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Improving Management of Solid Waste in Buildings

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Abstract
This paper discusses the feasibility of using newspaper discharged in the municipal solid waste (MSW) stream as biomass to produce ethanol. A production yield established in the literature indicates that 1 ton of newspaper has enough cellulose to produce 401 liters of ethanol though the enzymatic hydrolysis process. All paper found in the trash stream of a municipality has a potential to produce 9,452,158 million gallons of ethanol/year. The green building credits to handle construction waste and recyclables in an occupied building are discussed and results of real cases presented, the most recent data composition of the recyclables material found in the MSW is also presented, and suggestions are offered to design facilities in new buildings that will facilitate recycling to its occupants, a construction of a pilot plant to convert newspaper into ethanol is proposed to operate in a university campus environment the commercialization of the process.

Keywords
Biomass, Ethanol, Recyclables, Waste, Green

1. Introduction

The disposal of solid wastes started to be a problem since the time humans first began to congregate in urban areas; the exodus from rural areas into cities increased the population density per area and consequentially increased the need to shelter more people per square foot in one specific location. At the same time that residential and commercial buildings resolved the problem of housing more people per square foot, buildings turn to be a concentrated source of solid waste generation. According to EPA (2008) in the United States the generation of municipal solid waste (MSW) per capita increased from 2.68 lb/day in 1960 into 4.62 lb/day in 2007. At this rate the total amount of generated MSW reached the level of 254.1 million tons/yr. The management of solid waste is a challenge for each municipality.

Usually buildings are not designed to handle their generated solid waste and tax is paid for collection and disposal of their waste. The US Green Building Council-USGBC (2007) addresses the issue of solid waste management by granting points to green building contractors if they recycle the waste generated during building construction and if the building design provides means for the building occupants to perform a waste reduction and adopt a recycling program that will address the separation, collection and storage of materials for recycling or divert it from the landfill. This paper discusses the reasons why the construction industry has a social responsibility in providing sustainable projects by addressing recycling solid waste processes for the building occupants and focusing on the transformation of their solid waste in green energy and the implementation of facilities to facilitate the recycling of paper, glass, plastic, hazard waste, ferrous and aluminum.

2. Search for Green BTUs

The search for renewable fuels is receiving serious considerations from researches in order to replace the use of carbon fossil fuels by green based fuels. Due to the desperate need to find a more economical and clean source of energy the trash in the landfills is becoming a gold mine with possibility to extract green energy from it. After all it is in the landfill and in the municipal waste system that all biomass necessary to generate green fuel arrives and deteriorate, creating a sanitary problem that needs to be managed.

The main issue is to treat the solid waste at the source of its generation and not at the end of its deposit. The generation of valuable biomass that is able to be transformed in fuel starts at the kitchen and at the reading room of each building. In the kitchen the biomass is discharged into the sink trash disposal or in a plastic bag making its recovery difficult. In the reading room they start after reading a newspaper, mail, or any paper and then discharging them into the trash. In terms of cellulose content, which is the best source of biomass to produce ethanol, paper, especially newspaper, these are the solid waste components that have the highest cellulose content rate when compared with other secondary sources of cellulose as listed in Table 1. Then it is obvious that if one can create a system in the building that can handle all paper in a clean way ready to be used as raw material into the production of ethanol, one is generating a solution to reduce the volume of trash in the landfill and at the same time creating a source of income that can be converted to the building occupants in terms of tax credits, sharing the social responsibility to improve/protect environment.

Table 1: Composition of Cellulose and Hemicelluloses Content on Selected Biomass (Source: Sun and Cheng (2002), Pandey *et al.* (2000))

Source	Cellulose (%)	Hemicelluloses (%)
Residues from Sugar cane	33-36	28-30
Residues from Rice	33-37	19-24
Residues from corn	34-36	16-24
Residues from wheat	30-33	22-28
Newspaper	40-45	25-40
Wood	~50	~20

3. Paper Composition in the Trash

Paper and paper board products made up the largest component of the MSW generated. It accounts for 32.7% of the total MSW generated which equals for 83 million tons of paper available to be recovered. Table 2 (EPA, 2008) gives the breakdown of all types of paper in the MSW for year 2007 in the US.

