03 | 3,06E+04 | seJ/J | 1,82E+08 |
| Water, well, in ground | |  | 5,30E-04 | 6,89E+04 | seJ/J | 1,53E+08 |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  | Emergia | seJ | 3,99E+12 |
|  |  |  |  | UEV | seJ/g | 3,99E+09 |

Table S10. LCI-based emergy required to produce 1 kg of purified terephthalic acid.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | INPUTS |  |  | QUANTIDADE | UEV | UNIDADE | EMERGIA |
| 1 | Energy, gross calorific value, in biomass | | | 2,12E-01 | 6,75E+04 | seJ/J | 1,43E+10 |
| 3 | Peat, in ground | |  | 5,89E-06 | 3,19E+04 | seJ/J | 1,83E+06 |
| 4 | Wood, primary forest, standing | | | 1,76E-06 | 1,04E+04 | seJ/J | 2,07E+08 |
| 5 | Carbon dioxide, in air | |  | 3,48E-02 | 8,87E+07 | sej/g | 1,31E+07 |
| 6 | Energy, kinetic (in wind), converted | | | 1,32E-01 | 9,90E+04 | seJ/J | 1,31E+10 |
| 7 | Energy, solar, converted | | | 3,60E-02 | 7,93E+04 | seJ/J | 2,85E+09 |
| 8 | Energy, potential (in hydropower reservoir), converted | | | 2,42E-01 | 1,35E+05 | seJ/J | 3,26E+10 |
| 9 | Aluminium, 24% in bauxite, 11% in crude ore, in ground | | | 2,16E-05 | 5,40E+09 | seJ/g | 1,17E+08 |
| 10 | Anhydrite, in ground | |  | 1,82E-09 | 1,68E+09 | seJ/g | 3,05E+03 |
| 11 | Barite, 15% in crude ore, in ground | | | 3,43E-06 | 1,68E+09 | seJ/g | 5,77E+06 |
| 12 | Basalt, in ground | |  | 1,95E-10 | 7,56E+09 | seJ/g | 1,47E+03 |
| 13 | Borax, in ground | |  | 2,75E-10 | 1,68E+09 | seJ/g | 4,61E+02 |
| 14 | Cadmium, 0.30% in sulfide, Cd 0.18%, Pb, Zn, Ag, In, in ground | | | 1,06E-11 | 3,40E+13 | seJ/g | 3,62E+05 |
| 15 | Calcite, in ground | |  | 8,77E-03 | 1,68E+09 | seJ/g | 1,47E+10 |
| 16 | Carbon, in organic matter, in soil | | | 1,23E-08 | 2,77E+09 | seJ/g | 3,42E+04 |
| 17 | Cerium, 24% in bastnasite, 2.4% in crude ore, in ground | | | 1,43E-07 | 1,14E+10 | seJ/g | 1,63E+06 |
| 18 | Chromium, 25.5% in chromite, 11.6% in crude ore, in ground | | | 5,39E-07 | 1,50E+11 | seJ/g | 8,09E+07 |
| 19 | Chrysotile, in ground | |  | 5,35E-08 | 1,68E+09 | seJ/g | 8,99E+04 |
| 20 | Cinnabar, in ground | |  | 1,44E-08 | 1,68E+09 | seJ/g | 2,43E+04 |
| 21 | Clay, unspecified, in ground | | | 2,88E-04 | 4,80E+09 | seJ/g | 1,39E+09 |
| 22 | Coal |  |  | 8,20E-01 | 5,71E+04 | seJ/J | 4,68E+10 |
| 23 | Cobalt, in ground | |  | 2,89E-04 | 1,30E+11 | seJ/g | 3,75E+10 |
| 24 | Colemanite, in ground | |  | 7,62E-09 | 1,68E+09 | seJ/g | 1,28E+04 |
| 25 | Copper, in ground | |  | 1,62E-06 | 9,80E+10 | seJ/g | 1,59E+08 |
| 26 | Diatomite, in ground | |  | 3,37E-13 | 1,68E+09 | seJ/g | 5,65E-01 |
| 27 | Dolomite, in ground | |  | 3,91E-06 | 1,85E+10 | seJ/g | 7,24E+07 |
| 28 | Energy, geothermal, converted | | | 1,13E-03 | 4,52E+05 | seJ/J | 5,09E+08 |
| 29 | Europium, 0.06% in bastnasite, 0.006% in crude ore, in ground | | | 3,59E-10 | 1,68E+09 | seJ/g | 6,03E+02 |
