ENERGY CONSERVATION:

1. It is the practice of reducing the quantity of energy used.
2. It may be attained through efficient energy use; in this case, energy use is decreased at the same time getting a same outcome as a result, or by reduced consumption of energy services.
3. It is one of the easiest processes to help the globe by means of pollution in addition to make use of natural energy.
4. It may result in increase of financial capital, better environmental results, national security, personal security and human comfort. Individuals and companies are called as direct consumers of energy may need to conserve energy so as to reduce energy expenses and promote economic security.
5. Industrial and business class users may want to increase the efficiency and as a result, it maximizes their benefits as well.
6. Energy conservation is the reduction or removal of unnecessary or unwanted energy use.

Definition:
Conservation is the process of reducing demand on a limited supply and enabling that supply to begin to rebuild itself. Many times the best way of doing this is to replace the energy used with an alternate.

GOAL:
The goal with energy conservation techniques is reduce demand, protect and replenish supplies, develop and use alternative energy sources, and to clean up the damage from the prior energy processes.

NEED FOR ENERGY CONSERVATION:

The earth provides enough to satisfy every man's needs but not every man's greed said Gandhiji. Hard facts on why energy conservation is a must are outlined below.

1. We use energy faster than it can be produced - Coal, oil and natural gas - the most utilised sources take thousands of years for formation.
2. Energy resources are limited - India has approximately 1% of world's energy resources but it has 16% of world population.
3. Most of the energy sources we use cannot be reused and renewed - Non renewable energy sources constitute 80% of the fuel use. It is said that our energy resources may last only for another 40 years or so.

4. We save the country a lot of money when we save energy - About 75 per cent of our crude oil needs are met from imports which would cost about Rs.1, 50,000 crore a year
5. We save our money when we save energy - Imagine your savings if your LPG cylinder comes for an extra week or there is a cut in your electricity bills
6. We save our energy when we save energy - When we use fuel wood efficiently, our fuel wood requirements are lower and so is our drudgery for its collection
7. Energy saved is energy generated - When we save one unit of energy, it is equivalent to 2 units of energy produced
8. Save energy to reduce pollution - Energy production and use account to large proportion of air pollution and more than 83 percent of greenhouse gas emissions
9. An old Indian saying describes it this way - The earth, water and the air are not a gift to us from our parents but a loan from our children. Hence we need to make energy conservation a habit.

VARIUOUS FROMS OF ENERGY USED IN BUILDING:

Energy is defined as the capacity of a physical system to perform work. In other words, It can be explained as the ability to perform or complete any type of work whether it is physical or mental activity.

We can also explain "energy" which includes physical movements like shifting something from one place to another, warming something or lighting something. Energy exists in numerous forms such as heat, kinetic or mechanical energy, light, potential energy, electrical or many other forms.

It can be better described by giving the below mentioned natural example of environment, it shows a chain cycle of converting different forms of energy into heat and power:

- Oil burns to make heat
- Heat boils water
- Water turns to steam
- Steam pressure turns a turbine
- Turbine turns an electric generator
- Generator produces electricity
- Electricity powers light bulbs
- Light bulbs give off light and heat

We utilize energy in different forms in our daily routine life and cannot think even about to survive without it. We use energy to light our homes and for street lighting as well. to be able to power machineries and equipments in factories, helps to cook our food. for playing music and operating televisions and many more every day regular uses.

PRACTICAL METHODS OF ENERGY CONSERVATION:

Below are energy conservation techniques that can help you to reduce your overall carbon footprint and save money in the long run.

1. **Install CFL Lights:** Try replacing incandescent bulbs in your home with CFL bulbs. CFL bulbs cost more upfront but last 12 times longer than regular incandescent bulbs. CFL bulbs will not only save energy but over time you end up saving money.

2. **Lower the Room Temperature:** Even a slight decrease in room temperature lets say by only a degree or two, can result in big energy savings. The more the difference between indoor and outdoor temperature, the more energy it consumes to maintain room temperature. A more smarter and comfortable way of doing this is to buy a programmable thermostat.

3. **Fix Air Leaks:** Proper insulation will fix air leaks that could be costing you. During winter months, you could be letting out a lot of heat if you do not have a proper insulation. You can fix those leaks yourself or call an energy expert to do it for you.

4. **Use Maximum Daylight:** Turn off lights during the day and use daylight as much as possible. This will reduce the burden on the local power grid and save you good amount of money in the long run.

5. **Get Energy Audit Done:** Getting energy audit done by hiring an energy audit expert for your home is an energy conservation technique that can help you conserve energy and save good amount of money every month. Home energy audit is nothing but a process that helps you to identify areas in your home where it is losing energy and what steps you can take to overcome them. Implement the tips and suggestions given by those energy experts and you might see some drop in your monthly electricity bill.

6. **Use Energy Efficient Appliances:** When planning to buy some electrical appliances, prefer to buy one with Energy Star rating. Energy efficient appliances with Energy Star rating consume less energy and save you money. They might cost you more in the beginning but it is much more of an investment for you.

7. **Drive Less, Walk More and Carpooling:** Yet another energy conservation technique is to drive less and walk more. This will not only reduce your carbon footprint but will also keep you healthy as walking is a good exercise. If you go to office by car and many of your colleagues stay nearby, try doing carpooling with them. This will not only bring down your monthly bill you spend on fuel but will also make you socially more active.

8. Switch off Appliances when Not in Use: Electrical appliances like coffee machine, idle printer, desktop computer keep on using electricity even when not in use. Just switch them off if you don't need them immediately.

9. Plant Shady Landscaping: Shady landscaping outside your home will protect it from intense heat during hot and sunny days and chilly winds during the winter season. This will keep your home cool during summer season and will eventually turn to big savings when you calculate the amount of energy saved at the end of the year.

10. Install Energy Efficient Windows: Some of the older windows installed at our homes aren't energy efficient. Double panel windows and other vinyl frames are much better than single pane windows. Choosing correct blinds can save on your power bills.

OTHER ENERGY CONSERVATION TECHNIQUES:

The other few energy conservation techniques may surprise you. While there are practical methods such as insulation, changing light sources, using alternate fuels and carpooling rather than walking – understand the 6 core techniques beneath them will show you more about what to do in life.

1. Education: Education is probably the most powerful of the energy conservation techniques that can be used. Education is about more than teaching people the importance of conservation, it is about showing the alternative choices that can be used in construction, manufacturing and other processes.

2. Zero Energy Balance: Zero Energy Balance is more than techniques of conserving energy in green construction. It is a process of re-evaluating and retrofitting manufacturing and commercial operations so that they can harvest and store energy, as well as take and replace it onto the grid to relieve brown out stresses.

3. Alternative Power: There are more processes that are starting to use alternative power and fuel sources in many different areas of life. The use of alternative power is one of the most key energy conservation techniques because almost all of the transition models require that the existing processes be upgraded or replaced to more energy efficient models too.

4. Cap and Trade Agreements: Cap and trade agreements are used as part of the process of regulating and conserving consumption and pollution for manufacturing industries. The companies are "allowed" a certain emission rate which they can bid buy to extend. The extension bid is then used for compensating projects. While this may not seem like it is directly related to energy conservation it is very much at its core.

5. Reduced Demand: There are numerous initiatives that are working to reduce the overall demand on the energy resources of the world. This can range everywhere from education programs to changing the type of required insulation in new construction.

