

Summary Patent Information

| Patent | Patented Process | Protected Key Innovations | Resulting Key Economic Benefits |
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| 5,407,817 | Ethanol from Garbage | This patent is for a unique process of producing ethanol from garbage utilizing concentrated acid hydrolysis. Recyclables are separated from the garbage, with the bulk of the remaining waste treated with acid to yield sugars. These sugars are then fermented and distilled to produce ethanol. Waste water and sewage is used for processing water. Heavy metals are removed from the waste after a dilute acid pre-treatment. | This patent protects the use of garbage as a "negative" cost feedstock to produce ethanol. This transforms the process economics of garbage/sludge disposal and cellulose-to-ethanol production, providing a significant economic advantage. In traditional ethanol production from corn, up to 85% of production costs are associated with the raw materials. Beneficial use/recycling of 90% of the incoming waste reduces demand for landfill space and incineration, eliminates associated liabilities and costs while reducing overall collection/disposal costs for municipalities |

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| 5,571,703 | Ethanol from Garbage | <p>This patent has several improvements in the methods described in Patent No. 5,407,817. It covers the removal of heavy metals as described above as well as a process which provides for the elimination of the dilute acid pre-treatment and removal of heavy metals after treatment with concentrated acid. Sewage sludge and/or sewage sludge cake is used as a feedstock to improve economics. Also the use of other supplemental organic feedstocks is protected. This patent also involves the use of lignin byproducts, stillage and/or non-chlorinated plastic as fuel energy to further improve economics.</p> | <p>Elimination of the dilute acid pre-treatment eliminates the need for exotic metallurgy which reduces capital costs. Using sludge as a feedstock not only provides a “negative cost” water source, but also improves the energy balance. By extracting water from the waste, fresh water usage is minimized in the process, promoting municipal application. The use of lignin and other byproducts for fuel further enhances the energy and economics.</p> |
| 5,506,123 | Lactic Acid from Garbage | <p>This patent protects the production of lactic acid from garbage and sludge using a process similar to those listed above.</p> | <p>In addition to the benefits mentioned above, lactic acid has a higher unit value than ethanol and has diverse and growing market drivers so revenue can be further enhanced.</p> |
| Patent | Patented Process | Protected Key Innovations | Resulting Key Economic Benefits |
| 5,779,164 | Ethanol from Garbage | <p>This patent provides improvements to the patents listed above with changes in certain temperatures and digestion times. The diluted acid pre-treatment is eliminated with heavy metals removed after the</p> | <p>Elimination of the dilute acid pre-treatment allows for a more robust process while reducing capital and operating costs as described above.</p> |

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| | | waste is treated with concentrated acid. | |
| 5,968,362 | Acid/Sugar Separation Process | This patent protects a specific method for the continuous removal of heavy metals from the process described in the previous patents. Specifically, acid/heavy metal/sugar separation with anionic resin is covered. | The efficient removal of heavy metals provides a key long-term economic advantage. These metals are a significant environmental concern in the disposal of sewage sludge and could inhibit fermentation unless effectively removed. The use of an anionic resin allows the acid to be re-concentrated in a much more economical manner. The specific use of anionic exchange material significantly alters and improves the mass balances. The resulting economic impact is a key to economic sustainability. |
| 5,975,439 | Ethanol from Garbage | This patent protects the production of stillage useful as cattle feed as part of the garbage-to-ethanol process. | Stillage suitable for cattle feed provides another revenue item. |
| 6,267,309 | Ethanol From Garbage | The use of sewage sludge and lignin as fuel is further protected and additional improvements to retention times and temperatures are added. | This method further protects the use of lignin biofuel and certain plastics as additional energy sources, reducing operating costs. |

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| 6,391,204 | Acid/Sugar Separation Process | This patent provides additional improvements to patent 5,968,362 listed above, including the specific use of strong basic anionic exchange material. The separation of the acid/sugar stream uses continuous exchange or exclusion chromatography | The use of continuous chromatography enhances recovery of acid and economics. Acid recovery/re-concentration is a key economic advantage. |
| 6,419,828 | Acid/Sugar Separation Process | This patent incorporates the processes protected above including the use of a simulated moving bed for acid/sugar separation. | The use of a simulated moving bed apparatus allows for the continuous separation of acid and sugar, enhancing acid recovery efficiency and economics. |