MAXergy Update April 2016 (to be incorporated in general website texts)

Update on positioning, system borders, levels of impact, energy-mass, partial functional units, Labor, converting to EL factor g and f, Recycling

Continuing discussion have led to further detail the methodology. No essential changes, but better definitions, system-borders etc. Below these are described in detail.

Positioning
The simple definition of MAXergy is that it is a way to calculate the re-production of the resources used for a functional unit. All energy and materials is thus compensated to original quality. Which in fact always should involve a source from outside the system, which is solar energy, the only available source outside the system earth. The indicator is the Embodied Land involved in making the source available.

More specific : *MAXergy is based on a thermodynamic approach : By using resources, exergy is lost (resources get diluted and spread in the system) , and entropy grows (chaos in molecules) Maxergy analyses and calculates how much solar energy is required to restore the exergy to original levels.*
There are different ways of calculating exergy loss, (see the download topics section) , but restoring is a more easy and practical way to get an indicator for actual impact.
As such, Maxergy is not a extended LCA method, nor a further development of Ecological footprint or emergy approach. But has similarities and overlaps, and can use parts of these approaches, like land occupation data, or making a process inventory. As far as relevant these will be detailed. The website has already a more elaborated comparison with ecological footprint.

Two System borders
In analyzing environmental (thermodynamical) impact of functions in fact there is not one, but always two system borders that have to be defined: one is the system border for the function evaluated, the service provided within its own boundaries; and the second one is for the resource system supplying the function's energy and materials: in our global economy this has to be the total system earth.If thes system is chosen smaller, burdens can be shifted somewhere else, therfor the resource system border should always be chosen at the global system level. This is the overall system in which entropy takes place (resources get spread and many dissolved in the ocean) , and ultimately its about the total system balance , not about a local effect. *See Illustrations in PPT file*
In fact, as we studied LCA and exergy publications, this holds for these methodologies as well, but as far as we could find, this has not been defined very well in literature.
Within this global resource system, we have to make another distinction: to which order or level resources are taken into consideration to provide a function or service.

Levels of impact within resource system.
We have chosen for a fixed global resource border , which implies that everything counts. Except for limitations to the level of derivatives involved.

At the 1 st level are the resources directly applied within the *functional system*. Further levels are distinguished by the following definition: resources of the 2nd second order are those that are directly deployed in the *resource system* to provide the 1 st order . The 3rd order resources are deployed to provide the 2nd order , etc Any level consists of the resources to make a higher level possible.

At the 2nd level we distinguish 3 resource impact involved I making the level 1 function available:
Embodied energy EE

Embodied materials EM
Embodied Land EL
(the first two later to be recalculated for Embodied Land)

Embodied energy is energy which is directly and fully deployed , (and of which the exergy has been lost) via the treatment of a resource, or transport of the 1st level resource/end product. It can be the electricity for a sawing machine, petrol for a truck, labor, etc.
Embodied Materials: are materials which are directly and fully deployed, (and of which the exergy has been lost) for the treatment or transport of the (1st level) resource/end product. Which can be losses in sawing wood, packaging, form-work, etc.

Embodied Land; land that is directly deployed (and which has been taken " out of production") by the functional element from level 1 , like the land-footprint in case of a building function.

The 3rd level are the resources deployed to make possible the 2nd level resource function. Which usually can only be partly assigned to to the function delivered. The petrol for the transport vehicle is lost, but the vehicle can make X trips, of which a only a part is to be assigned to the evaluated service. Same for sawing machines etc etc.

The 4th level are the resources to make level 3 possible: The factory that houses the sawing machine, the infrastructure used for transport modes.

Both 3rd and 4th level can be split again in EE,EM and EL.

We decided that in any case level 1 and 2 will have to be included (see enxt issue) . This is called the base case. The indicators will have such distinguished values, that a clear evaluation between alternatives can be made. At least thats our impression so far. But it could require a more in depth study with levels 3 and 4 to do a real sensitivity analyses if level 1 and 2 will do for a indicative evaluation.

(In Emergy there is some reference to foreground and background levels: foreground could be level 1, and level 2 and lower levels seen as background.)

Energy =mass
The thermodynamic laws apply for energy as well as mass/materials. And in physics this relation is regularly referred to as energy being rest mass, or to mass as being rest energy. In fact they are two of the same in different manifestations. Which is also for MAXergy the starting point in evaluation. Energy can not be made useful without materials (as receiver of energy(embodied) , or as converter of energy) , and materials are useless without input of energy (in production or in use)[1] . In other words, any analyses should always consider energy and mass together.

In developing the calculation tool, this would imply that (direct) materials as well as energy would be in the first level of the resource boundary system. Both are of 1st order. Its has been tried to develop this in a practical tool. But this would also imply that the second level becomes very broad. The before described 4 levels would become 2 levels, which is unworkable , calculation-wise, and not practical nor flexible. Therefor its chosen to maintain the above described level approach, with the condition that at least two levels should be evaluated.

Partial Functional analyses.

1 Energy that heats the body seems mass-less, although the source of the source requires materials, and the heat effect is transferred to body mass. Even shadow is povided by mass in the form of a tree for instance. So far we have not found any function or service of solely energy or mass.

Maxergy starts from analyses of a functional unit, and originally departed from evaluating buildings, that is, the functional unit of a m2 sheltered floor, following basic requirements according a countries building regulations.
However the methodology is also applicable for other functions, as well as for components, as long as they are part of a functional unit, like for instance floor beams, a PV panel. These are calculated also to the second level, and can be added as composed element to the building evaluation (read m2 shelter evaluation) without there being double counting.
For other functions besides buildings the same approach applies.