6. Research & Development: Continued funding of research and development projects in the energy conservation field is how we discover the changes that can be made to reduce consumption and discover renewable methods to provide us with the energy that modern life requires. It should be one of the energy conservation techniques that are most valued as it is what holds the promise for leading to a solution to the world's energy crisis.

CASE STUDY: (Various Forms of Energy used in Buildings)

Whenever you save energy, you not only save money, you also reduce the demand for such fossil fuels as coal, oil, and natural gas. Less burning of fossil fuels also means lower emissions of carbon dioxide (CO_2), the primary contributor to global warming, and other pollutants.

You do not have to do without to achieve these savings. There is now an energy efficient alternative for almost every kind of appliance or light fixture. That means that consumers have a real choice and the power to change their energy use on a revolutionary scale.

The average American produces about 40,000 pounds of CO_2 emissions per year. Together, we use nearly a million dollars worth of energy every minute, night and day, every day of the year. By exercising even a few of the following steps, you can cut your annual emissions by thousands of pounds and your energy bills by a significant amount!

Home appliances

1. Turn your refrigerator down. Refrigerators account for about 20% of Household electricity use. Use a thermometer to set your refrigerator temperature as close to 37 degrees and your freezer as close to 3 degrees as possible. Make sure that its energy saver switch is turned on. Also, check the gaskets around your refrigerator/freezer doors to make sure they are clean and sealed tightly.

2. Set your **clothes washer** to the warm or cold water setting, not hot. Switching from hot to warm for two loads per week can save nearly 500 pounds of CO_2 per year if you have an electric water heater, or 150 pounds for a gas heater.

3. Make sure your **dishwasher** is full when you run it and use the energy saving setting, if available, to allow the dishes to air dry. You can also turn off the drying cycle manually. Not using heat in the drying cycle can save 20 percent of your dishwasher's total electricity use.

4. Turn down your **water heater** thermostat. Thermostats are often set to 140 degrees F when 120 is usually fine. Each 10 degree reduction saves 600 pounds of CO2 per year for an electric water heater, or 440 pounds for a gas heater. If every household turned its water heater thermostat down 20 degrees, we could prevent more than 45 million tons of annual CO_2 emissions - the same amount emitted by the entire nations of Kuwait or Libya.

5. Select the most energy-efficient models when you replace your old **appliances**. Look for the Energy Star Label - your assurance that the product saves energy and prevents pollution. Buy the product that is sized to your typical needs - not the biggest one available. Front loading washing machines will usually cut hot water use by 60 to 70% compared to typical machines. Replacing a typical 1973 refrigerator with a new energy-efficient model, saves 1.4 tons of CO_2 per year. Investing in a solar water heater can save 4.9 tons of CO_2 annually.

Home Heating and Cooling

6. Be careful not to overheat or overcool rooms. In the winter, set your **thermostat** at 68 degrees in daytime, and 55 degrees at night. In the summer, keep it at 78. Lowering your thermostat just two degrees during winter saves 6 percent of heating-related CO2 emissions. That's a reduction of 420 pounds of CO_2 per year for a typical home.

7. Clean or replace **air filters** as recommended. Energy is lost when air conditioners and hot-air furnaces have to work harder to draw air through dirty filters. Cleaning a dirty air conditioner filter can save 5 percent of the energy used. That could save 175 pounds of CO_2 per year.

Small investments that pay off

8. Buy energy-efficient **compact fluorescent bulbs** for your most-used lights. Although they cost more initially, they save money in the long run by using only 1/4 the energy of an ordinary incandescent bulb and lasting 8-12 times longer. They provide an equivalent amount of bright, attractive light. Only 10% of the energy consumed by a normal light bulb generates light. The rest just makes the bulb hot. If every American household replaced one of its standard light bulbs with an energy efficient compact fluorescent bulb, we would save the same amount of energy as a large nuclear power plant produces in one year. In a typical home, one compact fluorescent bulb can save 260 pounds of CO_2 per year.

9. Wrap your **water heater** in an insulating jacket, which costs just $10 to $20. It can save 1100 lbs. of CO_2 per year for an electric water heater, or 220 pounds for a gas heater.

10. Use less hot water by installing **low-flow shower heads**. They cost just $10 to $20 each, deliver an invigorating shower, and save 300 pounds of CO_2 per year for electrically heated water, or 80 pounds for gas-heated water.

11. **Weatherize** your home or apartment, using caulk and weather stripping to plug air leaks around doors and windows. Caulking costs less than $1 per window, and weather stripping is under $10 per door. These steps can save up to 1100 pounds of CO2 per year for a typical home. Ask your utility company for a home energy audit to find out where your home is poorly insulated or energy inefficient. This service may be provided free or at low cost. Make sure it includes a check of your furnace and air conditioning.

Getting around

12. Whenever possible, **walk, bike, car pool, or use mass transit**. Every gallon of gasoline you save avoids 22 pounds of CO2 emissions. If your car gets 25 miles per gallon, for example, and you reduce your annual driving from 12,000 to 10,000 miles, you'll save 1800 pounds of CO_2.

13. When you next buy a car, choose one that gets **good mileage**. If your new car gets 40 miles per gallon instead of 25, and you drive 10,000 miles per year, you'll reduce your annual CO2 emissions by 3,300 pounds.

Reduce, reuse, recycle

14. Reduce the amount of waste you produce by buying minimally packaged goods, choosing reusable products over disposable ones, and recycling. For every pound of waste you eliminate or recycle, you save energy and reduce emissions of CO2 by at least 1 pound. Cutting down your garbage by half of one large trash bag per week saves at least 1100 pounds of CO2 per year. Making products with recycled materials, instead of from scratch with raw materials, uses 30 to 55% less for paper products, 33% less for glass, and a whopping 90% less for aluminum.

15. If your car has an air conditioner, make sure its coolant is recovered and recycled whenever you have it serviced. In the United States, leakage from auto air

conditioners is the largest single source of emissions of chlorofluorocarbons (CFCs), which damage the ozone layer as well as add to global warming. The CFCs from one auto air conditioner can add the equivalent of 4800 pounds of CO2 emissions per year.

Home Improvements

When you plan major home improvements, consider some of these energy saving investments. They save money in the long run, and their CO2 savings can often be measured in tons per year.

16. **Insulate** your walls and ceilings. This can save 20 to 30 percent of home heating bills and reduce CO2 emissions by 140 to 2100 pounds per year. If you live in a colder climate, consider superinsulating. That can save 5.5 tons of CO2 per year for gas-heated homes, 8.8 tons per year for oil heat, or 23 tons per year for electric heat. (If you have electric heat, you might also consider switching to more efficient gas or oil.)

17. Modernize your **windows**. Replacing all your ordinary windows with argon filled, double-glazed windows saves 2.4 tons of CO_2 per year for homes with gas heat, 3.9 tons of oil heat, and 9.8 tons for electric heat.

18. Plant **shade trees** and paint your house a light color if you live in a warm climate, or a dark color if you live in a cold climate. Reductions in energy use resulting from shade trees and appropriate painting can save up to 2.4 tons of CO2 emissions per year. (Each tree also directly absorbs about 25 pounds of CO2 from the air annually.)

Business and community

19. Work with your employer to implement these and other energy-efficiency and waste-reduction measures in your office or workplace. Form or join local citizens' groups and work with local government officials to see that these measures are taken in schools and public buildings.
20. Keep track of the environmental voting records of candidates for office. Stay abreast of environmental issues on both local and national levels, and write or call your elected officials to express your concerns about energy efficiency and global warming.

