BIOFUELS

Biofuels are liquid fuels produced from plant materials through various chemical processes. They can be used in transportation or in cooking and heating application.

There are many different types of biofuels. The most prominent are listed below:

- Ethanol is now produced from the fermentation of the sugar contained in crops containing sugars, including sugar cane or sweet sorghum, or in the case of crops such as corn and cassava (manioc), the sugars are obtained from conversion of starch. It is mostly produced from sugar cane in Brazil and from corn in the US. Recent technology breakthroughs point toward the possibility of producing 'cellulosic ethanol,' with the break-down of cellulose into constituent materials that include fermentable sugars. Since cellulose is a widely available material present in plants, this technology would expand the list of useful feedstocks for ethanol production. Existing gasoline-fueled vehicles can operate without modification using blends with less than 5% ethanol (typically denoted as 'E5,' with the numeral denoting the percentage of the mixture that is ethanol); relatively small modifications are required for blends up to E25. More substantial adaptations are required for vehicles operating on mixtures in excess of E85. Typically, ethanol-gasoline mixes are available in blends up to E25 or in blends with small amounts of gasoline (E85 to E100). So-called flex-fuel vehicles (FFVs) are available in the U.S. and Brazil that can accommodate both gasoline-ethanol blends and pure ethanol fuels.
- Biodiesel is obtained from the chemical transformation ("transesterification") of vegetable oils (such as palm, soy, mustard and sunflower, among others), animal fats (beef tallow, for example) and new feedstocks, such as jatropha. It can be used in diesel engines either as pure biodiesel (B100) or as a mixture with petroleum-based diesel (for instance B2, which is 2% biodiesel). Existing diesel motors can operate on mixtures containing low admixtures of biodiesel without any special modifications, but vehicles will require minor modifications to operate on mixes containing higher percentages of biodiesel. Biodiesel has a solvent action that actually cleans exposed surfaces, which is helpful but at the same can lead to clogging of filters with the dislodged material.
- While vegetable oils are generally not used as fuel, they can be; lower-quality vegetable oils are being used to this end. Used vegetable oil recovered from restaurants and institutions is increasingly being processed into biodiesel.

Brazil has spearheaded the development of ethanol technologies for several decades using a highly productive sugar cane-based technology. Although it has recently been overtaken by the US as biggest world ethanol producer, more than 50% of the gasoline market in Brazil is based on ethanol. Ethanol in the US is produced mostly from corn. Hundred of ethanol plants have been built throughout the American market.

In part because of the rapid growth of ethanol consumption in the U.S., biofuels have generated significant concerns among policymakers and the public that they may displace food production, causing prices to rise, an impact that would primarily affect the poor, as well as that lands devoted to biofuels production might be taken from smallholders, indigenous groups and other vulnerable populations.

CLEANER PRODUCTION

Cleaner production describes preventive industrial environmental protection projects intended to minimize waste and emissions as well as energy and water consumption while maximizing product output and business profitability. Examples of those measures include reducing process electricity consumption, treating and recycling effluent wastewater and displacing raw material with recycled material.

Cleaner production projects are usually initiated by the use of production assessment tools such as eco-efficiency analysis, life-cycle analysis, or environmental management accounting which allow tracking for process inefficiencies.

There is no typical cleaner production measure since the technologies employed will differ widely depending on the target industry: mines, energy, petroleum, chemicals, agribusiness, recycling, eco-tourism, etc. A sugar cane industry project for instance might encompass the combustion of bagasse in furnaces to produce electricity for the plant as well as a water treatment plant to clean process water before it is released in the environment. A coffee machinery producer might design a new pulp remover, which uses no water and replace toxic copper parts with aluminum parts. The new design allows users (coffee producers) to enhance their environmental performance by reducing water and energy consumption, as well as generation of effluents. The machinery will also be lighter and thus cheaper to transport.

ENERGY EFFICIENCY

Energy efficiency is an umbrella term for a wide variety of measures aimed at conserving energy. Energy efficiency measures target electricity, gas and fuel usage and exist for the residential, industrial, agricultural and commercial sectors.

