CHEMICAL STORAGE FOR ELECTRICITY SURPLUS – A COMPLEMENTARY POSSIBILITY OF PHYSICAL STORAGE?

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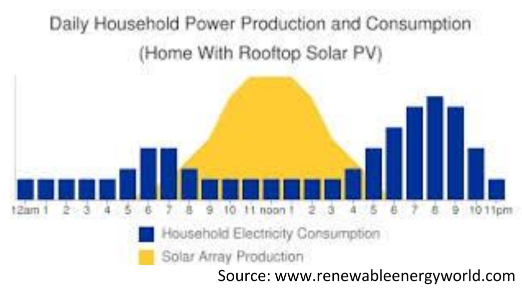
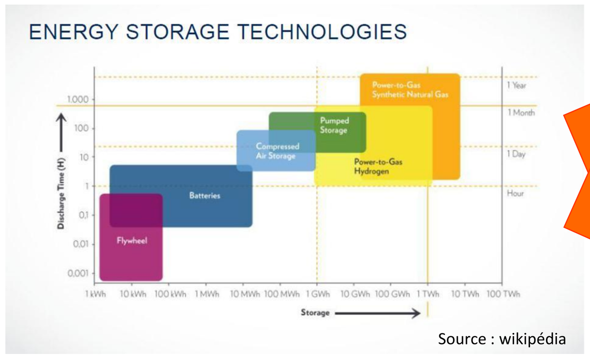
Introduction

The increase of renewable sources for electricity production has induced several problems in terms of electricity management. The major problem is the intermittency of electricity production which is not systematically consumed at the same time of its production.

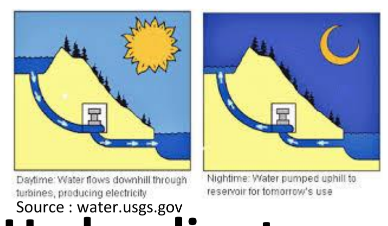
Increase of renewable energy production



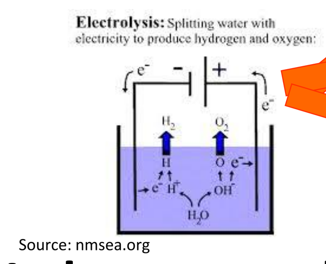
Increase of intermittency



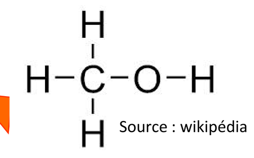
Needs of storage



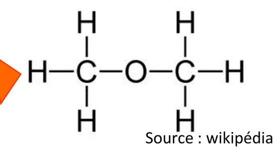
Hydraulic storage



Hydrogen production



Methanol



Dimethylether (DME)

Synthetic Natural Gas (SNG)

Materials and Methods

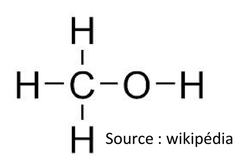
Goal definition

The aim of this study is to evaluate, from an environmental point of view, the potential of chemicals production using biomass and hydrogen obtained thanks to excess electricity. The question to be answered is: "What is the best chemical to produce from an environmental point of view, using exceeded electricity from wind power?".

Electricity from wind power

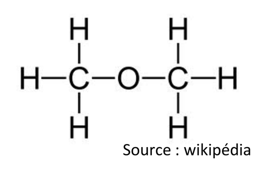
Production of hydrogen

Wood pellets



Methanol

vs.



DME

vs.

SNG

Methods

Life Cycle Assessment methodology has been performed in accordance with ISO Standards 14040 [1] and 14044 [2] and ReCiPe 2008 [3] method at midpoint level has been chosen to evaluate environmental impacts of each scenario. Figure 1 presents common steps for chemical production scenarios. Steps relative to use or end-of-life are not included. Two systems have been modelled for each product i.e. the gasification of biomass with H_2 produced thanks to excess electricity or without H_2. Modelling of each production scheme has been performed for each chemical using Aspen software.