OPTIONS FOR DIRECT USE OF SUSTAINABLE ENERGY:

1. **Bioenergy:**

What is it? This is a type of renewable energy derived from biomass to create heat and electricity (or to produce liquid fuels used for transportation, like ethanol and biodiesel). Biomass refers to any organic matter coming from recently living plants or animals. Even though bioenergy generates about the same amount of carbon dioxide as fossil fuels, the replacement plants grown as biomass remove an equal amount of CO_2 from the atmosphere, keeping the environmental impact relatively neutral. There are a variety of systems used to generate this type of electricity, ranging from directly burning biomass to capturing and using methane gas produced by the natural decomposition of organic material. ***How can an organization use it?*** Depending on your operation, there are many ways to incorporate bioenergy into your sustainable energy plans:

- Organizations can convert to fleet vehicles that use biofuels such as ethanol or biodiesel.
- Manufacturing facilities can be equipped to burn biomass directly, producing steam captured by a turbine to generate electricity. In some cases, this process can power the facility as well as heating it. For example, paper mills can use wood waste to produce electricity and steam for heating.
- Farm operations can convert waste from livestock into electricity using small, modular systems.
- Towns can tap the methane gas created by the anaerobic digestion of organic waste in landfills and use it as fuel for generating electricity.

2. **Geothermal:**

What is it? Geothermal energy, as the name implies, is derived from the heat of the earth itself. This heat can be sourced close to the surface or from heated rock and reservoirs of hot water miles beneath our feet. Geothermal power plants harness these heat sources to generate electricity. On a much smaller scale, a geothermal heat pump system can leverage the constant temperature of the ground just ten feet under the surface to help supply heat to a nearby building in the winter, or help cool it in the summer.

How can an organization use it? Geothermal energy can be part of a commercial utility energy solution on a large scale, or be part of a sustainable business practice on a local level. Direct use of geothermal energy may include:

- Heating office buildings or manufacturing plants
- Helping to grow greenhouse plants
- Heating water at fish farms
- Aiding with various industrial processes (e.g. pasteurizing milk)

3. **Hydroelectric:**

What is it? Remaining waterwheels previously used to operate the gristmills and sawmills of early America are now largely functioning as historic sites and museums. Today, the kinetic energy of flowing rivers is captured in a much different way and converted into hydroelectricity. Probably the most familiar type of hydroelectric power is generated by a system in which dams are constructed to store water in a reservoir. When released, the water flows through turbines to produce electricity. This is known as "pumped-storage hydropower"—water is cycled between lower and upper reservoirs to control electricity generation between times of low and peak demand. Another type, called "run-of-river hydropower," funnels a portion of river flow through a channel and does not require a dam. Hydropower plants can range in size from massive projects like the Hoover Dam to micro-hydroelectric power systems. ***How can an organization use it?*** Direct use of hydroelectric power is naturally dependent on geographic location. Assuming a dependable waterway source is accessible and available, it could be used in the following ways:

- Micro-hydroelectric plants can be constructed to supply electricity to farm and ranch operations or small municipalities.
- Small towns can harness the energy of local waterways by building moderately-sized hydroelectric power systems.

4. Hydrogen:

What is it? Hydrogen is the simplest (comprised of one proton and one electron) and most abundant element in the universe, yet it does not occur naturally as a gas on earth. Instead, it is found in organic compounds (hydrocarbons such as gasoline, natural gas, methanol and propane) and water (H_2O). Hydrogen can also be produced under certain conditions by some algae and bacteria using sunlight as an energy source. Hydrogen is high in energy, yet produces little or no pollution when burned. Hydrogen fuel cells convert the potential chemical energy of hydrogen into electricity, with pure water and heat as the only byproducts. However, practical and widespread commercialization of these fuel cells will likely be limited until costs come down and durability improves. ***How can an organization use it?*** Almost all the hydrogen used in the United States is used in industry to refine petroleum, treat metals, produce fertilizer and process foods. In addition, hydrogen fuel cells are used as an energy source where hydrogen and oxygen atoms are combined to generate electricity. There are also currently a few hundred hydrogen-powered vehicles operating in the United States, a number that could increase as the cost of fuel cell production drops and the number of refueling stations increases. Other practical applications for this type of renewable energy include:

- Large fuel cells providing emergency electricity for buildings and remote locations
- Marine vessels powered by hydrogen fuel cells

5. Ocean:

What is it? There are two types of energy that can be produced by the ocean: thermal energy from the sun's heat and mechanical energy from the motion of tides and waves. Ocean thermal energy can be converted into electricity using a few different systems that rely on warm surface water temperatures. Ocean mechanical energy harnesses the ebbs and flows of tides caused by the rotation of the earth and the gravitational influence of the moon. Energy from wind-driven waves can also be converted and used to cut business electricity costs. There are also lesser-developed technologies that leverage ocean currents, ocean winds and salinity gradients as sources of power conversion.

How can an organization use it? Ocean energy is an evolving sector for alternative energy production, but with over 70 percent of the surface of our planet covered by ocean, its future looks promising. Commercial and public applications for this energy resource are limited to geography and regulatory guidelines. Practical uses for energy derived from the ocean include the following:

- Cold ocean water from deep below the surface can be used to cool buildings (with desalinated water as a common byproduct).
- Seaside communities can employ the methods to tap natural ocean energy described above to supplement municipal power and energy needs.

6. **Solar:**

What is it? Except for geothermal and hydrogen, the sun plays a significant role in each of the other types of renewable energy listed here. The most direct use of this renewable energy source, however, is achieved by capturing the sun's energy directly. A variety of solar energy technologies are used to convert the sun's energy and light into heat, illumination, hot water, electricity and (paradoxically) cooling systems for businesses and industry. Photovoltaic (PV) systems use solar cells to convert sunlight into electricity. Solar hot water systems can be used to heat buildings by circulating water through flat-plate solar collectors. The sun's heat can be concentrated by mirror-covered dishes that are focused to boil water in a conventional steam generator to produce electricity. Commercial and industrial buildings can also leverage the sun's power for larger-scale needs such as ventilation, heating and cooling. Finally, thoughtful architectural designs can passively take advantage of the sun as a source of light and heating/cooling.

How can an organization use it? Public and private entities can take advantage of the benefits of solar power for business in a wide variety of ways:

a. Install a commercial solar power system (rooftop equipment, field array or carport) and become an owner/operator, lessee or participant in a solar power purchase agreement (PPA).

b. Purchase solar energy that's been generated by an offsite commercial solar installation.

c. Construct or retrofit a building to incorporate a solar hot water, cooling or ventilation system.