| 30 | Feldspar, in ground | |  | 1,58E-14 | 1,68E+09 | seJ/g | 2,66E-02 |
| 31 | Fluorine, in ground | |  | 8,34E-07 | 1,68E+09 | seJ/g | 1,40E+06 |
| 32 | Fluorspar, 92%, in ground | | | 1,77E-05 | 8,38E+08 | seJ/g | 1,48E+07 |
| 33 | Gadolinium, 0.15% in bastnasite, 0.015% in crude ore, in ground | | | 8,96E-10 | 1,68E+09 | seJ/g | 1,50E+03 |
| 34 | Gas, natural, in ground | | | 1,11E+01 | 6,83E+04 | seJ/J | 7,56E+11 |
| 35 | Gold, in ground | |  | 4,06E-17 | 5,00E+11 | seJ/g | 2,03E-02 |
| 36 | Granite, in ground | |  | 1,54E-14 | 8,40E+08 | seJ/g | 1,29E-02 |
| 37 | Gravel, in ground | |  | 1,05E-02 | 8,40E+08 | seJ/g | 8,79E+09 |
| 38 | Gypsum, in ground | |  | 2,10E-08 | 2,85E+09 | seJ/g | 5,99E+04 |
| 39 | Indium, 0.005% in sulfide, In 0.003%, Pb, Zn, Ag, Cd, in ground |  |  | 1,68E-13 | 4,03E+11 | seJ/g | 6,75E+01 |
| 40 | Iron, 46% in ore, 25% in crude ore, in ground | | | 5,94E-06 | 1,20E+10 | seJ/g | 7,13E+07 |
| 41 | Kaolinite, 24% in crude ore, in ground | | | 3,57E-06 | 1,68E+09 | seJ/g | 6,00E+06 |
| 42 | Kieserite, 25% in crude ore, in ground | | | 9,32E-10 | 1,68E+09 | seJ/g | 1,56E+03 |
| 43 | Lanthanum, 7.2% in bastnasite, 0.72% in crude ore, in ground | | | 4,30E-08 | 1,68E+09 | seJ/g | 7,22E+04 |
| 44 | Lead, 5.0% in sulfide, Pb 3.0%, Zn, Ag, Cd, In, in ground | | | 4,60E-11 | 4,80E+11 | seJ/g | 2,21E+04 |
| 45 | Lithium, 0.15% in brine, in ground | | | 3,77E-13 | 9,27E+11 | seJ/g | 3,49E+02 |
| 46 | Magnesite, 60% in crude ore, in ground | | | 2,85E-07 | 1,68E+09 | seJ/g | 4,78E+05 |
| 47 | Manganese, 35.7% in sedimentary deposit, 14.2% in crude ore, in ground | | | 5,04E-04 | 3,50E+11 | seJ/g | 1,76E+11 |
| 48 | Metamorphous rock, graphite containing, in ground | | | 3,33E-08 | 1,68E+09 | seJ/g | 5,58E+04 |
| 49 | Molybdenum, 0.025% in sulfide, Mo 8.2E-3% and Cu 0.39% in crude ore, in ground | | | 1,29E-06 | 7,00E+11 | seJ/g | 9,01E+08 |
| 50 | Neodymium, 4% in bastnasite, 0.4% in crude ore, in ground | | | 2,36E-08 | 1,68E+09 | seJ/g | 3,97E+04 |
| 51 | Nickel, 1.13% in sulfide, Ni 0.76% and Cu 0.76% in crude ore, in ground | | | 2,19E-06 | 2,00E+11 | seJ/g | 4,37E+08 |
| 52 | Oil, crude, in ground | |  | 4,08E+01 | 9,45E+04 | seJ/J | 3,86E+12 |
| 53 | Olivine, in ground | |  | 6,06E-10 | 1,68E+09 | seJ/g | 1,02E+03 |
| 54 | Pd,in ground | |  | 1,80E-10 | 1,20E+11 | seJ/g | 2,16E+04 |
| 55 | Phosphorus, 18% in apatite, 12% in crude ore, in ground | | | 3,33E-06 | 2,07E+10 | seJ/g | 6,89E+07 |
| 56 | Praseodymium, 0.42% in bastnasite, 0.042% in crude ore, in ground | | | 2,51E-09 | 1,68E+09 | seJ/g | 4,21E+03 |
| 57 | Pt, in ground | |  | 5,57E-12 | 3,70E+11 | seJ/g | 2,06E+03 |
| 58 | Rh, in ground | |  | 4,99E-12 | 1,20E+12 | seJ/g | 5,98E+03 |
