GREEN TECHNOLOGY

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Summary

In consequence of spiraling global environmental concerns such as global warming, climate change and depleting energy resources, green technology has emerged as an important trend and development in the 21st century. It is believed that the development will lead to global, sustainable and macro-economic powers that impact economics, societies, cultures and way of life in the future. In actual fact, perspectives from

current green technological advancement have indicated prospects of intense innovation and changes in daily life of similar magnitude to the "information explosion" in the 1960s. While predictions on economics and potential outlook for green technology are promising, green technology development must be sustainable, and environmental challenges and growths need to be addressed in a mutually reinforcing manner. Its impacts should be carefully analyzed, taking into consideration both environmental effectiveness and economic efficiency. Thus, the importance of looking for win-win solutions across the entire economy where sustainability and growth can be achieved in a cost-effective manner must be emphasized. This chapter provides an overall perspective of green technology challenges and opportunities in line with global effort and trend towards sustainable development. Emerging green technologies covering a wide spectrum of areas are outlined. Challenges from the perspectives of market, technology, financing and regulatory, as well as opportunities for green technology end users, solution providers, financial investors, regulators, policy-makers and other stakeholders to address challenges and to promote the growth of green technology market are also delineated.

1. An Overview of Green Technologies

Green technology is the application of the environmental science and technology for the development and application of products, equipment and systems to conserve the natural resources and environment, as well as to minimize or mitigate the negative impacts on the environment from human activities. While 'Green Technology' is trendier terminology, it carries meaning no other than 'Clean Technology' or the more traditionally used 'Environmental Technology'. The field of green technology encompasses a continuously evolving group of environmental friendly methods and materials, from techniques for generating non-conventional energy source such as solar power to management tools that help in auditing greenhouse gas emissions. Green technology development must be sustainable, meaning "balancing the fulfillment of human needs with the protection of the natural environment and resources so that these needs can be met not only in the present, but in the indefinite future". Scheme of sustainable development can be fulfilled at the confluence of three key dimensions, viz. environment-social-economic, thus satisfying 'bearable' environment and social impact, 'equitable' social and economic solutions, and 'viable' economic and environmental options.

Conventional green technologies have been applied in the fields of water and wastewater treatment, air pollution control, environmental remediation, waste treatment and management, and energy conservation. The following sections discuss some basic knowledge and applications of green technologies in these fields.

1.1. Water Treatment

Water treatment is the process of removing undesirable chemical, physical and biological contaminants from raw or contaminated water. The purpose is to produce water suitable for a specific application. Water treatment may be designed for a variety of applications, including meeting the requirements of human consumption (potable water), medical and pharmacology, chemical and industrial applications.

The common stages of treatment include pre-chlorination, coagulation and flocculation, sedimentation, filtration, disinfection, post-chlorination and fluoridation (Figure 1). The main purpose of pre-chlorination is to remove odor, taste and smell of raw water in particularly those containing organic substances such as humid acids. Coagulation and flocculation and chemical process that removing fine and suspended solids in the water. The flocculated solids are removed via the sedimentation tank.

Fines particulates that escape the coagulation-flocculation-sedimentation process will be trapped in the downstream sand filter beds. Some modern treatment plants adopt unconventional green technology to increase the filtration efficiency, such as the use of membrane filtration. The water after filtration needs to be disinfected using chlorination to eliminate pathogenic microorganisms such as parasites, bacteria, algae, viruses, fungi. Because of the concern of formation of carcinogenic trihalomethane in drinking water arising from the use of chlorination, more and more treatment plants are switching to ozonation as the disinfection method, albeit ozonation is relatively more expensive in the first and running costs.

As ozone is highly unstable and it reverts to oxygen soon after it is produced, it has no residual disinfection effect as chlorination does. To provide residual disinfection capability, post-chlorination is still being practiced in many treatment plants. To complete the water treatment process, the last step of treatment is fluoridation with an objective of preventing teeth decay of the population.