7. **Wind:**

What is it? Wind can be considered a form of solar energy because winds are caused by the uneven heating and cooling of the atmosphere by the sun (as well as the rotation of the earth and other topographical factors). Wind flow can be captured by turbines and converted into electricity. On a smaller scale, windmills are still used today to pump water on farms. ***How can an organization use it?*** Wind is one of the sustainability ideas for business that can be incorporated to cut business electricity costs. Commercial grade wind-powered generating systems are available to meet the renewable energy needs of many organizations:

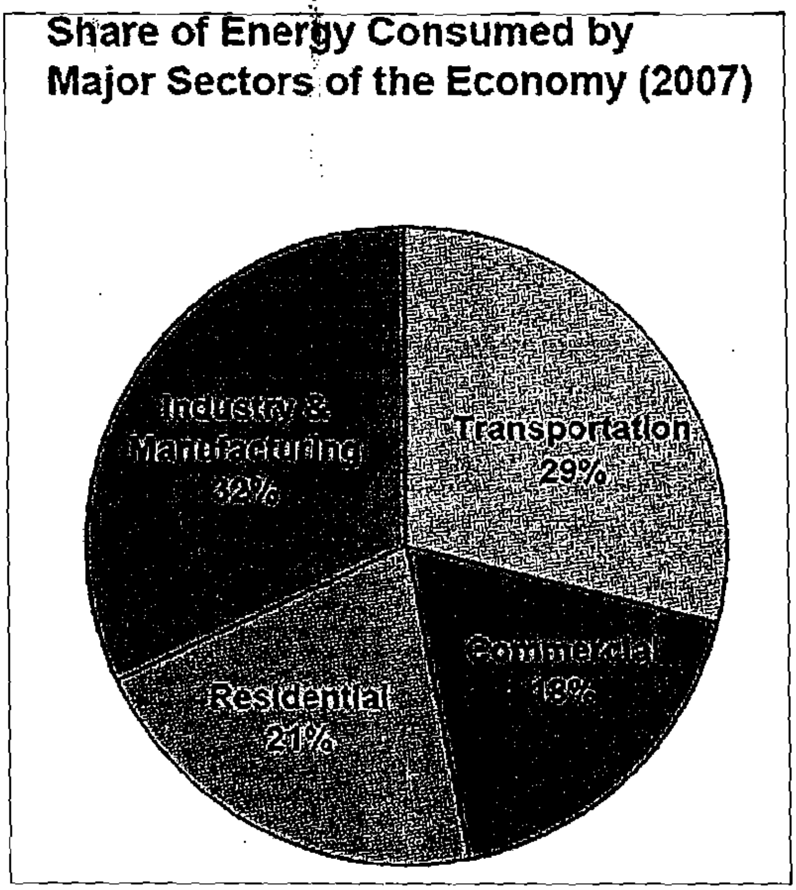
a. Single wind turbines generate electricity as a supplement to an organization's existing electrical supply (when the wind blows, power generated by the system goes to offset the need for utility-supplied electricity).

b. Utility-scale wind farms generate electricity that can be purchased on the wholesale power market, either contractually or through a competitive bid process.

Uses of Energy

Residential- homes
Commercial - buildings
Industry and Manufacturing
Transportation- cars, trucks, planes, etc.

links page
recent statistics



Note: Due to rounding, data may not sum to exactly 100 percent.

The United States is a highly developed and industrialized society. We use a lot of energy - in our homes, in businesses, in industry, and for traveling between all these different places.

The industrial sector uses almost one-third of the total energy. The residential and commercial sectors combined use 39 percent of all energy. These two sectors include all types of buildings, such as houses, offices, stores, restaurants, and places of worship. Energy used for transportation accounts for more than a quarter of all energy.

Last Revised: March 2009
Source: Energy Information Administration, *Annual Energy Review 2007*, Washington, DC, June 2008.

Residential Energy Use - Energy Used in Households

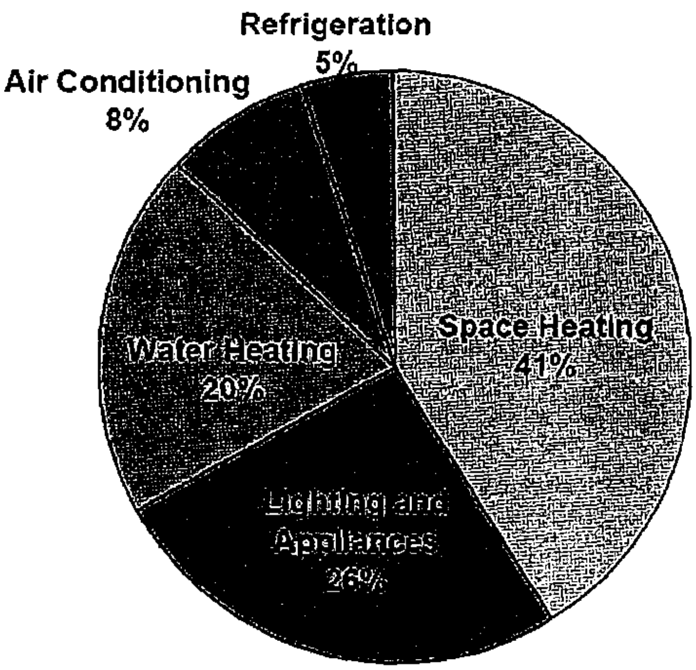
links page

USES OF ENERGY IN HOMES

The ability to maintain desired temperatures is one of the most important accomplishments of modern technology. Our ovens, freezers, and homes can be kept at any temperature we choose, a luxury that wasn't possible 100 years ago. Keeping our homes comfortable uses a lot of energy. Over 40 percent of the average home's energy consumption is used for heating. Another 20 percent is used for water heating, 8 percent for cooling rooms, and 5 percent for refrigeration.

Almost one-fourth of the energy used in homes is used for lighting and appliances. Lighting is essential to a modern society. Lights have revolutionized the way we live, work, and play.

How Energy is Used in Homes (2005)



Due to rounding, percentages may not add to exactly 100 percent.

Most homes still use the traditional incandescent bulbs invented by Thomas Edison. These bulbs convert only about ten percent of the electricity they use to produce light, the other

90 percent is converted into heat. In 1879, the average bulb produced only 14 lumens per watt, compared to about 17 lumens per watt today. By adding halogen gases, the efficiency can be increased to 20 lumens per watt.

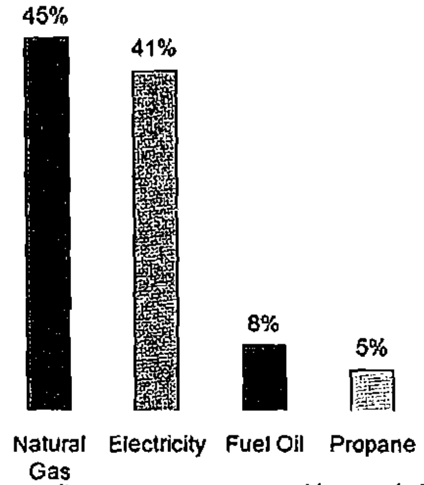
Compact fluorescent bulbs, or "CFLs", have made inroads into home lighting systems in the last few years. These bulbs last much longer and use much less energy, producing significant savings over the life of the bulb.

Appliances such as refrigerators, washing machines and dryers are also more energy efficient than they used to be. In 1990 Congress passed the National Appliance Energy Conservation Act, which requires new appliances to meet strict energy efficiency standards. Learn more about energy efficient light bulbs and appliances, and other ways to save energy at home.

TYPES OF ENERGY USED IN HOMES

Natural gas is the most widely consumed energy source in American homes, followed by electricity, heating oil and propane. Natural gas and heating oil (fuel oil) are used mainly for home heating. Electricity may also be used for heating and cooling, plus it lights our homes and runs almost all of our appliances including refrigerators, toasters, and computers. Many homes in rural areas use propane for heating, while others use it to fuel their barbecue grills.

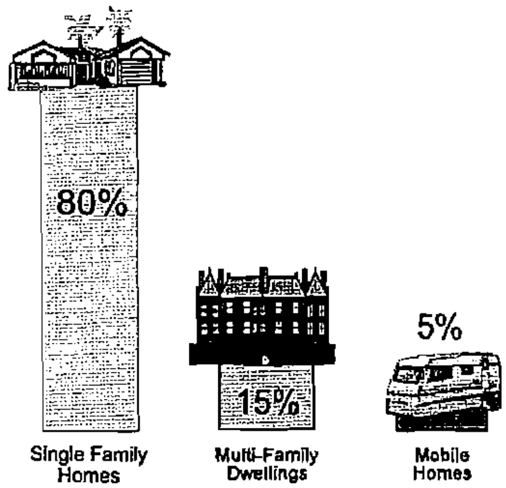
Types of Energy Consumed in Homes (2005)



Note: Due to rounding, percentages may not add to exactly 100 percent.