4. From Newspaper into Ethanol

According to Roehr (2001) there are plants in operation in Germany and Russia since 1930's producing ethanol from newspapers. The conversion process is known as enzymatic hydrolyze where cellulose and hemicelluloses are broken before fermentation that will produce ethanol. This process is well documented by Betancur (2005), Sakkas, (2002) and will be not discussed here. According to Murphy and Power (2006) 1ton of newspaper with 8.9 % of moisture can produce 401 litters (144.1 gal.) of ethanol using the process cited above. At this rate using only the percent of newspaper found in the total paper available in the MSW it is possible to produce 1,253,064 thousands gal of ethanol/year. If all paper can be converted into ethanol the volume produced can reach the mark of 9,472,158 thousands gal of ethanol per year. Today 78.6 % of the newspaper found in the MSW is recovered to be reused as

paper, however if a recycled newspaper is selected to be used, the raw material to produce green energy, the aggregate value added to the material will benefit more society and the environment. There are other creative forms to create profit by managing some of the MSW contents, however in terms of quality biomass; paper is placed in the top of the list when trash components are considered.

Table 2: Paper and Paperboard Products in MSW, 2007
(In thousands of tons and percent of generation)

Product Category	Generation	Recovery	%
Newspaper	7,840	6,160	78.6
Inserts	3,140	2,380	75.8
Total Newspapers	10,980	8,540	77.8
Office Papers	6,000	4,310	71.8
Standard Mail	5,910	2,380	40.3
Commercial Printing	6,260	3,590	57.3
Books	1,340	350	26.1
Magazines	2,550	1,010	39.6
Telephone directories	700	140	20.0
Other papers	9,320	Neg.	Neg.
Total paper and paper board	46,060	20,320	47.2
Containers and packaging	39,940	24,920	62.4
Total paper and paperboard	83,000	45,240	54.5

5. Case Study

The California EPA agency, a 25 story 950,000 sf. building claim that they save annually $48,000 in collection and storage of recyclables, $60,000 with the elimination of garbage can liners, $ 29,000 with occupants recycling and $10,000 with reduced landfill disposal costs (USBC, 2006b).

A case study reported by the Urban Environmental Institute (2002) for storage end collection of recyclables indicated a cost/benefit analysis with an annual savings of $3,363.60 in a 28 unit residential building using four cubic yard container for recyclables, 32/ gallon glass container, and 4 cubic yard container for garbage scheduled for weekly service. This saving was possible due to the incentive provided by the City of Seattle offering recycling services to residential buildings free of charge. The only change made in the project of this case was to build a kitchen cabinet with the four dedicated containers to motivate tenant/owner to sort his/her own solid waste and then discharge it in the designated recycling area.

The same study shows a savings of $79,940 by recycling the construction waste generated during construction of a building during a period of 5 years. Contractors report that on average 2.5 pounds of waste is generated per square foot of construction. Using a selected data for disposal costs, one can forecast the potential savings of $64,723that will be able to reach during construction of a 100,000 sf. commercial building.

5.1 Glass

The participation of glass in the MSW increased from 6.7 million tons in 1960 to 13.6 million tons in 2007. The rate of glass generation into the MSW was lower than the rate for paper because glass was displaced by other material as aluminum and plastic. 48.74% of the glass in the MSW comes from beer and soft drink bottles. The recovery of glass containers are used to make new glass containers and have

one more noble recovery that is to produce fiberglass insulation for construction and aggregate for road construction EPA (2008).

5.2 Plastic

The participation of plastic in the MSW increased from 0.39 million tons in 1960 to 30.7 million ton in 2007. The recovery for recycling is low at the level of 6.8% of the plastic generation. PET (polyethylene terephthalate) used for softy drink has the highest level of recovery followed by the HDPE (high density poly ethylene) that is used for milk container EPA (2008). Construction uses plastic films in their constructive process; investigation should be made to see if it is feasible to manufacture construction film using recyclable plastic. This will help to reduce the amount of plastic that ends up in the landfill.

5.3 Metals

The generation of metals in the MSW comes mainly from construction industry however they are not classified as part of the MSW. Iron and steel from appliances furniture and tires are the main composition of the MSW. Aluminum, accounts for 3,350 million ton out of the total of 20,750 million tons of metal found in the MSW (EPA 2008). The recovery of Aluminum is very low (21.8%) when compared with the aluminum recovery on other countries.