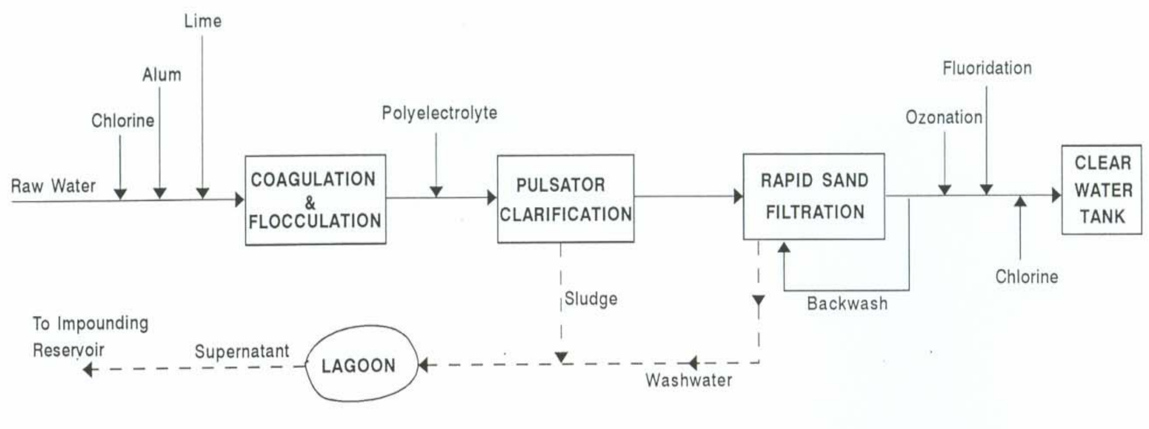

Figure1. Schematic Unit Processes in a Typical Water Treatment Plant

The standards for drinking water quality are typically set by governments or by international standards such as the World Health Organization. It is not possible to tell whether a water sample is of an appropriate quality by visual examination. Chemical analysis, while expensive, is the only way to obtain the information necessary for deciding on the appropriate method of treatment.

According to a 2007 World Health Organization report (WHO 2007), 1.1 billion people lack access to an improved drinking water supply, 88% of the 4 billion annual cases of diarrheal disease are attributed to unsafe water and inadequate sanitation and hygiene, and 1.8 million people die from diarrheal diseases each year.

The WHO estimates that 94% of these diarrheal cases are preventable through modifications to the environment, including access to safe drinking water. Simple green technologies for treating water at home, such as chlorination, filters, and solar disinfection, and storing it in safe containers could save a huge number of lives each year (WHO 2005). It appears that reducing deaths from waterborne diseases is a major public health goal in many developing countries.

1.2. Wastewater Treatment

Wastewater treatment is the process of removing contaminants from wastewater and household sewage, both industrial effluents and domestic. It includes a series of green technologies to remove physical, chemical and biological contaminants with an objective to produce an environmentally-safe treated effluent stream.

The purpose of wastewater treatment is to prevent water pollution of the receiving watercourse. Before discharging wastewater back into the environment, it is necessary to provide some degree of treatment or purification in order to protect public health and environmental quality. This is achieved by wastewater treatment plants designed to:

- reduce dissolved biodegradable organics
- remove most of the suspended solids
- destroy pathogenic microorganisms

When effluents are discharged into sensitive areas which may intermittently suffer eutrophication, they must also comply with nutrient standards. Two additional important parameters are total phosphorus and total nitrogen. Disinfection, usually with chlorine, serves to destroyed most pathogens.

Wastewater treatment processes are often divided into four stages:

- Pre-treatment
- Primary treatment
- Secondary treatment
- Tertiary or advanced treatment

A schematic diagram of a typical wastewater treatment plant is shown in Figure 2. The preliminary and primary treatment processes involve separating the floating and suspended solids from the wastewater. This separation is usually accomplished by screening and sedimentation.

The effluent from primary treatment will usually contain a considerable amount of organic material with a relatively high biochemical oxygen demand (BOD). Secondary treatment involves further treatment of the primary effluent. Removal of the organic matter and the residual suspended material is generally accomplished by biological processes.

The effluent from secondary treatment usually has little BOD. Advanced treatment is used for the removal of dissolved and suspended materials remaining after normal biological treatment when required for water reuse or for the control of eutrophication in receiving waters.

