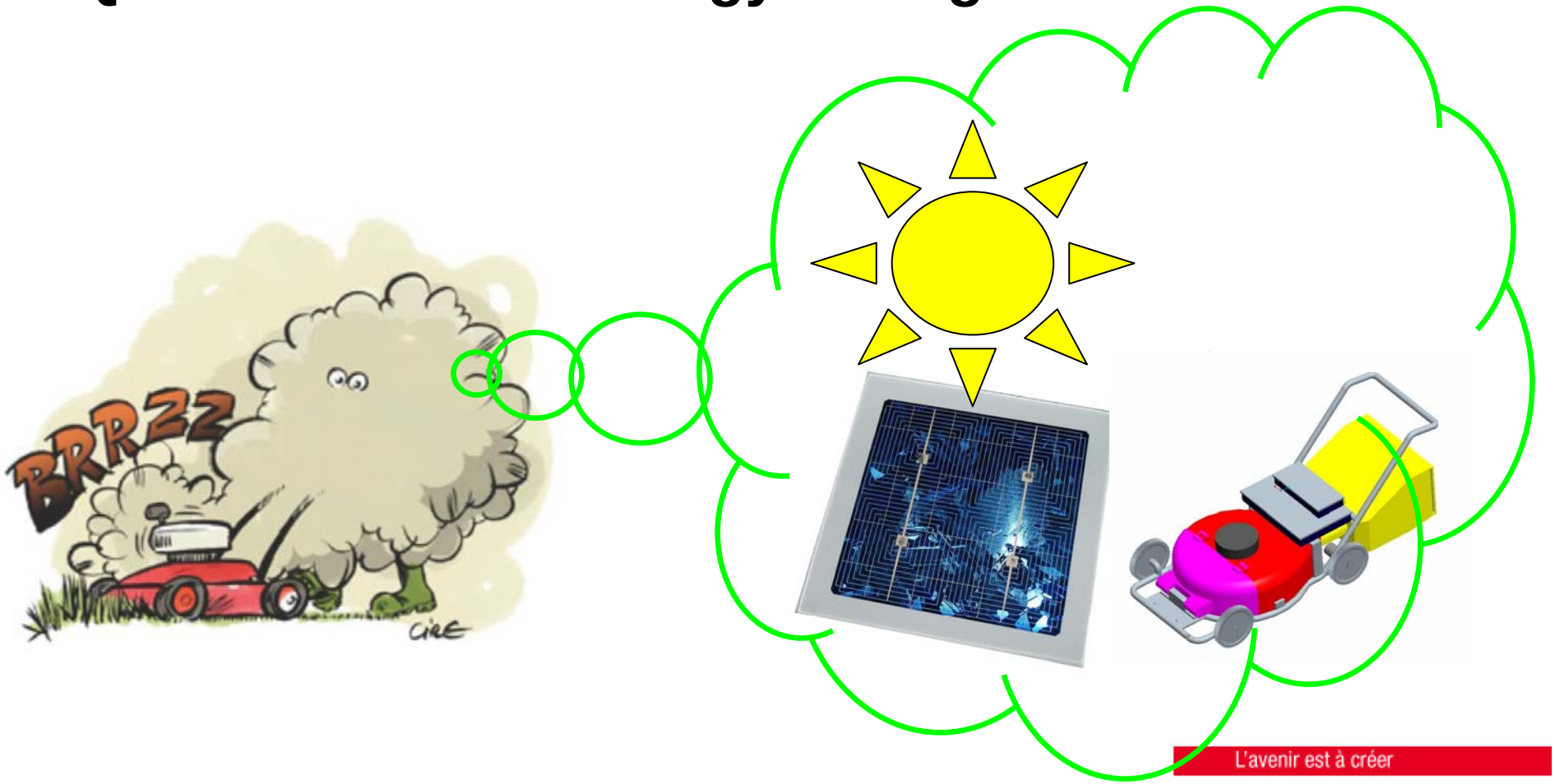
What can be learned by an exercise of eco design of solar lawn mower?
Questions about energy storage with batteries.



