CONSEQUENTIAL LIFE CYCLE ASSESSMENT OF END-OF-LIFE WOOD PARTICLEBOARDS MANAGEMENT SYSTEM FOR PUBLIC POLICY-MAKING SUPPORT

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Keywords: Consequential LCA; Policy-making; Wood resources; End of life management

ABSTRACT

At the European level an important stock of particleboards (PB) from end-of-life furniture is currently managed without considering its potential as secondary resource. In France the Grenelle 2 policy recently introduced the principle of "extended producer responsibility", which fostered public policy to reorganize management of end-of-life PB. The ADEME (French EPA) has commissioned a study to assess the current management system and to propose alternatives. In order to assess these alternatives from an environmental point of view, a Consequential Life Cycle Assessment (cLCA) of several prospective scenarios was carried out. Results demonstrated the added-value of assessing the environmental impacts of a global management system in the associated macro-economic environment, and the importance of a precise definition of the policy context.

INTRODUCTION

An increasing demand for wood resources is observed on the market worldwide, inducing a global rise of the extracted volume of wood. The increased demand results from local incentives for GreenHouse Gas (GHG) emissions reduction and from the development of biomass energy including wood. The increased demand for wooden based products such as household and professional furniture, due to societal factors (e.g. shorter replacement cycles before the existing furniture is worn out, increasing demand for a wider variety of products than in the past) is an important driver as well (International Trade Centre UNCTAD/WTO and International Tropical Timber Organization, 2005). Due to this pressure, the availability of wood resources for furniture industry is a subject of debate because of the competition with the energy sector. In parallel, an important stock of particleboards (PB) from end-of-life furniture is currently managed without considering its potential as secondary resource. As of 2012, in France the Grenelle 2 policy introduced the principle of "extended producer responsibility" (REP) for the furniture industry, which fostered public policy to reorganize and improve the chains of collection, valorization and treatment of end-of-life PB. The ADEME (French EPA) has commissioned a study to a consortium of scientists and industrial

practitioners aimed to assess the current French PB management system and to propose environmentally-sound alternatives. In order to support the policy-making process steering the strategic evolution of the PB management system, Steelcase, leader in eco-designed professional furniture, and CRP Henri Tudor have carried out a consequential LCA (cLCA) of several prospective policy scenarios, in combination with an attributional LCA (aLCA) of the system at status-quo conditions.

MATERIALS AND METHODS

The study addressed two questions. The first one is related to the assessment of potential environmental impacts generated by the average operation of the PB management system, before and after the changes occurring from the implementation of the "extended producer responsibility" principle. The year 2009 was considered as reference, reflecting the existing system operation at status-quo conditions, mainly because of the availability of inventory data regarding the PB stock, collection, valorization and treatment (Lescop et al, 2010). The year 2020 has been chosen as the year reflecting system operation after changes occurred, because of the related political objectives set at the national and European level (e.g. energy and climate "20-20-20" objectives). Status quo situations at the two time horizons were evaluated through aLCA approach (Figure 1). The second question aims at evaluating the environmental consequences generated by the "extended producer responsibility" principle implementation, through a consequential LCA (cLCA) approach (Figure 1).
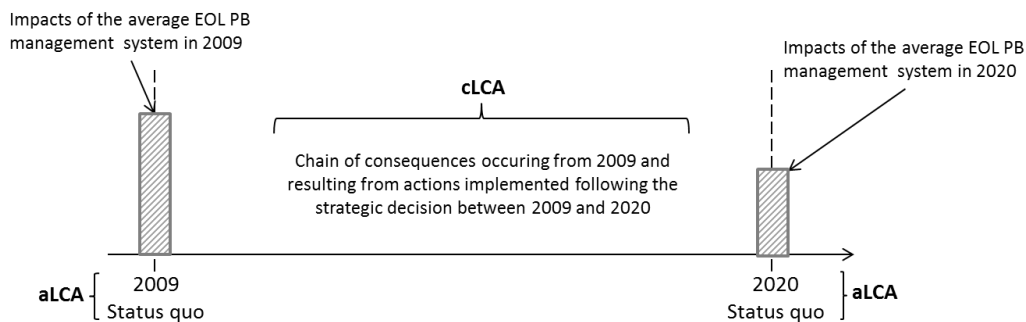

Figure 1: Combination of aLCA and cLCA .

Three prospective scenarios representing different (economic) drivers were considered. The first one (Scenario 1) is based on the EU and French legislation objectives, promoting the recycling of end-of-life PB and reserving the raw wood to the wood energy sector. The second prospective scenario (Scenario 2) takes into account the use of raw wood for PB production and the use of end-of-life PB for energy production. This scenario ultimately depends on the flexibility of regulations regarding waste wood incineration. The last scenario (Scenario 3) is in between the two others, assuming a realistic technical capacity to integrate end-of-life PB in the different treatment technologies considered, based on interviews with experts in the field. For each scenario, the flows of end-of-life PB and treatment technologies – i.e. municipal incineration, energy production in industrial boiler, recycling in PB production, reuse, recycling in cement production and in steel production – were calculated based on accurate analysis of present and prospective regulatory, market, and technical issues. For most of the consequence chains, the scope of cLCA was limited to the direct (first level)

consequences from the implementation of the three scenarios, because of the limited constrains and co-product effects in the foreground life cycle inventory system.