ENERGY USE IN DIFFERENT TYPES OF HOMES

About 80 percent of residential energy use is consumed in single family homes, while 15 percent is consumed in multi-family dwellings such as apartments, and 5 percent is consumed in mobile homes.



More than half of the energy used for heating in **single-family homes** (either attached or detached) is natural gas, about one-fourth is electricity, and one-tenth is fuel oil (heating oil). Over three-fourths of single-family homes have some type of air conditioning. Most single-family homes have a washing machine and a dryer.

Among Single-Family Dwellings:

In 2005, for the Main Heating Fuel and Equipment:

- 56% use Natural Gas
- 26% use Electricity
- 7% use Fuel Oil
- 6% use LPG
- 1% use Kerosene

84% of single-family homes have air conditioning (central system, wall/window units - or both)

For Appliances:

- 95% have a clothes washer
- 92% have a clothes dryer
- 74% have a personal computer

Multi-family dwellings such as apartments use about equal amounts of natural gas and electricity for heating. More than 80 percent of multi-family homes have air conditioning and more than one-third contain washers and dryers.

Among Multi-Family Dwellings:

In 2005, for the Main Heating Fuel and Equipment:

- 47% use Natural Gas
- 41% use Electricity
- 7% use Fuel Oil

82% of multi-family homes have air conditioning (a central system, wall/window units - or both)

For Appliances:

- 40% have a clothes washer
- 35% have a clothes dryer
- 55% have a personal computer

Mobile homes are more likely than the other types of homes to heat with propane(LPG). More than one-third of mobile homes use electricity and about one-third use natural gas for heating. Most mobile homes contain washing machines and dryers.

Among Mobile Homes:

In 2005, for the Main Heating Fuel and Equipment:

- 27% use Natural Gas
- 42% use Electricity
- 3% use Fuel Oil
- 19% use LPG
- 4% use Kerosene

84% of mobile homes have air conditioning(central system, wall/window units - or both

For Appliances:

- 87% have a clothes washer
- 78% have a clothes dryer
- 49% have a personal computer

Last Revised: June 2009

Sources: Energy Information Administration, 2005 Residential Energy Consumprion Survey.

The National Energy Education Development Project, *Secondary Energy Infobook*, Manassas, VA, 2004.

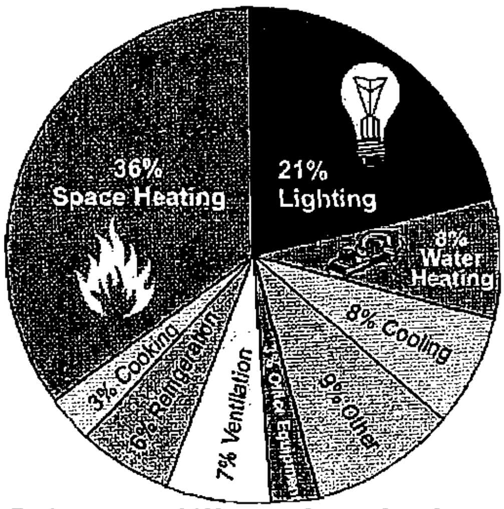
Commercial Energy Use

links page

ENERGY USE IN COMMERCIAL BUILDINGS

Commercial buildings include a wide variety of building types—offices, hospitals, schools, police stations, places of worship, warehouses, hotels, barber shops, libraries, shopping malls—and that's just the beginning of the list. These different commercial activities all have unique energy needs but, as a whole, commercial buildings use more than half their energy for heating and lighting.

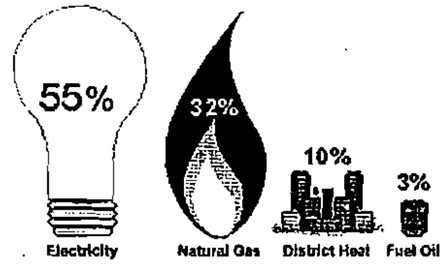
How Energy is Used in Commercial Buildings



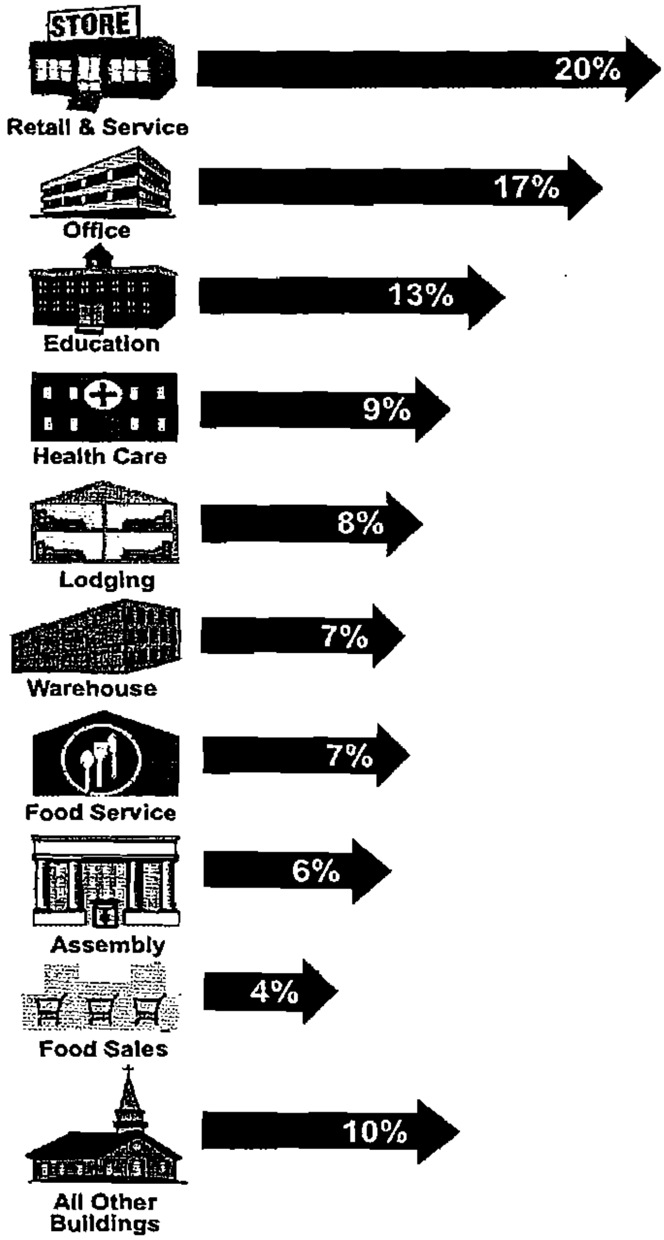
Note: Total may not equal 100 percent due to independent rounding.

TYPES OF ENERGY USED IN COMMERCIAL BUILDINGS

Electricity and natural gas are the most common energy sources used in commercial buildings. Commercial buildings also use another source that you don't usually find used in residential buildings—district energy. When there are many buildings close together, like on a college campus or in a big city, it is sometimes more efficient to have a central heating and cooling plant that distributes steam, hot water, or chilled water to all of the different buildings. A district system can reduce equipment and maintenance costs, as well as save energy.