Hes·so Genève
Haute Ecole Spécialisée de Suisse occidentale

L'avenir est à créer

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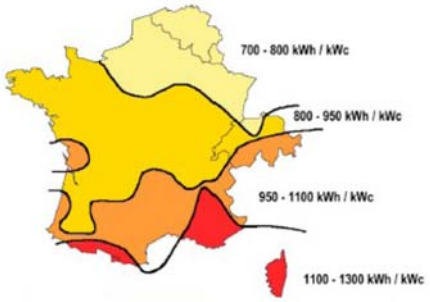
Haute école du paysage, d'ingénierie et d'architecture de Genève

Solar lawn mower specifications

The basic idea of this lawn mower using 100% renewable energy was, for typical private consumer.

- mow 1000 – 1500 m2 lawn ~ once a week
- 4 KW
- Self towed



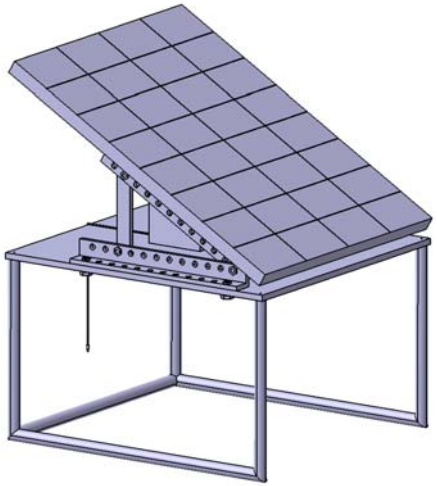
Rayonnement global journalier mesuré à Paris sous différentes expositions

Lawn growth rate is well correlated to solar energy input

=> It is needed to mow the lawn 16-20 times in a year from April to October

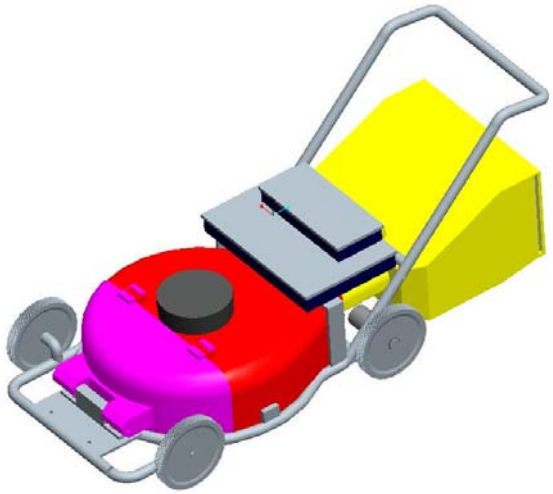
Solar lawn mower concept:

1.5 m2 photovoltaic cell (multi-Si)



15 kg Li-Io batteries

General assembly



Eco design exercise
Student: Gizem CAN, Jérémy GRANDJEAN, Victor NGUYEN, Maxime PRAZ, Pedro SANCHEZ, Sylvain TOZZINI

Solar lawn mower comparative LCA :