| 59 | Rhenium, in crude ore, in ground | | | 1,44E-12 | 8,93E+12 | seJ/g | 1,29E+04 |
| 60 | Samarium, 0.3% in bastnasite, 0.03% in crude ore, in ground | | | 1,79E-09 | 1,68E+09 | seJ/g | 3,00E+03 |
| 61 | Sand, unspecified, in ground | | | 3,43E-08 | 1,68E+09 | seJ/g | 5,77E+04 |
| 62 | Shale, in ground | |  | 5,14E-09 | 1,68E+09 | seJ/g | 8,64E+03 |
| 63 | Silver, in ground | |  | 1,09E-16 | 4,50E+11 | seJ/g | 4,90E-02 |
| 64 | sodium bromide | |  | 4,19E-04 | 1,68E+09 | seJ/g | 7,03E+08 |
| 65 | Sodium chloride, in ground | | | 1,12E-02 | 1,68E+09 | seJ/g | 1,87E+10 |
| 66 | Sodium nitrate, in ground | | | 9,78E-15 | 1,68E+09 | seJ/g | 1,64E-02 |
| 67 | Sodium sulphate, various forms, in ground | | | 4,85E-06 | 1,40E+09 | seJ/g | 6,77E+06 |
| 68 | Stibnite, in ground | |  | 3,50E-14 | 1,68E+09 | seJ/g | 5,88E-02 |
| 69 | Sulfur, in ground | |  | 1,45E-05 | 2,08E+10 | seJ/g | 3,03E+08 |
| 70 | Sylvite, 25 % in sylvinite, in ground | | | 1,87E-08 | 1,68E+09 | seJ/g | 3,14E+04 |
| 71 | Talc, in ground | |  | 7,89E-08 | 2,80E+10 | seJ/g | 2,21E+06 |
| 72 | Tantalum, 81.9% in tantalite, 1.6E-4% in crude ore, in ground | | | 3,96E-17 | 1,70E+11 | seJ/g | 6,73E-03 |
| 73 | Tellurium, 0.5ppm in sulfide, Te 0.2ppm, Cu and Ag, in crude ore, in ground | | | 5,33E-18 | 5,04E+13 | seJ/g | 2,69E-01 |
| 74 | Tin, 79% in cassiterite, 0.1% in crude ore, in ground | | | 2,68E-10 | 1,70E+12 | seJ/g | 4,56E+05 |
| 75 | TiO2, 54% in ilmenite, 2.6% in crude ore, in ground | | | 1,02E-05 | 3,82E+10 | seJ/g | 3,89E+08 |
| 76 | Ulexite, in ground | |  | 2,02E-17 | 1,68E+09 | seJ/g | 3,39E-05 |
| 77 | Uranium, in ground | |  | 2,92E-06 | 1,60E+11 | seJ/g | 4,68E+08 |
| 78 | Zinc, 9.0% in sulfide, Zn 5.3%, Pb, Ag, Cd, In, in ground | | | 1,18E-06 | 7,20E+10 | seJ/g | 8,47E+07 |
| 79 | Zirconium, 50% in zircon, 0.39% in crude ore, in ground | | | 5,44E-17 | 3,18E+10 | seJ/g | 1,73E-03 |
| 80 | Magnesium, 0.13% in water | | | 6,24E-18 | 1,68E+09 | seJ/g | 1,05E-05 |
| 81 | Water, cooling, unspecified natural origin | | | 3,81E-02 | 2,70E+05 | seJ/g | 1,03E+10 |
| 82 | Water, lake | |  | 7,32E-06 | 4,52E+05 | seJ/g | 3,31E+06 |
| 83 | Water, process, unspecified natural origin | | | 3,56E-03 | 6,74E+04 | seJ/J | 4,93E+05 |
| 84 | Water, river | |  | 2,57E-02 | 3,41E+05 | seJ/g | 5,08E+09 |
| 85 | Water, salt, ocean | |  | 3,37E-03 | 5,36E+04 | seJ/J | 1,37E+09 |
| 86 | Water, salt, sole | |  | 7,07E-04 | 5,36E+04 | seJ/J | 7,56E+08 |
| 87 | Water, unspecified natural origin | | | 2,05E-03 | 3,06E+04 | seJ/J | 9,05E+07 |
| 88 | Water, well, in ground | |  | 2,86E-04 | 6,89E+04 | seJ/J | 5,90E+08 |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  | Emergia | seJ | 5,00E+12 |
|  |  |  |  |  | UEV | seJ/g | 5,00E+09 |