ENERGY USE BY TYPE OF BUILDING



Due to rounding. Percentages may not

Retail and service buildings use the most total energy of all the commercial building types. This isn't too surprising when you think of all the stores and service businesses in most towns. Offices use a large share of energy, too. Education buildings, like your school, use 13 percent of all total energy, which is even more than all hospitals and other medical buildings combined! Lodging buildings (like hotels or dormitories) use 8 percent of all energy. Warehouses and food service (like restaurants) each use 7 percent. Public assembly buildings, which can be anything from libraries to sports arenas, use 6 percent; food sales buildings (like grocery stores and convenience stores) use 4 percent. All other types of buildings, like places of worship, fire stations, police stations, and laboratories, account for the remaining 10 percent of commercial building energy.

add to exactly 100 percent.

Last Revised: October 2008
Source: Energy Information Administration, 2003 Commercial Buildings Energy Consumption Survey.

Industrial and Manufacturing Energy Use

Energy Use in Industry/Manufacturing
Types of Energy for Industry/Manufacturing
Energy Use by Type of Industry

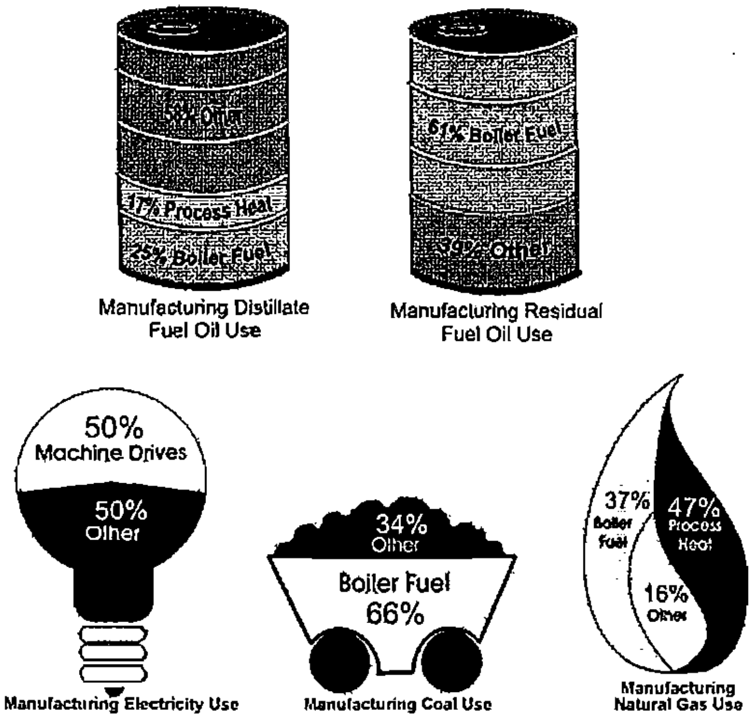
links page

ENERGY USE IN INDUSTRY/MANUFACTURING

The United States is highly industrialized. Industry accounts for about one-third of the energy used in the country.

There are many different uses and a variety of different energy sources in the manufacturing sector. One main use is as boiler fuel, which means producing heat that is transferred to the boiler vessel to generate steam or hot water. Another use is as process heating, which is when energy is used directly to raise the temperature of products in the manufacturing process; examples are separating components of crude oil in petroleum refining, drying paint in automobile manufacturing, and cooking packaged foods.

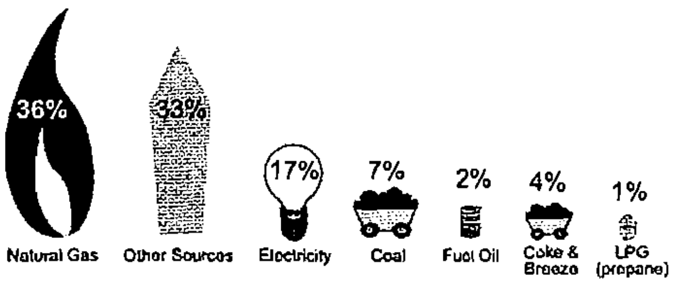
Major End Uses of Some Common Energy Sources
(Percent of Energy Source Used for an End Use)



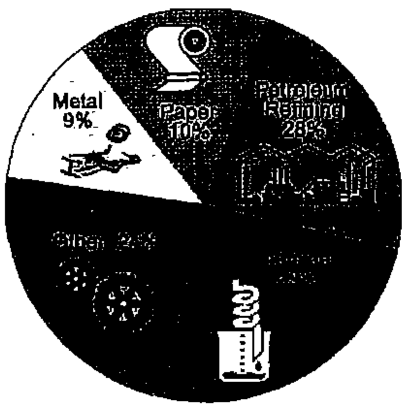
TYPES OF ENERGY FOR INDUSTRY/MANUFACTURING

In the manufacturing sector, the predominant energy sources are natural gas and electricity (a secondary source). Manufacturers also use other energy sources for heat, power, and electricity generation. Many uncommon energy sources are also used by manufacturers as a feedstock(a raw material used to make other products).

Sources of Energy Used for Industry and Manufacturing



ENERGY USE BY TYPE OF INDUSTRY



Every industry uses energy, but there are a handful of energy-intensive industries that use the bulk of the energy consumed by the industrial sector.

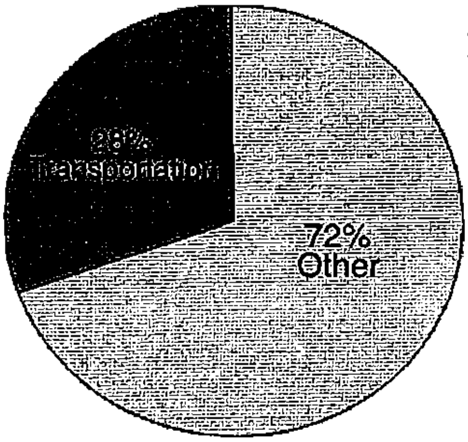
The chemical industry is the largest industrial consumer of energy, followed closely by petroleum refining. The refining, chemical, paper and metal industries together use:

- 94% of the feedstock
- 92% of the byproduct energy
- 70% of total inputs of energy for heat, power, and electricity generation

Last Revised: July 2006
Source: Energy Information Administration, 2002 Manufacturing Energy Consumption Survey

Transportation Energy Use

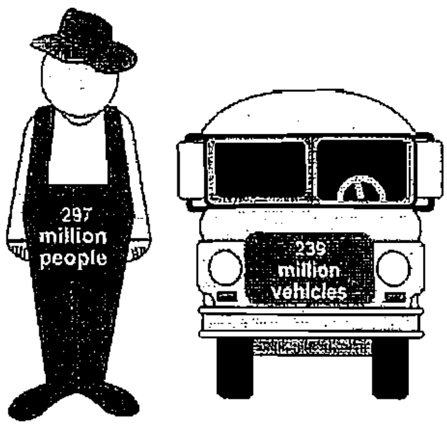
ENERGY USE FOR TRANSPORTATION



America is a nation on the move. About 28 percent of the energy we use goes to transporting people and goods from one place to another.

Cars, vans, and buses are commonly used to carry people. Trucks, airplanes, and railroads can be used to carry people and freight. Barges and pipelines only carry freight. In 2005, there were almost 239 million vehicles (cars, buses, and trucks) in the United States. That's more than three motor vehicles for every four people!