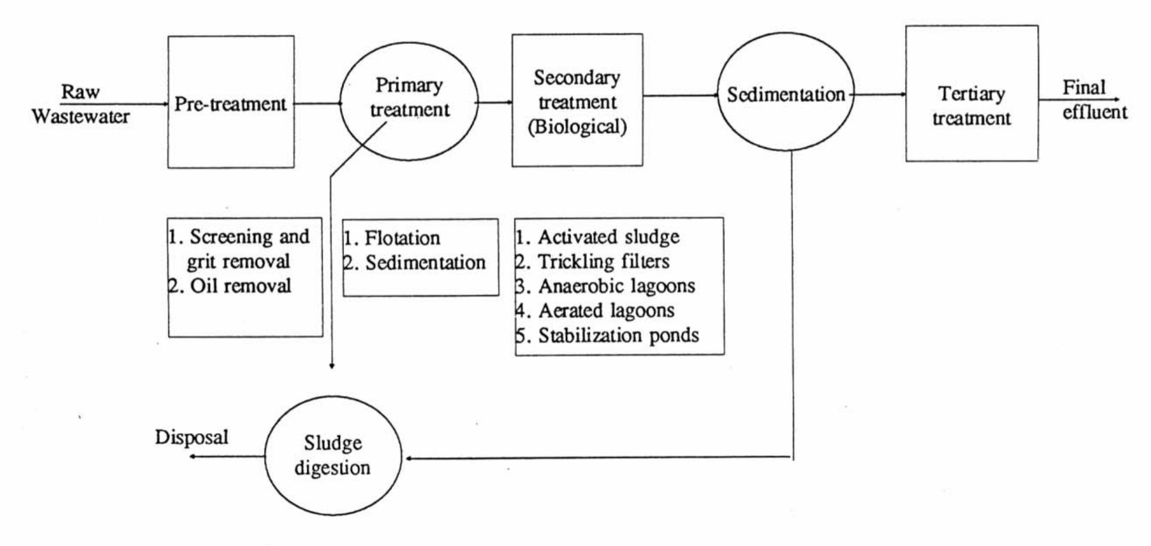

Figure 2. Schematic Flow Diagram of a Typical Wastewater Treatment

The rising cost of water as natural resources and increasing environmental awareness have driven many businesses to deploy green technologies to reduce carbon footprints and to minimize wastewater production. Coupled with an increasing demand for high purity water from other industries, several industries are forced to seek out technological solutions, such as seawater desalination and process/wastewater recycling, to fulfill their water needs (such as seawater desalination, or process/wastewater recycling). Using advanced green technology, it is now possible to reclaim wastewater effluent for reuse purposes including drinking water.

Water scarcity issues have made treated wastewater an attractive source for some industries (for example, livestock watering and irrigation) in some arid areas. Many industries are taking effort and initiatives to reduce production costs by establishing closed-loop recycling systems within the plants. In many cases, the costs associated with production are directly related to the production of ultra-pure water that is used in the manufacturing process. The consensus is that in many instances throughout the process at manufacturing facilities, it is far more beneficial to treat water through recycling of used water. This gives these facilities a water quality that is much higher than a traditional water source. In turn, the reclaim water produces a product quality that is much more enhanced, while in effect curtailing expenses at the manufacturing facility. It is simpler to recycle water with known constituents, such as the process water, than to formulate a plan to produce pure and ultra-pure water from raw groundwater sources.

Efficiency gains and revolutionary technological developments are expected to make recycled water cost-competitive with other water provision options. Advancements in membrane technologies, for example, have increased the potential uses for membranes in treating both process water and wastewater streams achieving both cost and quality competitiveness. As competition intensifies, price cuts will provide some respite to cost-conscious customers and further boost the uptake of water recycling equipment.

1.3. Air Pollution Control

Air pollution is the introduction of chemicals, particulate matter, or biological materials that cause harm or discomfort to humans or other living organisms, or cause damage to the natural environment or built environment, into the atmosphere.

To destroy contaminants or remove them from an exhaust stream before it is emitted into the atmosphere, pollution control devices are commonly used by industry or transportation devices to control particulates, NOx, acid gas/SO_2, volatile organic carbon, mercury, dioxin, furan and other air toxins.

