Kyoto Protocol-compliant waste-to-renewable energy with zero air, water, and solids pollution

In any waste-to-energy technology, the basic concept is to manage wastes as a valuable resource by creating something useful in its place. Generating electricity seems to satisfy the fundamental idea. Most waste-to-energy technologies, however, also generate the potential for significant air, water, and solids pollution while generating electricity. What is the solution?

Most waste-to-energy technologies are successful only partially because of the residual by-products which remain after the energy is produced. There are, for example, over 50 municipal solid waste-to-energy plants in North America and more than 200 world-wide, mostly in Japan. They operate sequentially by burning municipal solid wastes (MSW) to produce heat. The heat is then used to generate high pressure steam similar to the operation of a steam boiler. The steam is then beneficially used to drive a steam turbine to generate electricity. A steam turbine is similar to a jet engine.

The many gaseous emissions from MSW incineration must be carefully controlled to minimize, and hopefully prevent, the discharge of carcinogenic dioxins, hazardous mercury, acid rain gases [sulfur oxides (SOx), nitrogen oxides (NOx), hydrogen chloride (HCl), and carbon dioxide (CO_2)], vaporized heavy metals, particulate matter, and several other lesser air pollutants. CO_2 is also a harmful greenhouse gas (GHG). Acid rain gases are frequently permitted to be discharged without limitation. The sterile ash remaining within the incinerator contains ferrous and non-ferrous (iron, copper, and aluminum) metals along with other inorganic materials. The metals are separated out for sale. The remaining ash is then transported to a sanitary landfill for disposal.

Operating revenues are generated by MSW tipping fees and marketplace sale of electricity and scrap metals. Because of the high moisture content of MSW, its inherent Btu value is significantly diminished, thereby reducing the overall efficiency of this waste-to-energy technology. Combustion inefficiency coupled with significant air and solids pollution control equipment capital and operational costs makes MSW-to-energy technology but marginally profitable to its owners with continuing significant operational risks to the global environment. The major risks always focus on the existence, performance, and reliability of the associated pollution control equipment that is required to effectively manage the many by-product residuals.

Landfill gas-to-energy is another mature waste-to-energy technology with many hundreds of active projects in North America. The technology is now gaining momentum throughout the world.

That waste-to-energy technologies seem to get their start in North America is quite natural as this is where most wastes are generated. This fact has generated a great environmental awareness in North America of the abject necessity to develop sustainable solutions that address the problem. MSW-to-energy represents a single solution.

Landfill gas-to-energy is but another. Landfills, meanwhile, produce both CH_4 (methane) and CO_2 GHGs due to the continuing anaerobic digestion of MSW. Scientists have determined that CH_4 gas is about 20 times more harmful to the environment than CO_2. Landfill gas-to-energy projects use landfill gas as a fuel to power a combustion engine which drives a generator that makes electricity. In so doing, the CH_4 gas is converted into CO_2. Landfill gas-to-energy technology significantly reduces the harmful effects of GHG emissions but hardly eliminates the problem.

Most wastewater treatment plants it North American municipalities employ biological processes. Biological processes almost always use anaerobic digesters to stabilize the biological solids. Biogas discharged from municipal anaerobic digesters is generally flare wasted similar to the waste gas flare practice at oil refineries.

In the last 25 years many municipalities have begun to install digester biogas-to-energy technology to generate electricity. The biogas generated electricity provides from one-third to one-half of the municipal treatment plant's total electricity requirements using conventional high rate anaerobic digesters.

The European Union (EU) began this practice ahead of North America. The EU has a much stronger appreciation of anaerobic digestion than North America. The only real downside of this waste-to-energy technology is that the fully digested sludge must still be sent to a landfill or used as a feedstock in the production of compost. Applying digested sludge to farm land has been widely practised in the past but this particular disposal method is now under heavy attack by environmenta-lists because of its many residuals.

The three industries that generate more kg of waste per kg of finished product than all other industries are sugar cane milling, pulp and paper manufacturing, and palm oil mills. All three industries use waste biomass to fuel their steam boilers to produce both steam and electricity. All three continue to cause significant air and water pollution. Their biomass-to-energy technology works for routine production but causes significant air pollution damage to the environment.