Automobiles, motorcycles, trucks, and buses drove nearly 3.0 trillion miles in 2005. That's almost one-twelfth the distance to the nearest star beyond the solar system. It's like driving to the sun and back 13,440 times.

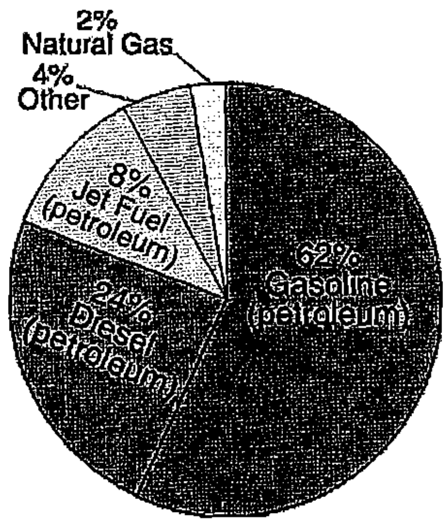


TYPES OF ENERGY USED FOR TRANSPORTATION

Gasoline is used mainly by cars, motorcycles, and light trucks; diesel is used mainly by heavier trucks, buses, and trains. Together, gasoline and diesel make up 86 percent of all the energy used in transportation.

There is currently a push to develop vehicles that run on fuels other than petroleum products, or on blended fuels. Today, there are some vehicles that run on electricity, natural gas, propane, and ethanol. Hybrid-electric vehicles combine the benefits of gasoline engines and electric motors, reducing the amount of fuel required for moving a vehicle. This is why hybrid-electric vehicles can get more miles per gallon of gasoline compared to vehicles that run on gasoline alone.

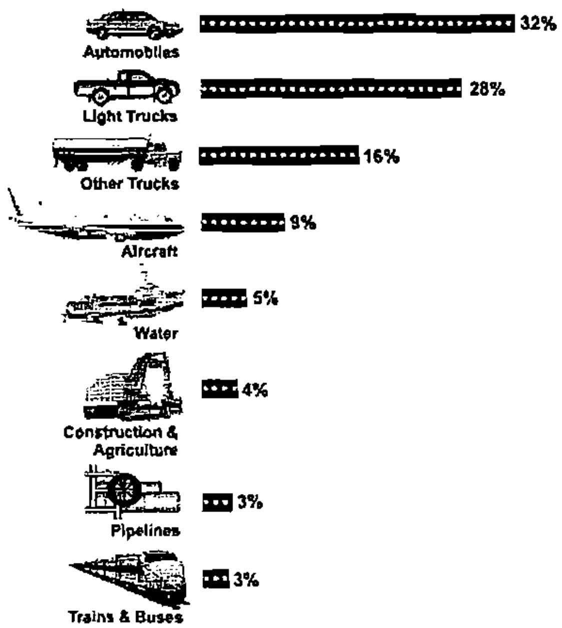
Fuels Used for Transportation



Note:Due to rounding, data may not sum to exactly 100 percent.

ENERGY USE BY TYPE OF VEHICLE

The people in the United States have always had a love affair with the automobile. Personal vehicles (like cars and light trucks) consume 63 percent of the total energy used for transportation, while commercial vehicles (like large trucks and construction vehicles), mass transit (like airplanes, trains, and buses), and pipelines account for the rest.



Last Revised: October 2007
Source: U.S. Department of Energy. *Transportation Energy Data Book*: Edition 26-2007.

MATERIAL	EMBODIED ENERGY MJ/kg	MJ/m3
Aggregate	0.10	150
Straw bale	0.24	31
Soil-cement	0.42	819
Stone (local)	0.79	2030
Concrete block	0.94	2350
Concrete (30 Mpa)	1.3	3180
Concrete precast	2.0	2780
Lumber	2.5	1380
Brick	2.5	5170
Cellulose insulation	3.3	112
Gypsum wallboard	6.1	5890
Particle board	8.0	4400
Aluminum (recycled)	8.1	21870
Steel (recycled)	8.9	37210
Shingles (asphalt)	9.0	4930
Plywood	10.4	5720
Mineral wool insulation	14.6	139
Glass	15.9	37550
Fiberglass insulation	30.3	970
Steel	32.0	251200
Zinc	51.0	371280
Brass	62.0	519560
PVC	70.0	93620
Copper	70.6	631164
Paint	93.3	117500
Linoleum	116	150930
Polystyrene insulation	117	3770
Carpet (synthetic)	148	84900
Aluminum	227	515700

NOTE: Embodied energy values based on several international sources - local values may vary.

Water savings opportunities

1. Low-flow plumbing fixtures

Many breakthroughs have been made in building water systems. These results have led to the replacement of large water-consuming fixtures with low-flow water fixtures (see Figure 1-3). Aerators for faucets, reduced-flow shower heads, and high-efficiency toilet and urinal flush valves are available with an initial capital investment; they often pay back the investment in less than a year, especially when they are used often. Low-flow fixtures in themselves are not a remedy as they don't save you water if you are filling a pot, getting a glass of water, or doing other things that require a fixed volume of water. They do, however, save a significant amount of water when the number of usages is held constant.

In 1992, the National Energy Policy Act mandated the use of water-conserving plumbing fixtures. Since the law's inception, low-flow plumbing fixtures—including flush valves for water closets, urinals, faucet aerators, and showerheads—have been further developed to save substantial amounts of water compared to conventional fixtures while providing the same utility through design features such as improved bowl, aerator, and flush valve design. Payback is not addressed here because water rates vary widely across the United States. See Table 1 for the evolution of water-conserving fixtures. Although no one is specifying the pre-1992 fixtures, the percentage of pre-1992 fixtures in existing commercial building stock is fairly significant, though specific data to quantify this is hard to come by.

Dual flush can significantly reduce flow to an average 0.96 gpf based on 5 flushes/day/person with only one 1.6 gpf flush and four 0.8 gpf flushes.

No-flow urinals are not considered, as many municipalities and codes do not allow these fixtures.

However, one major caveat to using low-flow fixtures is in effectively moving solids great distances in horizontal sanitary lines. Particular care must be applied in the design process to avoid buildups and backups due to decreased water flow and the resulting reduction in the effective transport of solids. This is particularly important in retrofitting low-flow fixtures in existing facilities with rough pipe and minimal pitch in sanitary lines. Another is that low-flow faucets lead to less hot water flowing through pipes, resulting in water waste due to longer wait times until hot water reaches faucets.

Accepting the premise that a significant stock of existing buildings has pre-1992 fixtures, fairly significant water savings can be obtained through an engineered retrofit program that takes the above-mentioned flow through horizontal pipes into concern.

While water-conserving devices are generally low-maintenance items, they cannot simply be installed and forgotten. Technicians should check all units regularly and make periodic adjustments to flow-control devices. Automatic flow controls that are not hardwired require battery replacement, and flow-control openings should be checked for dirt and contaminants in the water system that can easily clog the smaller flow ways. Building owners and operators also need to establish a schedule for inspecting and testing all water-conserving devices. In setting up a program as the devices are installed, building operations teams can ensure that the low-flow fixtures will achieve their greatest potential.

2. Grey water

The idea behind grey water reclamation is simply getting the most out of water through reuse (see Figure 4). The water used in most commercial buildings has long been thought of in terms of clean clear water coming in, and sewage—or black water—going out. Grey water, however, is something in between. By most definitions, grey water is tap water soiled by use in washing machines, tubs, showers, and bathroom sinks that is not sanitary, but it's also not toxic and generally disease-free. Grey water reclamation is the process that capitalizes on the water's potential to be reused instead of simply piping it into a sewage system. Engineers are advised to consult with the local authority having jurisdiction (AHJ) to verify that grey water systems are allowed and determine if any special accommodations must be included in the design.