Biomass → Gasification → Gas cleaning → Chemical Synthesis → Purification → **Final product**

Figure 1. System boundaries for chemicals production

Results and Discussion

Main results

Results relative to the comparison between production processes with or without H_2 are presented in Figure 2. The second part of this study is the comparison between products. The production of each chemical, using biomass gasification and H_2, has been compared in Figure 3 for climate change, human toxicity and acidification categories. As it is not relevant to compare these three products at a mass level, a same energy unit has been used.

Main results of this study are summarized below:

- Concerning processes with or without H_2
  - Gasification step, including the use of biomass assumed to be wood pellets, leads to the highest part of the impact, in each category for methanol production without external addition of H_2. This impact is mainly due to the preparation of wood pellets using electricity.
  - When H_2 is used during the process, the amount of required biomass diminishes and allows a reduction of GHG emissions and fossil fuel consumptions.
- Concerning chemicals comparison
  - For human toxicity and climate change, the best score is obtained by SNG. It allows a reduction of 20% for GHG emissions and around 10% for human toxicity impact.
  - Terrestrial acidification results for SNG are explained by the emissions modelled during the process.

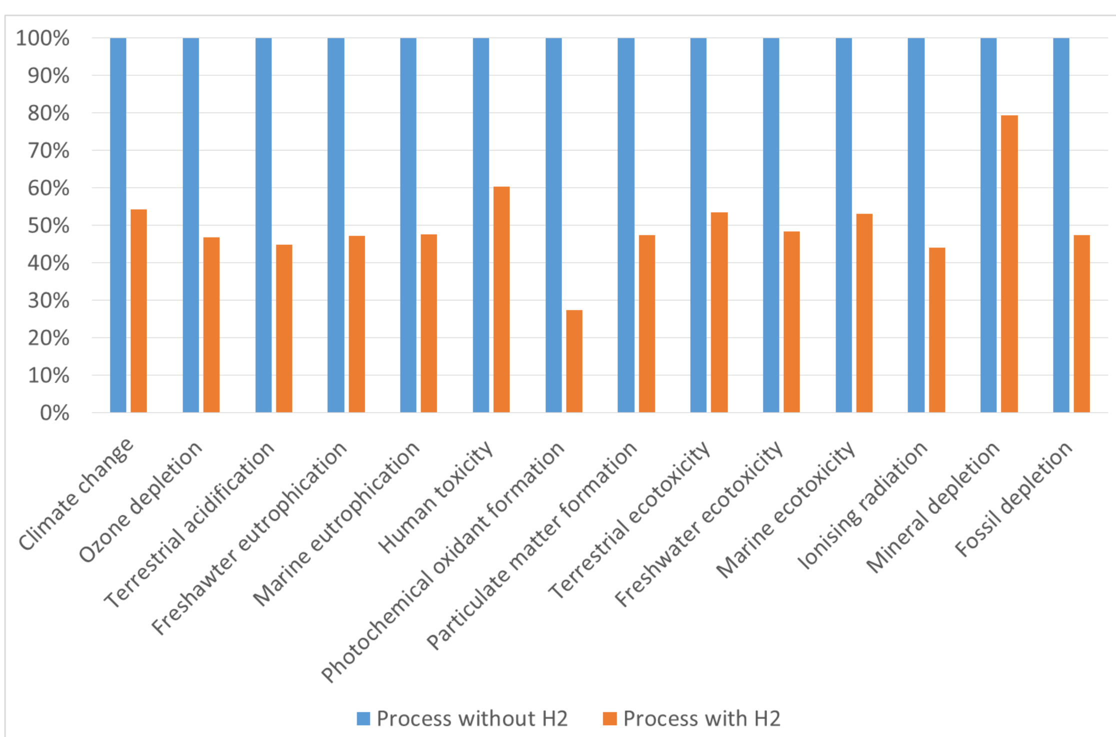


Figure 2: Comparison between both production processes of methanol: without or with H_2