Our concern on air pollution has been escalating. Concentrations of pollutants emitted from many of man's activities arising from urbanization and industrialization thus built up to levels which override those caused by natural phenomena, and are sufficient to have adverse affects on our living environment. Of growing concern is the greenhouse gas emissions which have been identified as the main culprit for global warming and climate change. The greenhouse effect is a phenomenon whereby greenhouse gases create a condition in the upper atmosphere causing a trapping of heat and leading to increased surface and lower troposphere temperatures. Carbon dioxide emissions from combustion of fossil fuels are a main source of greenhouse gas emissions. Other greenhouse gases include methane, hydrofluorocarbons, perfluorocarbons, chlorofluorocarbons, nitrogen oxides, and ozone. This effect has been understood by scientists for about a century, and technological advancements during this period have helped increase the breadth and depth of data relating to the phenomenon. Currently, scientists are exploring new green technology to mitigate greenhouse gas emission such as development of fossil fuels replacement fuels like biofuels, renewable energy, carbon dioxide sequestration and many other ways and means to reduce emission of greenhouse gases.

1.4. Waste Management

Waste management is the purification, consumption, reuse, disposal and treatment of solid waste that is looked after by the government or the ruling bodies of a city/town. The term 'solid waste' usually relates to materials produced by human activity, and is generally undertaken to reduce their effect on health, the environment or aesthetics. Waste management can involve solid, liquid, gaseous or radioactive substances, with different methods and fields of expertise for each. In some instances, green waste management is also carried out to recover resources from it.

Green waste management practices differ for developed and developing nations, for urban and rural areas, and for residential and industrial producers. Management for non-hazardous waste residential and institutional waste in metropolitan areas is usually the responsibility of local government authorities, while management for non-hazardous commercial and industrial waste is usually the responsibility of the generator.

The waste management industry has been slow to adopt new technologies such as Radio Frequency Identification (RFID) tags, GPS and integrated software packages which enable better quality data to be collected without the use of estimation or manual data entry. Technologies like RFID tags are now being used to collect data on presentation rates for curb-side pick-ups which is useful when examining the usage of recycling bins or similar. Benefits of GPS tracking is particularly evident when considering the efficiency of adhoc pick-ups where the collection is done on a consumer request basis. Integrated software packages are useful in aggregating this data for use in optimization of operations for waste collection operations.

Integrated waste management using life cycle analysis attempts to offer the most benign options for green waste management. A number of broad studies have indicated that waste administration, source separation and collection followed by reuse and recycling of the non-organic fraction and energy and compost/fertilizer production of the organic waste fraction via anaerobic digestion to be the favored waste management option. Non-metallic waste resources are not destroyed as with incineration, and can be reused/ recycled in a future resource depleted society.

1.5. Environmental Remediation

Environmental remediation deals with the removal of pollution or contaminants from environmental media such as soil, groundwater, sediment, or surface water for the general protection of human health and the environment or from a Brownfield site intended for redevelopment. Environmental remediation is the removal of pollutants or contaminants for the general protection of the environment. This is accomplished by various chemical, biological, and bulk movement methods, in conjunction with environmental monitoring. Remediation is generally subject to an array of regulatory requirements, and also can be based on assessments of human health and ecological risks where no legislated standards exist or where standards are advisory.

Various remediation technologies have been developed which can be categorized into ex-situ and in-situ methods. Ex-situ methods involve excavation of effected soils and subsequent treatment at the surface, In-situ methods seek to treat the contamination without removing the soils. The more traditional remediation approach consists primarily of soil excavation and disposal to landfill "dig and dump" and groundwater "pump and treat". In situ technologies include Solidification and Stabilization and have been used extensively.

1.6. Energy Efficiency

Energy efficiency refers to the goal of efforts to reduce the amount of energy required to provide products and services. It involves the use of green technologies and devices that require smaller amounts of energy in order to reduce the consumption of electricity. Energy efficiency can be achieved through increased efficient energy use, in conjunction with decreased energy consumption and/or reduced consumption from conventional energy sources.

There are various motivations to improve energy efficiency. Reducing energy use reduces energy costs and may result in a financial cost saving to consumers if the energy savings offset any additional costs of implementing an energy efficient technology. Reducing the use of electricity through energy efficiency causes less fossil fuels to be burned and hence contribute to greenhouse gas emissions mitigation. Energy efficiency can result in increased financial capital, environmental quality, national security, personal security, and human comfort. Individuals and organizations that are direct consumers of energy choose to conserve energy to reduce energy costs and promote economic security. Industrial and commercial users can increase energy use efficiency to maximize profit.