RESULTS

Life cycle impact assessment (LCIA) results for both the attributional and consequential LCA approaches are illustrated in Figure 2.
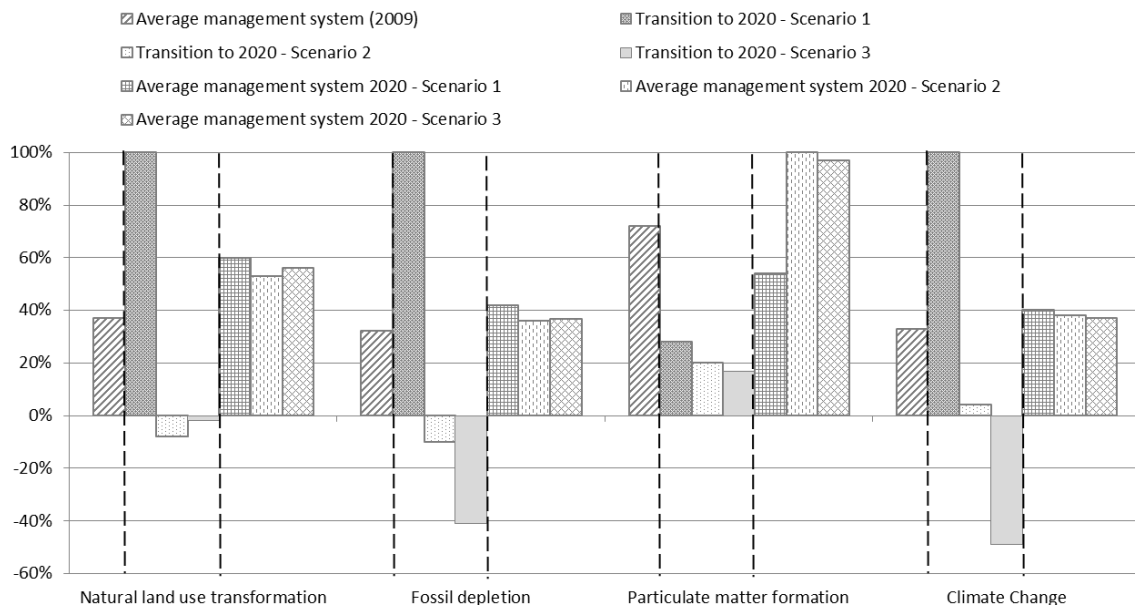

Figure 2: Life Cycle Impact Assessment (LCIA) results

Regarding natural land transformation, assessed using the ReCiPe methodology (Goedkoop et al, 2009), the consequences following scenario 1 are more important than for scenarios 2 and 3. This is due to the higher PB recycling rate of scenario 1 which leads to the replacement of raw wood for PB production and the corresponding avoided impact of natural land transformation. As a consequence, the demand for raw wood from the energy production processes increases (as well as the demand for fossil fuel, supplied by natural gas), in order to substitute the part of PB originally sent to municipal incineration and valorization in industrial boiler. This indirect effect generates an additional impact on natural land transformation. In the case of scenarios 2 and 3, the effect is less important since the demand for raw wood for novel PB production process is not significant compared to the additional demand for energy production processes observed in scenario 1. Regarding the impacts on fossil depletion, using EDIP2003 (Hauschild et al, 1998) and ReCipE, scenarios 2 and 3 show an evident advantage because of valorization of end-of-life PB in energy production processes, replacing fossil fuels. Scenarios 2 and 3 present a larger contribution to particulate matter formation (using ReCiPe) than in Scenario 1, due to the larger amount of PB incinerated in order to produce energy.

Concerning Climate Change, the additional combustion of natural gas in scenario 1 generates a higher impact score than scenarios 2 and 3, which show a significant avoided impact due to the substitution of petroleum coke and natural gas in cement plant. In scenario 3, the valorization of 4% end-of-life PB in steel electric furnace production, replacing anthracite and

pulverized coal, represents an additional significant avoided impact. In order to account for the carbon storage in the PB recycled and reused against the carbon release through PB incineration, the Time Adjusted Warming Potential (TAWP; Kendall, 2012) was used. Time series were considered in order to account for the cumulated biogenic carbon emissions over an observation period 2009-2104, representing the period during which a fraction of end-of-life PB stock from 2009 is kept into the system. The results showed a much more important delay of carbon recirculation in the case of transition scenario 1. The comparison of the environmental impacts from the average operation of end-of-life PB management system following the three 2020-scenarios show the same trends, except for particulate matter formation.

DISCUSSION

Results for Scenario 1 are hampered by the LCA methodological shortcomings regarding the accounting of wood extraction impacts and the regionalised assessment of land transformation. Consequential models for scenarios 2 and 3 should be refined in order to include emissions from the combustion of PB in industrial processes. Also, additional indirect impacts in the chain of consequences should be better investigated, and the geographical area beyond the French boundaries should be extended, in order to account for import/export of raw wood and end-of-life PB. Results have demonstrated the particular interest of transition scenario 1 regarding the recirculation of biogenic carbon stored in PB, and for the amount of raw wood made available for energy production. Transition scenarios 2 and 3 present clear advantages due to the substitution of fossil resources by PB and to the flexibility of energy production processes as compared to recycling, for which infrastructures exist only in a few regions of France. Also, the added-value of assessing the environmental impacts of a global management system in the associated macro-economic environment, beyond the analysis of specific technical barriers, was demonstrated, requiring an accurate definition of the policy context and the involvement of decision-makers.

CONCLUSIONS

The final recommendation is to promote PB recycling, based on the actual capacity of PB manufacturers to use end-of-life PB in the production processes, and to set realistic recycling percentages objectives for 2020, which would not require substantial investments. The potential of PB valorization in cement and steel production should also be explored further although these sectors, especially steel, does not seem to be ready for this transition.

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