6. Green Building Credits

The main goal of the green building concept in terms of the construction waste generated during construction is to divert construction and demolition debris from disposal in landfills and incinerators. If a contractor can divert 50% of its generated debris it will receive 1 credit, if this percentage increases to 75% the contractor is entitled to receive 1 more credit (USGBC, 2006a)

There is another area suggested by USGBC (2007) that is to receive credits for existing buildings, upgrades, operation and maintenance in relation with the solid waste management. A total of 3 credits can be acquired if occupants of the building have a waste and recycling program that address the separation, collection and storage of material for recycling, including at minimum paper, glass, plastic, cardboards, metals, batteries and fluorescent light bulbs that should be diverted from landfill or incineration. One credit is granted if 30% of the total stream is diverted /recycled; one more credit is added if this percentage increase to 40% and one additional credit is granted if the percentage reaches the 50% mark. These implementations require that building designers and architects should address an adequate space and facility to comply with the USGBC requirements.

7. New Design Requirements

Green projects are required to include in the design a dedicated space to storage the recyclables collected by occupants in order to receive credits on occupant recycling section. Architects should include in the kitchen design clean compartments that will facilitate the separation and collection and transportation of the recyclables into the facility storage place. It is implicit that the recycling process generates savings in energy when it is compared with the energy used to manufacture the material. However when a recyclable like paper and paper board products are analyzed in terms of potential energy that they can generate it become the most valuable source of biomass among other recyclables and for this reason it should receive special consideration in design efficient systems to maximize the utilization of this biomass material.

Commercial buildings and institutions that generate large amounts of paper in their waste stream should be equipped with an efficient system to collect, transport and store the volume of paper that is discharged as a trash. The paper separation should have a special treatment to avoid cross contamination with other *components* of the MSW. One suggestion is to incorporate in the building design a special shuttle that will connect all floors of the building, properly designed to deliver the recycled paper into a container that once it reaches capacity that paper can be compacted and stored avoiding humidity in order to be sold as clean biomass for the production of ethanol. The ideal scenario is to have a fermentation and distillation facility to produce ethanol with enough capacity to attend the needs of the community operated by the municipality. In retribution to the clean biomass delivered by the community adequate tax credit should be provided according to the weight or volume of biomass provided. This is a win/win solution to divert paper from the landfill or incinerator once it will generate profit for the waste generators and the generation of a powerful green source of energy ready to be used, after all un gallon of ethanol can supply approximately 76,000 BTU. The environment also will be benefit. The benefits to use paper and cardboard paper as biomass material in place to be used as raw material to manufacture more paper is that it will contribute to decrease the volume of fossil fuels in the energy grid and consequentially generate the benefits associated with a cleaner environment.

8. Advantages of Recycling

According to EPA (2007) there are several advantages in recycling. They are:

1. Reduces methane emissions from landfills. Waste prevention and recycling (including composting) divert organic wastes from landfills, thereby reducing the methane released when these materials decompose.

2. Reduces emissions from incinerators. Recycling and waste prevention allow some materials to be diverted from incinerators and thus reduce greenhouse gas emissions from the combustion of waste.

3. Reduces emissions from energy consumption. Recycling saves energy – because manufacturing goods from recycled materials typically requires less energy than producing goods from virgin materials. Waste prevention is even more effective at saving energy – because when people reuse things or when products are made with less material and/or greater durability, less energy is usually needed to extract, transport, and process raw materials and to manufacture replacement products. What's more, when energy demand decreases, fewer fossil fuels are burned and less carbon dioxide is emitted to the atmosphere.

9. Conclusions

The data collected to identify the components of the MSW indicates that the volume of MSW increases every year. This trend is correlated with the increase of population, construction of new buildings, new packaging materials, and new habits. In the case of paper there is no significant decrease in the amount of paper discharged in the MSW along of the years meaning that the supply of discharged source of biomass will have a trend to increase along of the time.

The data collected in the literature for the production of ethanol from newspaper indicates the results of research at the laboratory level. No data was found in the literature displaying the results of a pilot plant or a commercial facility that uses newspaper as biomass to produce ethanol in the US. The literature informs about existing plants in Germany and Russia, but the process data is not disclosed. For this reason it is recommended to design and build a pilot plant in a university campus by using the paper from the MSW produced by the university, with the results of a pilot plant it will be possible to generate a design to build commercial plants tailored to attend municipalities.

The final conclusion and recommendation is a call for educators to motivate and stimulate competitions among Architecture, Civil, and Construction Management students to develop creative solutions to improve the management of solid waste in buildings. It is time to create a critical mass of thinkers that will understand that sustainability should be a must in all construction projects.

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