According to the International Energy Agency, improved energy efficiency in buildings, industrial processes and transportation could reduce the world's energy needs in 2050 by one third, and help control global emissions of greenhouse gases (Hebden 2006). Energy efficiency and renewable energy are said to be the *twin pillars* of sustainable energy policy (Prindle et al. 2007). In many countries energy efficiency is also seen to have a national security benefit because it can be used to reduce the level of energy imports from foreign countries and may slow down the rate at which domestic energy resources are depleted.

2. Emerging Green Technologies

For populations to achieve sustainable living on this planet, conventional technologies may no longer able to tackle emerging environmental issues arising from wasteful energy policies, overuse of resources, water supply shortages, climate change, global warming and deforestation. Advancement in science and technology has contributed to the development of emerging green technologies that might help to solve some, if not all, of the environmental issues that we are facing. As we move towards technological advancement, we will be positively affected with the new economy. This section discusses emerging green technologies that will propel our economy in the near future.

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Bibliography

BIAC (2010). “ Technology development and deployment to address green growth challenges”. Business and Industry Advisory Committee to the OECD, 25 Oct 2010, Paris, France, pg 1-4. [A comprehensive discussion of the role of innovation and the spread of technologies in addressing green growth challenges.]

Hebden, S. (2006). "Invest in clean technology says IEA report". Scidev.net. Retrieved 2010-07-16. http://www.scidev.net/en/news/invest-in-clean-technology-says-iea-report.html. [A report describing a series of scenarios showing how key energy technologies can reduce emissions of carbon dioxide, the greenhouse gas which is most responsible for climate change.]

World Health Organization WHO and UNICEF. 2005. *Water for Life: Making it Happen*. ISBN9241562935. [This report charts the effect that lack of drinking water and sanitation has on people’s lives, and looks at a range of interventions that are being advocated and analyses their potential impact on progress towards the target of the Millennium Development Goals (MDGs) for access to safe drinking water and basic sanitation.]

World Health Organization WHO. 2007. *Combating Waterborne Diseases at the Household Level*. Part 1. ISBN9789241595223. [This presents household water treatment approaches and safe storage of water.]

Prindle, B., Eldridge, M., Eckhardt, M., and Frederick, A. (2007) "The Twin Pillars of Sustainable Energy: Synergies between Energy Efficiency and Renewable Energy Technology and Policy". A CEEE Report Number E074, American Council for an Energy-Efficient Economy, Washington D.C. [A report presenting comprehensive discussion of synergies between energy efficiency and renewable energy technology and policy.]

Carberry, E. G. and Hancock, R. S. 2009. The China Greentech Report 2009, MangoStrategy, LLC, Shanghai, China. [Findings summarizing and defining green technology markets, government's regulatory response, green technology solutions and challenges, and green technology opportunities.]

Biographical Sketch

Dr Show Kuan Yeow is currently lecturing as Professor and Chair Professor of the SP Setia Environmental Engineering and Green Technology at the Faculty of Engineering and Science, University Tunku Abdul Rahman, Malaysia. Prior to joining the university in 2007, Dr Show was serving as Associate Professor in the School of Civil and Environmental Engineering, Nanyang Technological University (NTU), Singapore. He was serving as Deputy Director of the Joint National Environmental Agency - NTU Environmental Engineering Research Centre in 2004-2007, and as Deputy Director of LIEN Institute for the Environment, NTU in 2006-2007. Dr Show's expertise includes biohydrogen production from dark fermentation, anaerobic granulation, emission reduction and carbon credit from anaerobic granular processes, ultrasound applications for sludge and wastewater treatment, and novel conversion of sludge and wastes into engineering materials. He has published over 136 technical papers in refereed international journals and conferences, 65 research reports and short courses, 1 book and 1 journal issue editorships, 1 co-authored book and 16 book chapters. He has been awarded one United States Patent 6793822 and one International Patent WO 2003/070649 on a biogranulation technology for wastewater treatment.