It is clear that all of these something-to-energy technologies have substantial technical limitations. All are of continuing interest to regulatory agencies and environmentalists alike. None is even remotely close to compliance with Kyoto Protocols. Notwithstanding this environmentally deficient state-of-the-art report, every single one of the above referenced technological deficiencies has been scientifically solved by next generation technology with the very real potential for absolutely phenomenal marketplace results.

MSW-to-energy, for example, is based on incineration technology. Greenpeace and Friends of the Earth effectively and correctly argue there is no place for incineration as it is a polluting process and a waste of valuable materials that can be recycled or reused. Incineration is a dry technology and moisture always retards its efficiency. Anaerobic digestion technology, by comparison, is a wet technology in that significant moisture is always scientifically necessary for its effective application. Anaerobic digestion of MSW is easily capable of producing over twice as much electricity as incineration because of this scientific fact.

The next generation technology approach to MSW-to-energy consists of combining municipal sanitary wastewater with municipal solid wastes for the purpose of anaerobically digesting the combined wastes. By adding reverse osmosis membrane technology, virtually all of the nutrients in the wastes may be beneficially captured in the form of a liquid fertilizer concentrate for sale to the marketplace. Ferrous and non-ferrous metals are still reclaimed and sold as before. Heavy metals end up in the digester solids, which can then be sold to the marketplace as a soil amendment, soil conditioner, or organic fertilizer. Heavy metals are essential micronutrients which greatly benefit soil fertility and associated crop production. CH_4 from the anaerobic digesters is used as a clean fuel to power an internal combustion engine or turbine to generate electricity. The waste heat from the engine or turbine is used to produce high pressure steam. The steam is used to drive a steam turbine to produce even more electricity. Using these two methods simultaneously to generate electricity is called combined cycle power generation.

CO_2 from anaerobic digesters is beneficially used to produce fish food through photosynthesis. The excellent quality reverse osmosis (RO) water may be beneficially used to recharge the municipality's local aquifer or surface water impoundment. For the last 25 years the Los Angeles (Water Factory 21, Orange County, California), has been treating its sanitary wastewater with reverse osmosis to recharge its diminishing groundwater aquifer (see www.ocwd.com/_html/wf21.htms).

It is this same anaerobic digestion of combined municipal and sanitary wastes incorporating RO treatment waste-to-energy technology that can likewise solve major aquifer depletion problems in the EU, India, China, United States, and Mexico City. For example, the massive aqueduct project now underway in China wouldn't even be necessary if the above technology were embraced by communities in northern China. Mexico City is due to run out of its aquifer water within 20 years without a single solution yet in sight. In the United States it has been proposed to pay northern plains irrigation farmers tax money not to farm to retard further depletion of the famous Ogallala Aquifer. The southern half of Florida is undergoing seawater intrusion due to the excessive use of its fresh water aquifer. Unless a marketplace solution is found very soon, a massive investment in desalination equipment will be necessary.

The marine life in the Chesapeake Bay is being destroyed because excessive nutrients are being discharged by many municipal treatment plants. Irrigation farmers in India and the EU are now changing to less water-dependent crops because of diminished groundwater aquifer resources. Less water-dependent crops are also less profitable.

The sugar cane industry provides many seasonable jobs in over 100 countries. White sugar marketplace prices are eroding while governmental subsidies and mill air and water pollution continue to increase. It is today an unhappy worldwide industry at best. In order to return to profitability, the industry will have to produce value-added products, such as white sugar and fuel ethanol, while engaging in plant modernization. These initiatives can positively succeed by anaerobically digesting bagasse rather than using it as a boiler fuel. This change will enable the mill to generate much greater energy only some of which will be required for raw sugar refining and ethanol distillation. There will still be significant electricity left over for sale to the local power grid.

The pulp and paper industry has a different set of problems consisting mostly of high energy costs and significant water and air pollution. This industry also uses organic waste to inefficiently produce steam and electricity for routine operation. By anaerobically digesting its forest product solids, gaseous condensables, and high organic strength liquid wastes each mill may obtain both water and energy independence while generating significant excess electricity for sale to the power grid. Biological treatment can also effectively eliminate the mill's discharge of non-condensable stinky sulfur gases.

The palm oil industry is a third industry that uses residual biomass as boiler fuel to produce steam while generating electricity. All three of these biomass-for-fuel industries can use the same anaerobic digestion coupled with RO treatment to achieve better profitability while eliminating all air and water pollution on a sustainable basis.