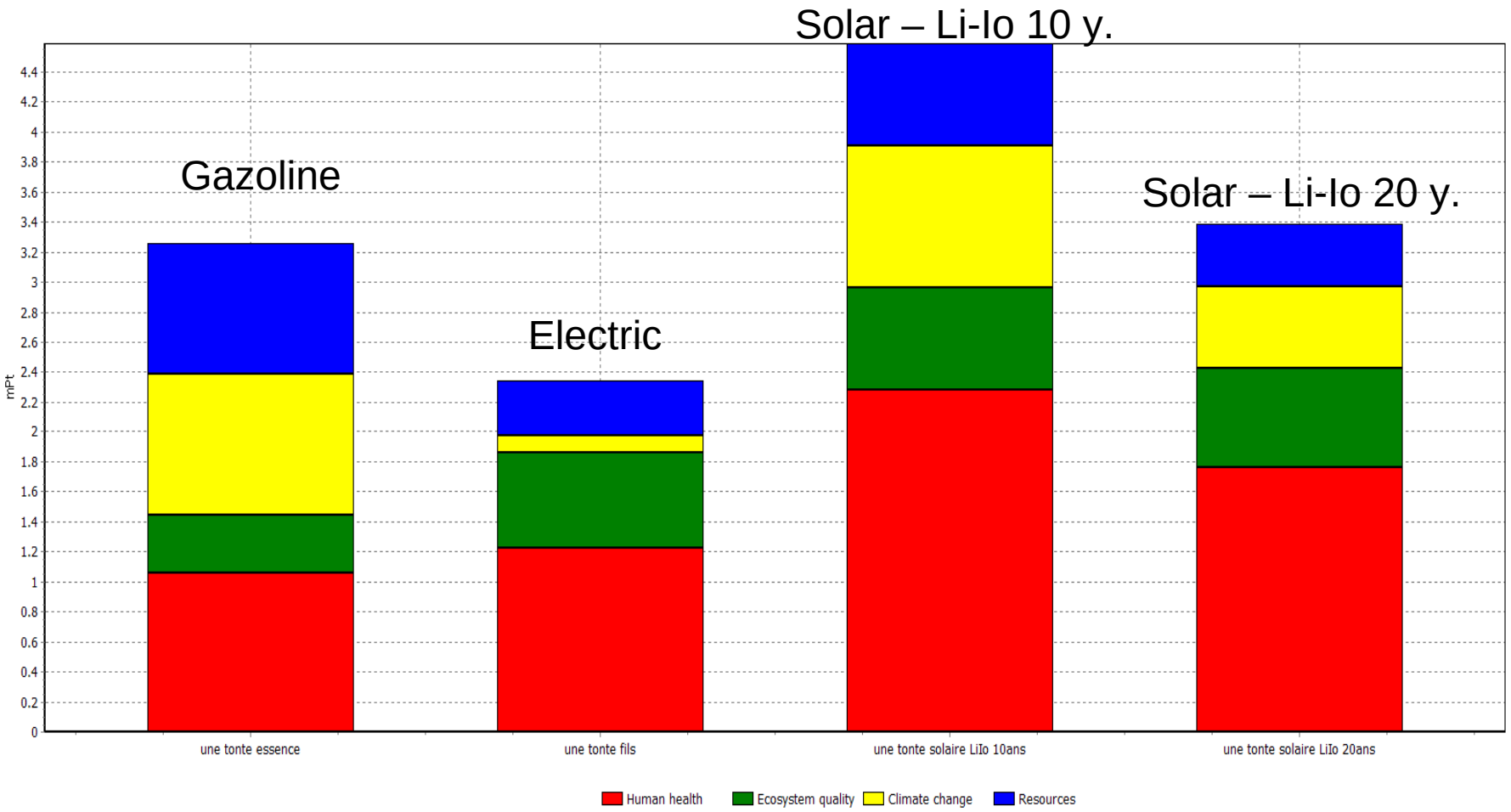
Scenarios considered for comparison:

- Gasoline lawn mower (~ 3 l / lawn mow)
- Electric lawn mower (6.75 kWh CH electricity)
- Solar lawn mower
  - Li-Io batteries 10 years longevity
  - Li-Io batteries 20 years longevity

LCA model with:

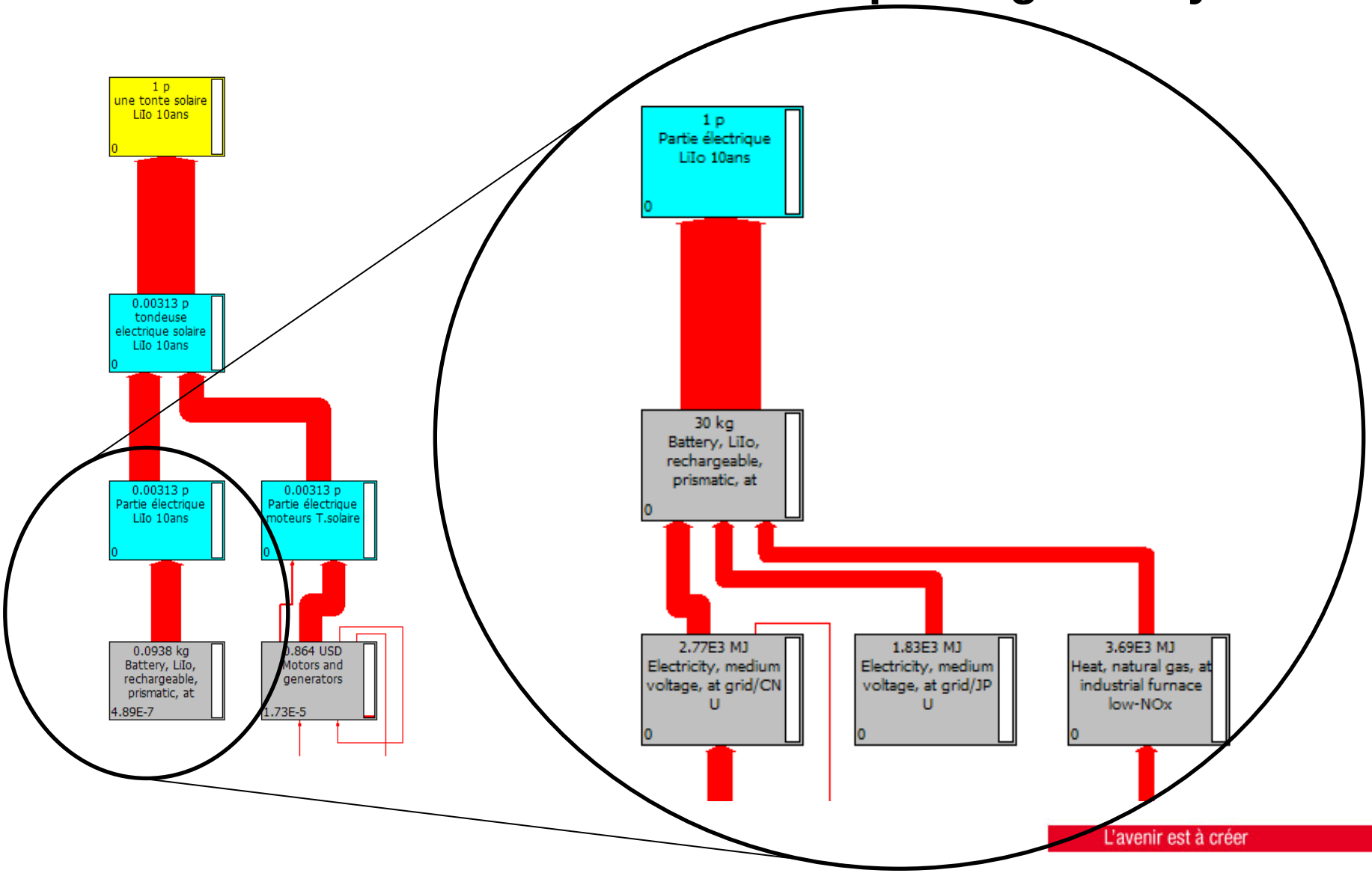
SIMAPRO / Data from ECOINVENT + USA input-output database / IMPACT2002+

Solar lawn mower comparative LCA score:



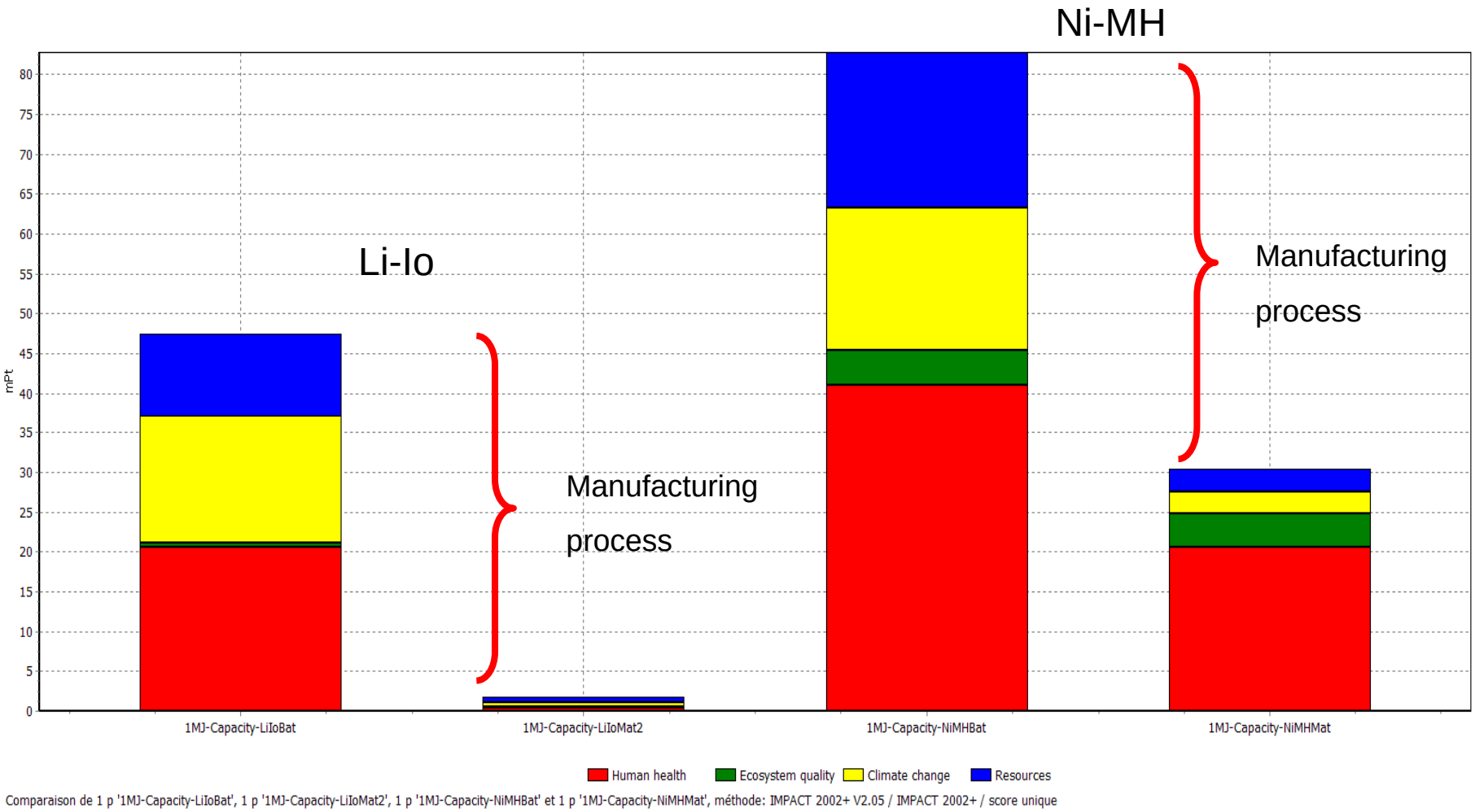
Comparaison de 1 p 'une tonte essence', 1 p 'une tonte fils', 1 p 'une tonte solaire LiIo 10ans' et 1 p 'une tonte solaire LiIo 20ans', méthode: IMPACT 2002+ V2.05 / IMPACT 2002+ / score unique

Solar lawn mower – Li-Io batteries impacting heavily:



Some Investigation on NiMH & Li-Io batteries

Comparison [battery - material only] to
[battery - including manufacturing process]



Some observations about batteries

Li-Io (as well as NiMH) batteries manufacturing process need much energy (electricity from China and Japan).

Energetic efficiency ratio :: [manufacturing energy] / [stored energy]

- ECOINVENT document (Li-Io batteries for labtop):
  - E-ratio = 736 [MJ manuf /MJ]
  - E-ratio 2220 [MJ nre /MJ]
- JAPAN - Central Research Institute of Electric Power Industry document (Li-Io batteries for automotive application):
  - E-ratio = 477 [MJ ? /MJ]

Conclusion

- Manufacturing process seems to contribute heavily to environmental impacts.
- Manufacturing “green” batteries from total live cycle point of view is a great challenge and many improvements have to be done.
- LCA is a crucial tool to help to this.
- It is needed to know more about batteries.
- Data base also need to be fulfilled and updated.
- Sill lot of work!