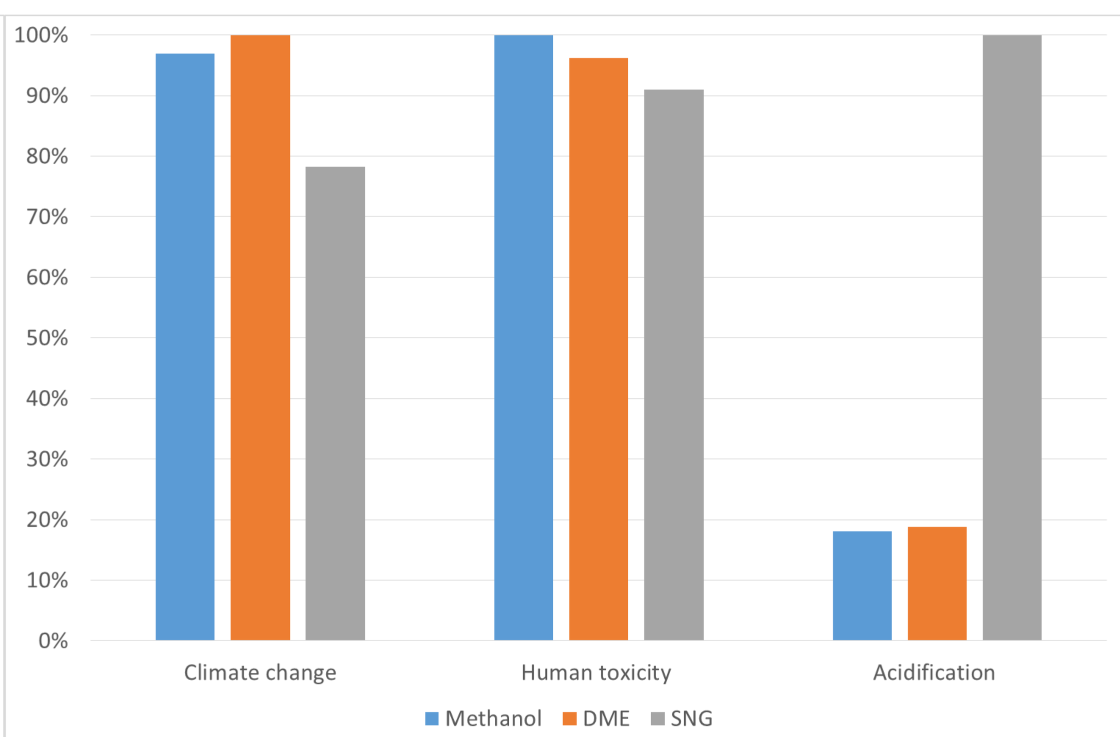


Figure 3: Comparison between Methanol, DME and SNG on an energy basis

Conclusions

This study highlights the environmental impacts of energy storage through chemicals production. The impact is mainly due to the gasification step and more specifically to wood pellets production. Use of H_2 produced in a green process allows a high impact reduction in every category. It increases the yield and decreases the amount of biomass needed. More specific details about this use should be obtained to get more accurate results. This production pathway using renewable H_2 should be compared to the classical way, using fossil fuels. .

References

[1] International Standardization Organization, ISO 14040 : Management environnemental - Analyse du cycle de vie - Principes et cadre. 2006, ISO.
[2] International Standardization Organization, ISO 14044 : Management environnemental - Analyse du cycle de vie - Exigences et lignes directrices. 2006, ISO.
[3] Goedkoop, M., et al., ReCiPe 2008 - A life cycle impact assessment method which comprises harmonised category indicators at the midpoint and the endpoint level, Ruimte en Milieu, Editor. 2009.

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