

17.12: Some Sensible Measures for Sustainability

Some ideas for measures to enhance sustainability are discussed here. Some of these are simple and readily implemented. Others are grandiose and even “far out.” Most have probably been suggested in one form or another by others or have been implemented in some places. Few require the invention of anything new. They are presented here with the idea of stimulating thought and discussion. Probably the reader can suggest other ideas for sustainability. Although most of these ideas are presented from the viewpoint of their potential implementation in the United States, most of them, or closely related measures, could be implemented in other countries as well.

The Methane Energy Economy

The basic idea of the methane energy economy is to greatly increase the role of natural gas as a fuel, particularly for transportation. Methane, CH_4 , is the cleanest burning of the fossil fuels and produces the least greenhouse gas per unit energy generated. Significantly more energy can be stored in a pressurized tank of methane than is the case for elemental hydrogen. Largely regarded as a rapidly depleting source of fuel as recently as the turn of the century (2000), natural gas has emerged as an abundant energy source. There are two major reasons for this abundance. One is a revolutionary development of methods for gas extraction from hydraulically-fractured tight shale formations. These formations, previously inaccessible for natural gas extraction, are widely distributed in many countries including in the U. S. wide areas of Pennsylvania, Arkansas, Louisiana, and Texas (one of the richest deposits lies beneath the city of Fort Worth, Texas). A second factor is the construction of large depots for the export of liquified natural gas from countries that formerly burned it in flares as a waste byproduct of crude oil production. As of 2010 it was projected that the U.S. had 100 years of natural gas reserves and might become an exporter of this fuel.

As depletable underground sources of methane become exhausted, methane can be made by gasification of coal and biomass and the byproduct carbon dioxide from solids gasification converted to methane by reacting CO_2 with hydrogen made from water electrolysis using electricity from renewable sources such as wind. Methane is readily distributed by pipeline, and a system for so doing is already in place in the U.S. and many other nations. Once properly installed underground, a pipeline is a less disruptive, highly reliable, means of transporting energy than is a high-voltage electrical line or transport of liquid fuels by train or barge. An important consideration is that the pipeline infrastructure must be very well designed, constructed, and maintained to avoid destructive blowouts. A very bad natural gas pipeline failure happened on September 9, 2010, with the rupture of a 30-inch natural gas pipeline in San Bruno, California. This devastating incident resulted in an explosion and massive fire that killed 8 people, destroyed 38 houses, damaged many more homes, and left a crater 12 meters deep, 51 m long, and 8 m wide.

Conversion to Highly Efficient Hybrid Vehicles

As noted above, methane is a very sustainable energy source that can replace most existing applications of fossil fuels. One of the most attractive options is to use methane to power locomotives, trucks, and other vehicles. The Clean Air Power Company has designed highly energy-efficient truck engines that get 90% of their energy from methane fed into the engine with intake air and that are ignited by a small amount of diesel fuel injected at the peak of the compression stroke.⁵ This is an application of the stratified-charge ignition concept that enables internal combustion engines to run on a fuel/air mixture that is too lean (fuel-deficient) to ignite with a spark but can be ignited by a small fuel-rich ignition zone created by injecting fuel directly into a small region of the combustion chamber (in a spark-ignited engine directly onto the spark plug).

The ultimate in automobile fuel economy would be a plug-in hybrid vehicle with a natural gas fueled stratified-charge ignition engine (see above). The battery on such a vehicle could be charged by plugging into a source of electricity and with a full charge could be driven several tens of miles distance before the internal combustion engine would need to be engaged. When needed to charge the battery, the internal combustion engine could be run at optimum speeds for comparatively long periods of time for maximum efficiency and minimum pollution. One problem with hybrid vehicles is the need for the internal combustion engine to start immediately in cold weather to provide heat for the vehicle heater. This problem may be overcome with a phase-change material held as a heated liquid in an insulated container and that releases latent heat as it solidifies.⁶

Diverting the Mississippi

In Chapter 8 a scheme was presented to utilize the vast resource of the Mississippi River by diverting part of its flow from the Gulf of Mexico to water-deficient regions of the southwestern U.S. and northern Mexico. The scheme would impound a fraction of the river discharge into a contained wetlands area at the mouth of the river, allow natural processes to purify the water, and use wind

energy to pump the purified water as much as 2000 miles as far as southern California for municipal water supply and irrigation. Major sustainability aspects of this scheme are the following:

- Plant growth in the constructed wetlands impoundment would remove nutrients from the water thereby reducing their discharge into the Gulf of Mexico where they cause a eutrophied “dead zone.”
- Plant biomass harvested from the constructed wetlands could be used for synthetic fuels production.
- River sediment collected in the impoundment would aid in coastal restoration.
- Water transported to arid regions would reduce current excessive demand for water from the Colorado and Rio Grande rivers.
- Fish and freshwater shrimp grown in the waterway and impoundments along its course could provide a significant source of protein

Three Day Per Week Mail Delivery

In the modern electronic age, communication by conventional mail is relatively less important than it was in the pre-computer age. Significant cost and energy savings could be achieved by reducing mail delivery to three days per week, Monday, Wednesday, Friday on some routes and Tuesday, Thursday, Saturday on alternate routes. Such a system would need to be implemented gradually to avoid layoffs of personnel.

Rail Connections to and within All Major Airports

Ground transportation systems to many major airports are cumbersome, slow, and wasteful of time and energy. Each large airport should have an integrated rail system linking terminals to the rail system serving the city and, within the airport area itself, parking areas, car rental locations, hotels and other facilities. Such a totally integrated system would save energy and time and significantly reduce pollution in the airport complex.

Fertilization of Algae Beds with Exhaust Carbon Dioxide

This proposal is to use combustion exhaust gas from powerplant furnaces to enrich algae cultures with carbon dioxide. The efficiency of algal media to sequester carbon dioxide is enhanced by the ability of algae to make media basic in the production of biomass ($\{CH_2O\}$) by the following photosynthesis reaction



Such a system would further purify the exhaust gas by sequestering acid gas, particularly SO_2 , and particulate matter

Nuclear Fuel Reprocessing

Burying spent nuclear fuel in a permanent disposal repository is a wasteful practice inconsistent with the principles of sustainability and green chemistry. A much better practice is to reprocess the spent fuel as explained in the discussion of nuclear energy in Section 15.10. The relatively short-lived fission products can be isolated for burial and will decay to harmless levels within a few centuries. The longer-lived transuranic elements, several of which are useful fissionable fuels can be treated by neutron bombardment, a process called transmutation. As an interim solution, relatively long term storage of spent fuel elements at reactor sites (up to 100 years, for example) enables decay of a very large fraction of the initial radioactivity making it easier to reprocess the fuels. Such long term storage also allows time for the development of improved recycling technologies and breeder reactors that can use spent fuels.

Extraction of Heat from Wastewater

Wastewater is a significant source of heat that can be extracted with a heat pump for heating homes and commercial buildings. The concept involves collecting filtered sewage in a storage tank and pumping heat from the water with a heat pump. Subsequently, the water, cooled by several degrees, can be discharged to the sewer. The same system can be used for cooling in which case heat can be pumped into the water before it is discharged

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