The concept of value-added products along with the use of anaerobic digestion coupled with RO treatment also constitutes the scientific basis for food, electricity, fuel, and water independence. All of these grand accomplishments can be achieved at an attractive profit. By engaging in several value-added production activities at a single site, maximum fiscal asset productivity is realized along with maximum production of liquid and solid wastes. By anaerobically digesting these wastes coupled with RO treatment, maximum production of energy and other valuable co-products are also achieved. The economic benefits of these co-products add up to a significant and sustainable operational profit.

Growing and thereafter processing food animals (pigs, beef and dairy cattle, boiler and layer chicken, sheep, goats, fresh fish) when coupled with growing crops to feed them represents a large worldwide industry that generates significant air, water, and solids pollution. As discussed above, all of these solid and liquid wastes may be managed for profit and zero pollution. Additional crops can also be grown and processed if the production farm is large enough. A larger farm can be artificially created by switching from horizontal to vertical or greenhouse farming.

Greenhouse farming can significantly increase crop production by the use of precisely controlled moisture, temperature, light, humidity, crop health, and nutrient conditions. The successful application of inter-cropping can also be beneficially used. Intercropping is the farming practice of simultaneously growing two or more crops in a single soil matrix. All of the solid and liquid wastes associated with these activities are, of course, anaerobically digested to produce CH_4 gas and other valuable co-products while generating a sizeable and sustainable profit. A 50-story greenhouse is capable of producing about 500 times the amount of food per square foot of plan area compared with existing horizontal farming practice. The food independence technology has recently been donated to and accepted by the World Bank and the Food and Agricultural Organization of the United Nations for use in sub-Saharan Africa and South Asia.

The only substantial difference between food and fuel independence technology has to do with the specific crops grown within the greenhouse. If vegetable oil crops are grown, significant biodiesel fuel can be refined from vegetable oil. Biodiesel fuel can be used in diesel engines, as jet fuel, barge, train and ship fuel, and for heating.

In greenhouse farming, exhaust gases from combustion engines or turbine equipment entirely discharged into the greenhouse itself rather than to the environment. Exhaust gases consist of CO_2, oxides of nitrogen (NOx), and water vapor. Crops benefit from increased CO_2 concentrations by increased effectiveness of photo-synthesis. Crops also adsorb NOx beneficially. When generating electricity using CH_4 as the fuel, CO_2 and water are always combustion products in the ratio of 1 mole of CH_4 to 2 moles of H_2O, or 1 gram of CH_4 to 2.25 grams of H_2O. The complete capture of the water component using ordinary dehumidi-fication equipment makes each vegetable oil farming/biodiesel production facility water independent on a sustainable basis. Each 1 MW of generation (24 MWh/day) permits the capture of about 3,200 gallons/day of combustion produced water vapor. The same 1 gram of CH_4 produces 2.75 grams of CO_2 in combustion.

In each application of the anaerobic digestion-to-energy coupled with RO marketplace:

- 100 percent of the energy produced is renewable
- There are zero gaseous emissions to the environment
- There are zero residuals requiring landfill or other disposal
- 100 percent of the CO_2 and NOx gases are beneficially used and none is discharged to the environment
- There is 100 percent compliance with all Kyoto Protocols
- CO_2, NOx, SOx, and renewable energy credits are always generated
- No governmental subsidies or other financial support are necessary for economic viability or sustainability.

Through massive greenhouse farming, biodiesel can be produced at a cost which will enable it to profitably compete against petrodiesel. The electricity generated will have a cost basis less than that produced by coal-fired power plants thereby enabling the electricity to profitably compete against this electricity source. Additionally, since the greenhouses will be built on a distributed basis, distributed gene-ration is always less expensive than central station plant distribution thus further increasing its competitiveness.

All of these wonderful technologies will exhibit a deflationary effect on the economy which translates into splendid news for both consumers and industrial users. All are being marketed worldwide on build-own-operate (BOO) and build-own-operate-transfer (BOOT) bases depending on the business regulations in each use country. All such projects will be financed using non-recourse project financing that will be solicited from worldwide financial markets. Because of the extreme attractiveness of the several characteristics of this next generation technology, little difficulty is anticipated in rapid marketplace acceptance and use of all above described waste-to-renewable energy marketplace applications.

Courtesy: *C.G. (Chuck) Steiner*
President, WaterSmart Environmental, Inc