Labor
Labor , in the process of establishing or operating a functional unit, , can be seen , thermodynamically, as a energy input to the function. However in MAXergy we don't count labor. The arguing is that a human being , even if he would not make his or hers energy available, still requires energy input, like food (and land for this) , and degrades energy just for " living" or basic operation.
Excluding labor from the calculation does not imply it cant be useful, to the contrary, its a very sustainable energy source, the more since it requires energy anyway regardless the output.
It just does not belong to the a function-analyses that is developed to serve *that same human being.*

By not counting this, however, its becomes even a more sustainable source, since the more labor input the less " external energy and mass input is required.
It can be seen as a arbitrary decision, since there are some flaws: theoretically, and purely thermodynamically, this could lead to the " production of children" as free energy source...
(the slavery model from the past)
On a small scale it can however be neglected. And without mankind, there was anyhow no demand for impact assessment of functions serving mankind . The factual existence of mankind, and the continuation of the species, is a given fact, without which there would be no question ie demand at all.

Converting to Embodied Land.
The findings in energy and mass from the 1st and 2nd level (or 3rd and 4th) have to be converted to Embodied Land to become part of one integrated evaluation. Sometimes this can be done directly sometimes indirectly.
Its obvious that trees grow in forests, and that there is a certain production per hectare. The Embodied Land is directly derived from this. It could be that there are apparent losses between forest and function (direct losses, not extra energy or materialinput) Like for instance sawing losses (sawdust). It has been chosen to calculate directly in end product per hectare, (so including losses) in stead of hectare production times a loss factor.
There is however situations that a conversion should be applied. For instance when certain raw materials are produced in green houses: Greenhouses have a Embodied Land impact as well. And act as a energy conversion technology with incorporated losses. This could require the introduction of a factor which we call g: and the EL of factor g should be added to the process. (Similar as a PV panel acts as a intermediate between direct solar energy and end product.)
We have not detailed the *factor g* here, since its not relevant in this stage of development and not for buildings so far. But methodologically it should be mentioned, just as the next one.

<u>Factor f</u>
In the case there is no direct land impact, but only energy impacts involved, directly in the processing, or indirectly to restore a resource (requiring energy to (re-)collect molecules) , it requires a conversion step to recalculate final energy into required Solar input. This involves a conversion system, which has land impact (dolar energy comes in density/m2) It could be a piece

of land which houses a forest, the yield in biomass which can be used as fuel for electricity generation can be expressed in Land, or in the from of land occupied for solar PV panels, required to convert radiation in electricity. In the Closing Cycles Calculation Tool based on MAXergy its chosen to use PV panels as the conversion technology.
For this the factor f is introduced: to convert form final demand to solar input: " X MJ of demand require Y m2 of solar panels " In the Netherlands 1 m2 of multi crystalline PV panel produces 432 MJ/year. The factor f, via the PV route is multiplying the demand by 1/432 . f=1/x
However, also for the factor f , the conversion, there is a level approach applicable: The panels converting the solar radiation, will have to be produced : so in order to produce 432 MJ by 1 m2, it requires 2nd level input of a panel production. Etc.
Currently we have not yet defined 2nd and 3rd levels for the factor f. This is still a methodological discussion. For the calculation tool regarding factor f we use 1st level only: being the m2 (PV panels) required to produce the restoring energy. As soon as we have figured this out , it will be published here.
(is 2nd order in case of factor f in Pv-panels, the embodied energy of the panel, or the total EL of the panel, or is that 3rd level? The question for PV panels could be solved, but when using another conversion route like biomass, main discussion points arise:to be discussed and solved)

recycling
There is two ways to address recycling: From the users perspective and from the resources systems borders perspective. From the users perspective: its does not make any difference where the resource originates from: A mine or forest is just the same as a waste dump: just a collection of resources to use. Whether a copper pipe comes from the waste heap or out of a ore mining process, is not so relevant.
In what in daily practice is called re-use or recycling, the materials comes from a kind of waste heap, either organized (a building to demolish) or unorganized , the dumpsite . Fot the EL calculation it implies a re-used copper pipe is a resource with a somewhat lower process related Embodied Land, the step from ore to copper for instance is avoided. Nevertheless, also for a material from a waste heap the Circular energy required to re-store resources applies: Its just another starting point for the entropy process.

However, its different when starting from a resource system perspective. Which is the essential starting point for MAXergy: Maintaining exergy quality in the system (and avoiding entropy growth or slowing down entropy growth).
The copper pipe, also from the waste heap, is a resource that has been already part of of entropy increasing process: copper pipes don't grow in nature, and there has been exergy invested in the pipe form. Which most likely has not been compensated (in restoring the copper concentrations in the mining area) , and therefore still embodies/carries a impact load. (if compensated, it would of course be free of impact)

Which implies that using a copper pipe from a waste heap, can only be seen s prolonged use from formerly invested exergy. Implying that the impact is only spread over a longer period compared to using a new produced copper pipe. (In fact , its should be noted here, closed loops do not exist, since time proceeds Time passes and and a resource once used, degrades over time. Recycling are just moments in that time flow where energy and resources are invested to slow down or restore degradation, and prolong use.)
If it would ne known how long the recycled product hs been in use before the salvation from the waste heap, it would be possible to calculate a reduction factor for its re-use (time related, EL in m2-year). See the example in th xls file. If the time of previous use is unknown, its should be counted as new material (since its might have tworn away without previous use).

to be continued

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