- **Is it the best answer to energy storage problem from the sustainability point of view**

Addendum:

Some questions about batteries

There are many kind of batteries – usually using oxydo-reduction reaction (Pb-PbO, NiCd, NiMH, Li-Io*, Ag-Zn, Ni-NaCl).

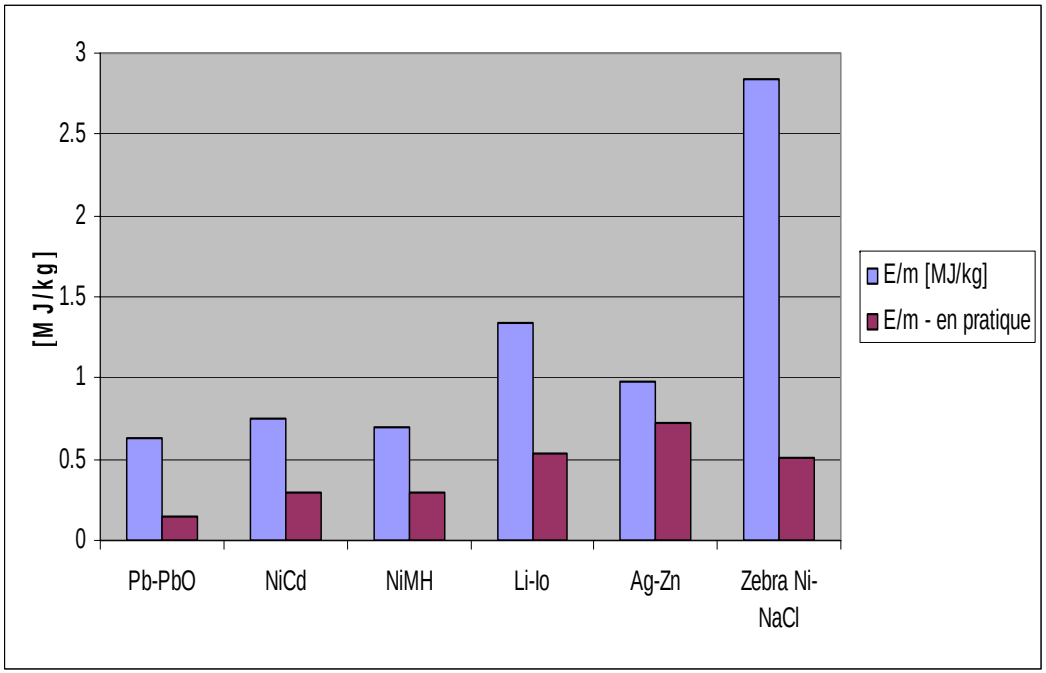
- What is the stored energy dependence from material ?
- What about sustainability according to material ?

*Li-Io uses Li migration trough membrane

Energy massive density of Pb-PbO, NiCd, NiMH, Li-Io, Ag-Zn, Ni-NaCl batteries

E/m (Energy massive density) :: [mass chemical elements] / [stored energy]