Examples of typical measures are detailed below:

- residential: compact fluorescent lamps (CFLs), energy efficient refrigerators or air conditioning equipment, plug-load sensors, fuel-fired furnace replacement with high efficiency electric furnace
- industrial: efficient chillers, compressed air systems optimization, variable frequency drives (VFD) (for motors and pumps), high efficiency gas boiler
- agricultural: VFDs for dairy pumps, efficient irrigation systems
- commercial: HVAC system efficiency improvement, fluorescent lights retrofits

Most residential measures (such as replacing incandescent light bulbs with CFLs) are easy to implement while more complex industrial measures such as VFDs or turbine efficiency measures can require the assistance of a specialized energy services company.

From a financial standpoint, a typical energy efficiency measure will bring a stream of steady energy savings that will allow recouping the initial investment. Paybacks vary very widely, with CFLs having a very short payback while double-pane energy efficient windows having a much longer payback.

A key feature of a successful energy efficiency measure is the persistence of the savings overtime. If the equipment can be easily removed (screw-in CFLs, plug-load sensor measures, computer time-out controls) or breaks down before the end of its useful life (refurbished equipment), the savings goal won't be reached and the project profitability will be negatively affected. Equipment repair measures are usually not eligible to avoid subsidizing maintenance issues. The same is true for operational changes that don't require any hardware cost as well as power factor correction and tariff classification changes.

RENEWABLE ENERGY

Biogas

Biogas is produced through the processing ("digestion") of organic material by microorganisms, which results in a mixture of gases including methane (CH_4). Biogas can be produced by feeding energy crops directly into anaerobic digesters or it can be captured from the decomposition that naturally occurs in landfills or in wastewater treatment plants sludge. Typically biogas contains a variety of other materials which may or may result in toxic and hazardous air emissions when combusted, hence local regulations frequently stipulate that these impurities must be removed from the gas prior to combustion, and if the gas is to be sold to a natural gas distribution company, it will require the gas it buys to meet quality criteria before it can be injected into the natural gas network.

Biomass

Biomass projects use plant materials to produce electricity, heat or materials of various types (bio-plastics, glue, etc). The sources of biomass can be very diverse, from energy crops for bio-plastics to wood and saw mill residues for wood pellets used in district heating plants.

Most electricity generated using biomass is produced by direct combustion in boilers. These boilers burn waste wood products generated by the agriculture and wood-processing industries. The boilers produce steam, which is used to spin turbines and generators and produce electricity. Many coal-fired power plants now allow for addition of biomass to their coal in order to lower plant emissions.

Biomass can also be used in district heating or residential heating applications. District heating plants burn wood chips. Residential heating applications entail the use of either a traditional chimney or of a more sophisticated wood insert where air is re-circulated in order to maximize combustion efficiency and to minimize emissions.

The chemical process used for making biofuels can also be used to make antifreeze, plastics, glues, artificial sweeteners, and gel for toothpaste.

Geothermal Energy

Below the Earth's crust, is a layer of hot and molten rock called magma where heat is continually produced from the decay of naturally occurring radioactive materials such as uranium. The amount of heat within 10,000 meters (about 33,000 feet) of Earth's surface contains 50,000 times more energy than all the oil and natural gas resources in the world. Geothermal plants are designed to capture that energy.

The areas with the highest underground temperatures are in regions with active or geologically young volcanoes. These "hot spots" occur mostly at plate boundaries. A major plate boundary stretches on the Western edge of the South American continent, is marked by the Andes mountain range and makes South America a prime geothermal energy production spot. Numerous geothermal facilities have been installed both in Central America and in South America along this plate border to capture geothermal energy.

The most common technique for capturing the energy from geothermal sources is to tap into naturally occurring hydrothermal convection systems where cooler water seeps into Earth's crust, is heated up, and then rises to the surface. When heated water is forced to the surface, it is relatively simple to capture that steam and use it in steam turbines to drive electric generators. Closed-loop systems that reinject water in the ground are usually preferred to open-loop systems that tend to release harmful gases (such as hydrogen sulfide) along with the underground steam. Geothermal projects sometimes include drilling wells to inject water underground but those types of operations present an increased financial risk given the uncertainty of drilling operations and are thought to create mild earthquakes creating problems with local communities. The size of geothermal plants is usually comprised between 20 and 150 MW.

