APS1012 Management of Innovation – Final Team Projects, Winter 2010

Sustainability through Green Engineering

Objective

With the current energy and environmental crisis, the word "sustainable" attracts a great deal of discussion.

Explore innovations towards sustainability in several fields: Alternative renewable energy sources (wind and solar power); alternative automotive fuels such as hydrogen; bio-membranes for water treatment; and ways to mitigate debris in low earth orbit. Examine each innovation, looking at how they function, the latest breakthroughs, and the potential benefits they bring in terms of sustainability.

Summary

Membrane Filtration Technology

Water shortage has been an ongoing issue for more and more countries. Membrane filtration systems were invented to solve this problem. MF (Micro Filtration) and UF (Ultra Filtration) are designed to treat wastewater. NF (Nano Filtration) and RO (Reverse Osmosis) are designed for drinking water treatment.

Membrane filtration systems have been in the market for almost 30 years and are continuously improving. The membrane filter consists of thousands of pored fibers; different types of membrane filters have different pore sizes. The process for membrane filtration is similar for all types of treatments; chemicals are added to the input water in the coagulant basin and then fed through membranes. Mechanical equipment is used to create pressure for the whole process. Most membranes need to be cleaned once a week, although this is highly dependent on the application.

Membrane filtration technology is definitely considered to be a green engineering product. It treats wastewater to reduce pollution and helps create drinkable water from lake water. Overall, it will help reduce pressure on the world's finite freshwater resources.

Hydrogen Fuel Technology

For more than a hundred years the automobile industry has driven the development and application of advanced technology. Vehicles have become indispensible in society, however they consume significant resources and energy to manufacture and rely on fossil fuels to operate. Sustainable technology can mitigate the large amount of waste and pollution that generated every day through the use of personal and commercial vehicles.

In recent years major companies like Toyota and Honda have demonstrated new vehicles powered by hydrogen. The operation of these cars is possible through a fuel cell that converts hydrogen and oxygen into electricity. The idea of an electric car is not new; General Motors fabricated the first one in 1966, which raises the question of why these vehicles were not developed in larger scale in the past? The answer perhaps lies in the same challenges that are present today: Hydrogen's higher cost relative to regular fuel, lack of hydrogen supply infrastructure, people's mentalities and resistance to change, and competition from well established oil companies and associated political implications.

The full development of this technology will reduce humankind's impact on the environment because hydrogen-fueled vehicles are emission free, the only by-products being water and heat. The use of these cars will decrease dependency on oil reserves. Government research funds and policies are key to encouraging the development of this technology; ultimately it must become affordable and feasible for the masses before it can have a real effect in terms of sustainability.

Innovations in Wind Power Energy

Wind power is the leading form of "alternative" renewable energy, however as with every new technology there are limitations to be addressed. An overview of current turbine-based technology is provided, along with a review of the challenges that wind power generation faces. The world's current and forecasted usage of wind power is presented, along with environmental benefits and public perception factors. Several innovations and breakthroughs that aim to tackle the current challenges faced by turbine-based technology are covered. Global policies towards renewable technologies with focus on wind power are described, with particular attention to the application of wind power in a development framework.

Sustainability in Earth Orbit

Where are we now, after 53 years of exploration of space in the proximity of Earth? Since the launch of Sputnik on October 4, 1957, some 4,600 launches have orbited more than 6,000 satellites. All of these activities have created a cloud of orbiting particles around Earth. This new environment is referred to as space debris or orbital debris. It has been estimated that the total mass of debris in orbit is 5,800 tons.

Most of the space debris population consists of fragments from explosions and collisions, but some are spent rocket stages and satellites that are no longer operational. The primary cause of concern from space debris is physical damage upon impact, and extensive efforts have been made for their detection. Out of an estimated debris population of 600,000 objects larger than 1 cm in diameter, only 19,000 can be tracked as of today.

As mentioned above, only a small fraction of the existing space debris population is detectable and tracked by ground systems. A smaller fraction is catalogued by special programs and/or departments of national space agencies. This is where statistics comes into play. Numerous models have been created in order to assess present collision risks associated with certain orbits and to predict future evolution of the debris environment around Earth.

Space debris mitigation measures are inherently innovative and they address issues in two major areas: protection from space debris and reduction of the space debris population growth. This report presents some current and future approaches in these areas, at the national level, in the United States, Canada, and, at the international level, by the United Nations and the International Organization for Standardization.

Several factors are identified that might delay the adoption of such innovative measures. Risks associated with these measures are grouped into two main categories, operational and re-entry related, and they are most likely to cause resistance from the policy makers. The economic implications are the increased costs of spacecraft and launch vehicles, as well as their operations, and they will generate resistance of adoption from the hardware manufacturers and the satellite operators. Decreased reliability of space systems is a factor that will affect the adoption rate as well.

An important observation to make is that as long as mitigation methods are not imposed upon hardware manufacturers, the early adopters will have a slight disadvantage. Slogans like "True, more expensive, but we are green!" might not do the trick in this case. In order to ensure sustainable space activities for future generations, these issues must be addressed.

Solar Power Management

The Sun is the biggest provider of energy in the entire solar system. Approximately 1/5000 of the energy that reaches our planet would be enough to power all mankind. Considering that other natural resource of energy – especially fossil fuels – will be unable to cover projected demand, human power management has to be focused on renewable energies. In this context the sheer infinite energy emitted by the Sun appears to be the logical solution. But how can we gain this power for our needs and what are the current constraints and problems of this technology?

To achieve sustainability through green engineering by using sunlight, current research and development has to put the emphasis on enhancing the efficiency, availability, reliability and profitability of solar

power management through solar photovoltaic and solar thermal systems. However, technological issues are not the only factors influencing the adoption of solar power to the worldwide energy supply system. As with any innovative problem solving process it is of great importance to achieve public acceptance and resolve people's concerns. In this context the opinion of every customer, the energy consumer, has to be informed and led towards a more reasonable and sustainable way of thinking. Financial and aesthetic aspects are still major obstacles to the customer's acceptance of solar power and therefore they hinder the diffusion of innovation.

It is typically politics and the economy that help people to overcome constraints in their minds. The United States, nowadays the biggest investor in renewable energy systems, provides their population with attractive financial programs in order to achieve a bigger acceptance. Furthermore, especially in the sun-flooded southwestern parts of the country, there is an ongoing record of large investments in new solar power plants.

Technological, economical, political and social improvements are required, along with green engineering initiatives, to establish a sustainable power supply system that takes greater advantage of solar energy.