Comparison of theoretical E/m with E/m in practice



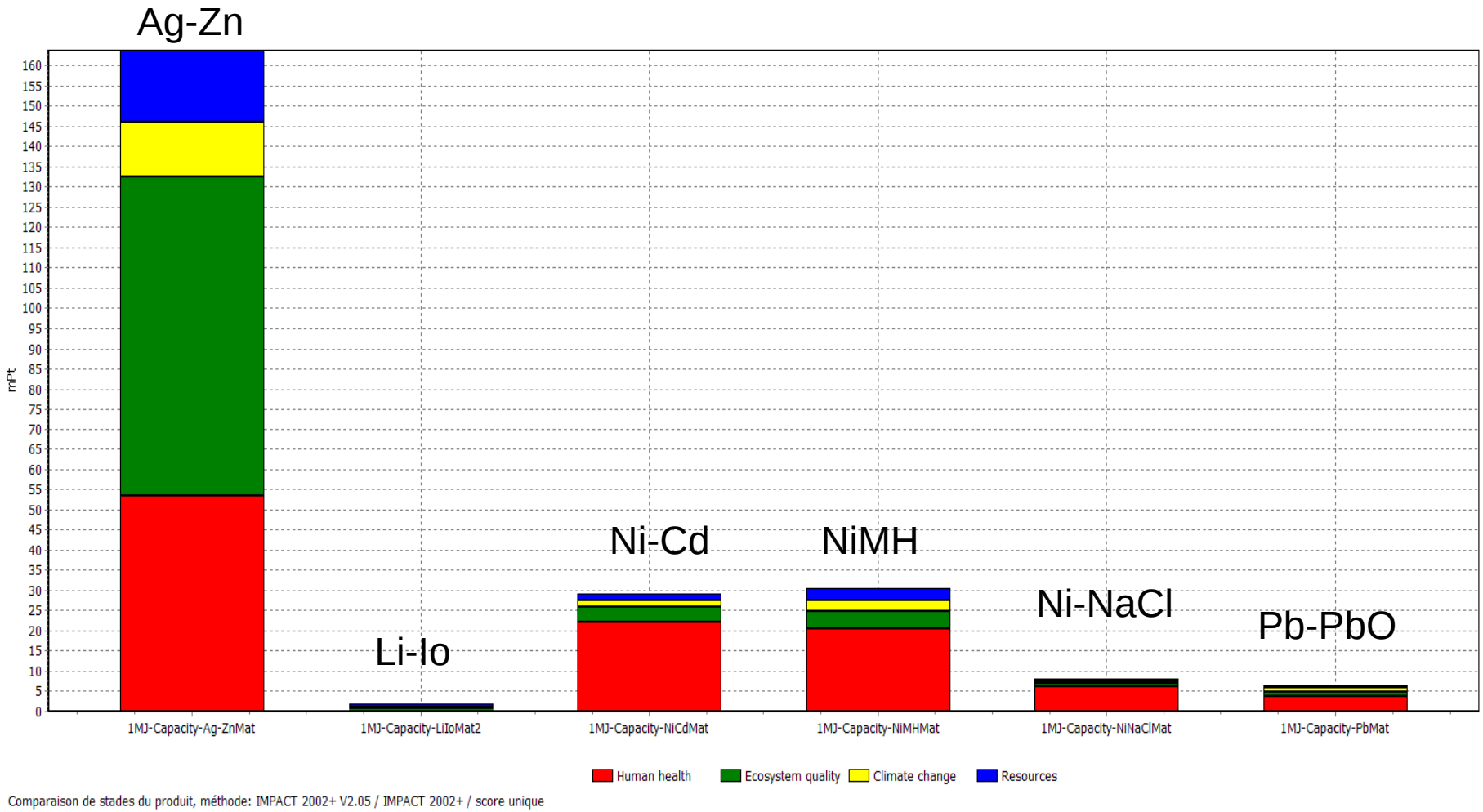
Li-Io, Ag-Zn, Ni-NaCl are the “best in class”.

Difference of “theoretical E/m” with “E/m in practice” related to the ratio [active surface] / [supporting structure]

Sustainability according to material of Pb-PbO, NiCd, NiMH, Li-Io, Ag-Zn, Ni-NaCl batteries

Sustainability according to material only (no manuf. ; no disposal)

- UF = 1 MJ storage capacity (with practical E/m)



Conclusion about addendum

- Li-Io, Ag-Zn, Ni-NaCl have interesting E/m ratio
- Ag-Zn already close to theoretical limit E/m ratio
- Ag-Zn sustainability is catastrophic due to Ag
- Li-Io and Ni-NaCl are interesting field to develop from sustainability point of view

- But:
- Manufacturing process of Li-Io should be optimized
- (Manufacturing process of Ni-NaCl unknown)

Thanks for attention

More information?

- **www.hepia.ch**
- **www.hes-imec.ch**

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