Hydroelectric Energy

Hydroelectric energy has been used for centuries and is adapted to both large and small scale applications. The energy hydroelectric plants draw from rivers is linked to 2 parameters: the flow of the river and the pressure applied on the turbine blades. The higher the dam, the higher the pressure, for that reason big scale dams have received a lot of attention in the past 50 years. However, giant dams require the flooding of entire valleys and the dislocation of local populations. They also adversely impact downstream ecosystems by increasing the water temperature downstream of the dam. Given their reduced size, small-scale hydroelectric plants have less of an adverse impact on ecosystems. They are very well adapted to distributed power schemes that bring power to isolated local communities. Electricity-producing micro-hydro plants can also be combined with industrial mechanical applications (saw mill, etc) which further enhance the profitability of the project. Small-scale hydro plants are divided into 2 categories:

- small dams which create a small scale headpond across the river
- run-of-river plants which exploit the force of the current without disrupting the river flow with a dam

Hydrokinetic Energy

Hydrokinetic energy technologies aim at harnessing waves, tides and current energy as well as converting temperature differences into energy. The field is still in its infancy and a wide variety of technologies is being developed. The different technologies available are described below:

- Wave energy: one of the types of devices include a chamber coupled with a turbine, when an incoming wave fills the chamber with water, the trapped air is released through a turbine, generating electricity; another type captures the up-and-down motions of the waves through floating or immersed devices.
- Tidal energy: practical only in areas with powerful tides. There has seen several commercial-scale projects developed in the past. Past projects have required damming of estuaries, raising environmental concerns.
- Current energy: is a technology under development that harnesses current power through underwater turbines which closely resemble windmills as shown on the picture to the right.
- Ocean thermal energy conversion (OTEC): uses the temperature difference that exists between deep and shallow waters to run a heat engine. The highest the temperature difference, the highest the power produced. Such devices are most adapted to tropical areas.

Solar Energy

Solar energy technology consists in capturing the energy contained in the sun radiation and transforming it into electricity. The energy produced in a given location will depend on the amount of sunlight received at that location over a year. Deserts in low latitude regions receive the highest amount of solar energy when high latitude locations receive much less solar radiation. Averaged over the surface of the Earth, 24 hours per day for a year, each square meter collects the approximate energy equivalent of almost a barrel of oil each year, (4.2 kilowatt-hours/day). Deserts, with very dry air and little cloud cover, receive the most sun (6 kilowatt-hours/day per square meter).

Two main technologies have been developed to capture the energy from the sun:

Photovoltaic (PV). Photovoltaic technology transforms sunlight directly into electricity: when sun rays hit a PV panel, they produce a so-called photoelectrical effect that in turn creates a current that can be fed to the electric grid. Individual PV cells are grouped into panels and arrays of panels that can be used in a wide range of applications. PV panels can be used individually on homes roofs to power individual houses (1-2 kW systems) or by the thousands in large power plants covering many acres (10-20 MW systems). PV panels can be mounted on a tracking system that pivots the mirrors and follows the trajectory of the sun in the sky, or can be mounted on a fixed base in which case they will be oriented so as to maximize solar energy collection (often by tilting the panels vertically and orienting them South or West).

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Concentrated Solar Power (CSP). CSP systems consist of large fields of mirrors and lenses that concentrate the rays of the sun and use them to heat up water and transform it into steam that is in turn fed into a steam turbine that produces electricity. One of the strong points of large scale solar thermal systems is the possibility of storing the sun's heat energy for later use, which allows for production of electricity at night. Properly sized storage systems, commonly consisting of molten salts, can transform a solar plant into a supplier of baseload electricity. Solar thermal systems now in development can reach 100 MW and will soon be able to compete in output and reliability with large coal and nuclear plants. Different CSP technologies have reached the commercial stage:

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- Parabolic troughs: as shown in the picture above, parabolic troughs concentrate the sun's energy on the water contained in a central pipe. This produces steam that is then used to drive turbines and in turn generate electricity.
- Solar tower: a field of mirrors concentrates the sun's energy on a central receiver on top of a massive tower (heights can range from 10 to 100m) as shown on the picture on the left. The heat is used to produce steam that in turn drives turbines and generators.
- Dish Stirling engine: the system is composed of a mirrors dish (several meters in diameter) that tracks the trajectory of the sun. The heat collected is concentrated at the focal point where a Stirling engine is installed that converts heat into electricity.
- Compact Linear Fresnel Reflector (CLFR): very similar to the parabolic troughs technology except that the mirrors are flat with several rows of mirrors reflecting sun rays on one central water-circulating pipe. As in the parabolic troughs system, steam is generated and used to drive turbines to produce electricity.

CSP systems are well adapted for large scale power plant projects connected to the grid. Albeit PV systems are also used in large scale power plant applications they are also well suited for small-scale rooftop-type applications. If the building is connected to the grid, it will be equipped with a net-metering device that will allow supplying (and reselling) some of the power produced back to the grid. For buildings in remote locations that are not connected to the grid, the solar panels are usually coupled to a diesel generator or a set of batteries that will provide power at night when the sun is not shining.

Wind Energy

Wind power is a form of energy that has been collected for centuries. Twelfth Century Dutch windmills are famous but records indicate even earlier evidence of windmills elsewhere, such as in Persia in the Ninth Century.

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Wind power is harvested through wind turbines, whose height can range from 10 to 100 meters. The technology has now reached maturity and is used all over the world, from Brazil to China. Wind turbines are the opposite of house fans: instead of needing electricity to spin their blades, they harvest wind that spins their two or three propeller-like blades and creates electricity. The blades spin around a shaft, which is connected to a generator. The blades spin the generator, creating electricity that can be fed into the electrical grid or in any stand-alone electrical system.

Small wind turbines are generally used for providing power off the grid, ranging from 250-watt turbines designed for charging up batteries on a sailboat, to 50-kilowatt turbines that power dairy farms and remote villages. Such small scale systems are usually added to a diesel generator to provide power generation capacity when the wind is not blowing.

Large wind turbines, most often used by utilities to provide power to a grid, produce power outputs ranging from 1 to 5 MW. Such large turbines are widely used offshore where the wind is stronger than inland. Utility-scale turbines are usually placed in lines to take advantage of prime windy spots such as mountain passes. When the installation comprises several hundreds of turbines it is called a wind farm.

SUSTAINABLE AGRICULTURE

Sustainable agriculture integrates three main dimensions: protection of the environment, farm profitability and prosperity of local communities. Sustainable agriculture is envisioned under a systems perspective, allowing a larger and more thorough view of the consequences of farming practices on both human communitities and the environment, and to explore the interconnections between farming and other aspects of the environment.

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Sustainable agriculture projects encourage the following:

- Protection of water resources (through reduced use of pesticides and fertilizers)
- Protection of the soil against erosion (reduction or elimination of tillage)
- Irrigation management to reduce damage by water runoff, soil plant cover protection
- Recycling of crop waste and livestock manure for direct use on the farm
- Reduction of fossil fuel inputs and their substitution for renewable energy sources.
- Developing systems that maintain and enhance the ability of people involved in the industry, or in servicing it, to provide for their social and cultural well-being.

Plant and animal production practices are also adapted to achieve sustainability. Sustainable plant production practices include selection of species and varieties well suited to conditions on the farm, diversification of crops to enhance biological and economical stability, soil protection and efficient use of inputs while animal production practices emphasize grazing management, animal selection, animal nutrition and herd health.

Organic farming is considered to be a means to achieve sustainable agriculture. This market has steadily expanded since the 1970s.

SUSTAINABLE BUILDING

Green building (or sustainable building) is the practice of creating structures that are environmentally sustainable. Green building emphasizes the following strategies:

- Structure design efficiency
- Energy efficiency
- Water efficiency
- Waste reduction
- Materials efficiency
- Indoor air quality
- Maintenance optimization

Several green building certification bodies exist that provide building assessment and certification services. From a financial standpoint, green building is slightly more costly than traditional construction practices. However several studies show that the financial benefits in terms of energy saved, water saved and increased employee productivity recoup several folds the increase in construction cost. Certified green buildings have been shown to command rent and sale prices significantly higher than non-certified ones.

SUSTAINABLE FORESTRY

Sustainable forestry consists in managing forests according to the principles of sustainable development which encompass very broad social, economic and environmental goals. A set of Forest Principles were adopted at The United Nations Conference on Environment and Development in Rio de Janeiro in 1992 in order to define the international consensus on sustainable forest management practices. Since then, forest products companies, conservation organizations and other entities have engaged in several different types of forest projects, including the introduction expansion of forest cover into areas not previously forested (afforestation), or the restoration of forest cover in areas that were previously forested (reforestation) and conservation of standing forests (encompassed by the term, Reduced Emissions from Deforestation and

Degradation, or REDD). Project revenues typically depend on sale of timber harvested in accordance with strict guidelines, harvest of non-timber forest products and sale of carbon emissions reductions based on the carbon stored in forests.

A number of indicators have since been developed to better define sustainable forestry and make it more enforceable at both the country and project level. Sustainable forestry indicators cover the following topics:

- Extent of forest resources
- Carbon storage, in the trees, soils, root systems and fallen vegetation
- Biodiversity
- Forest health
- Productive functions
- Protective functions
- Socio-economic functions
- Legal and policy framework

Numerous forest certification schemes have been created in the last two decades to provide consumers and corporations with a straightforward way of assessing if a wood product originates from a forest managed in a sustainable manner. The most prominent certification schemes are:

- FSC: Forest Stewardship Council. Spearheaded by environmental NGOs and tribal communities, FSC is one of the most stringent standards. It is also more expensive to implement.
- SFI: Sustainable Forestry Initiative. Initiated by the American timber industry, less stringent than FSC.
- PEFC: Program for the Endorsement of Forest Certification Schemes
- CDM: the Clean Development Mechanism (CDM) now has some approved methodologies for presenting forestry projects to the CDM for registration.

SUSTAINABLE TOURISM

The World Tourism Organization defines sustainable tourism as “tourism which leads to management of all resources in such a way that economic, social and aesthetic needs can be fulfilled while maintaining cultural integrity, essential ecological processes, biological diversity and life support systems”. Sustainability principles refer to the environmental, economic and socio-cultural aspects of tourism development, and a suitable balance must be established between these three dimensions to guarantee its long-term sustainability. Sustainable tourism is aimed at providing tourism services while ensuring the protection of the local environment and the sustainability of the economic and social development of the local communities. Sustainable tourism ensures that tourism is a positive experience for both local people and tourists. It emphasizes protection of the local culture, development of jobs and income for the locals as well as enforcement of labor rights.

Sustainable tourism projects usually emphasize conservation of energy and water as a minimum, source locally produced goods and services, educate tourists about the local culture and the environment, and can provide various services and funds to local communities, ranging from education programs, charity for poverty alleviation, and native ecosystems regeneration.

SUSTAINABLE TRANSPORTATION

Sustainable transportation refers to any means of transportation with a low impact on the environment. Sustainable transportation projects can be technology-oriented: hybrid or electric vehicles, flexfuel vehicles, electric light trains or high speed trains. They can also be planning-oriented or organizational in nature: carpool schemes, mass transit systems (bus rapid transit, subways), transit centers connecting different means of transportation, etc.

Low carbon vehicles (hybrid vehicles, flexfuel vehicles) although they have a higher up-front cost in most cases, reduce harmful emissions and have lower operating costs for they are less dependent on fossil fuels.

Planning projects that aim at taking cars off the road and redirect people to a mass transit system also offer the advantage of reducing the social costs of individual transportation (road crashes, air pollution, commuting time, etc).

Examples of recent sustainable transportation projects include the development by a private consortium of battery swapping stations for electric cars in Denmark and Israel, automatic congestion pricing systems in downtown London and Stockholm and the development of an extensive high-speed electric train system in China.