In commercial settings where bath, dish, and laundry water is available—excluding toilet wastes and free of garbage-grinder residues—grey water can provide a reasonable payback of investment. The grey water treatment process consists of a combination of solids separation, biological treatment, and ultraviolet disinfection. This system of water conservation uses simple diversion from the main plumbing system in which the water can be treated by sand filters, aeration, electroflotation (the removal of pollutants from water through the generation of bubbles that collect and carry pollutants to the surface), and pressure filtration ultimately being stored in above- or below-ground storage tanks. Once this process has taken place, the stored water can then be reused for applications such as toilet flushing, condenser water, and site irrigation. Grey water systems are not approved for storing and delivering potable drinking water. To minimize the possibility of cross-contamination, these systems must be in a separately piped system and specifically identified as a nonpotable source. This system also may prove to be problematic to vegetation and HVAC condensing water as harmful chemicals can be used to treat the reclaimed water. Consult with vendors of the receiving grey water systems to make them aware of the water source and quality.

Grey water systems require significant design effort and initial costs. They also bring the risk of contamination and pollution if mismanaged. Running costs for more involved systems can be high, with system payback potentially extending for many years. System maintenance and upkeep also play important factors in choosing this water conservation method. Filters, pumps, and treating stations all require attention. Grey water reclamation can be a difficult sell, but its potential can be fulfilled with the right application. Grey water systems are typically cost-effective in hospitality and similar buildings with high-volume, regular nonbiological contamination usage, such as laundry plants coupled with large nonpotable loads like toilet flushing and landscaping irrigation. Grey water systems are not cost-effective when the available grey water is not on par with demand. The upfront costs can be so high that the water savings just do not produce viable return on investment.

3. Rainwater harvesting

Commercial rainwater harvesting systems (see Figure 5) can be a viable option for owners and designers where a building with a large roof area also requires a high demand for nonpotable water. Again, this is based on the AHJ's guidelines. Capturing and storing rainwater is an easy and effective way to conserve water through a commercially viable payback period. Obviously, in areas where rainfall is more prevalent, it is easier to capture and store rainwater for meeting demands, thus providing payback of investment much earlier than in areas that have limited rainfall. With a design and components that are simple and a system that is generally easy to operate, upfront and operating costs can be an attractive proposition to the owner. A payback study can be accomplished by defining an area's annual rainfall and using the availability to compare demand savings based upon local water costs versus system upfront costs. The demands for a system of this type lie with irrigation and cooling tower makeup loads as the primary considerations behind implementing this method of water conservation. Therefore, the on-site requirements and performance of the storage components should be designed to meet the demand needs of the target load. Other uses of stored rainwater include laundry, toilet and urinal flushing, car washing, and ornamental water features.

Selecting a rainwater harvesting system is dependent on the collection area of the commercial site and the intensity of rainfall in the particular region of the country. Once the availability and demand are calculated, the system should be designed to meet the daily demand throughout the dry season. The system tank should be sized to be filled during conventional rain events with an overflow connected to the stormwater draining system. Additionally, the system should have a connection to the potable water system, through a break tank or some other form of physical air gap, to provide a supplemental water source during periods of low precipitation. Typically, direct rainwater collection systems intercept roof drain risers before they leave the building. The storage tanks can be located above or below ground. Site stormwater runoff can be collected through catch basins and site storm drainage at paved parking surfaces. Typically, there must be a system to separate oils and grit from the water before storing it. Significant coordination between the plumbing engineer and the civil efficiency. Some cooling towers can use recycled water like stormwater or grey water if the concentration ratio is maintained conservatively low. Similarly, blowdown water may be reused elsewhere on-site.

In an attempt to reduce water usage at cooling towers, the designer should focus on the two factors that can be controlled: drift (water droplets that are carried out of the cooling tower with the exhaust air) and blowdown (the removal of circulating water to maintain the amount of dissolved solids and other impurities at and acceptable level designated by the electrical conductivity of the water). Evaporation is integral to a cooling tower performance and cannot be reduced without an acceptable reduction in performance. Reducing blowdown to the minimum level consistent with good operating practice can conserve significant volumes of water. Treating the condenser water by chemical means usually reduces water loss. Installing conductivity meters on blowdown lines helps reduce water usage during the bleed/feed cycles. Drift can be reduced by baffles or drift eliminators. Not only do these devices reduce water loss from the system, they inherently contain water treatment chemicals within the system to improve operating efficiency and reduce environmental impacts.

These subtle improvements and modifications to the condenser water system should be incorporated into the installation at the design level to save significant amounts of water from the onset and provide an efficient system. Minimizing the condenser water loss, ensuring proper chemical levels, and constant system service will save valuable amounts of water.

9. Steam boiler blowdown

Boiler blowdown is the removal of water from a boiler to control boiler water conditions within prescribed limits to minimize scale, corrosion, carryover, and other specific problems. Blowdown is also used to remove suspended solids present in the system. Poor quality feedwater will result in more frequent blowdown.

A typical strategy used to reduce the need for blowdown is to use automated controls and treatment. Water can be conserved by controlling the amount of water lost due to excessive blowdown. Updated control equipment will prevent wide fluctuations in blowdown, which will reduce water loss and the energy used to heat that water. The rate of blowdown required depends on feedwater characteristics, load on the boiler, and mechanical limitations. Variations in these factors will change the amount of blowdown required.

10. Educate users

Water conservation is not only about innovation and good design practices, but also about building an understanding among water consumers to work together to achieve a greener and more energy-efficient environment. It is important to educate users about water scarcity issues and the impact of water conservation practices through signage and awareness campaigns at the point of use. The conservation of water reduces water waste and energy costs too, on both operation and production. Educated consumers will be better able to identify problems and think innovatively about ways to conserve or reuse water within the facility. Not only will the work environment benefit, but these tools can be taken back to the home, where individuals and families can use these practices to play an even larger role in the preservation of rapidly dwindling fresh water resources.

Water is a necessity for the sustenance of life on earth. While the supply may seem abundant, water is not an infinite resource, particularly fresh potable water necessary to our survival. Without our acknowledgement in the design and construction industry and in our everyday consciousness, this vital supply of water may be threatened. We, as owners, developers, and engineers, play a vital role in looking beyond our building codes and budgets to achieve higher levels of water efficiency. New technologies that use less water are becoming more important than ever, but our common sense and realization that our planet cannot give forever will ensure that future generations will enjoy the benefits of abundant fresh water because of the decisions that we make now.

engineer is crucial for a coordinated system. An effective rainwater harvesting system benefits not only the owner but also a municipality with an overburdened combined sewer system by diverting rainwater runoff. However, as with grey water, the inclusion of a rainwater harvesting system in a building's design may require the engineer to meet with governing authorities for approval.

4. Pressure reduction

In many high-rise and commercial settings, domestic water booster pumps are necessary to overcome the loss of pressure due to increases in elevation and to maintain water supply in water towers and supply tanks. With these higher pressures, water flows through the system with resulting greater flow through terminal fixtures beyond rated flow capacities, and this additional water is wasted as it serves no additional benefit to the rated performance. Most plumbing codes require pressure-reducing valves on systems where pressures exceed 80 psi. In most cases, these pressures could be lowered by the implementation of additional pressure-reducing valves. Additionally, the higher pressures can rupture pipes and damage fixtures. This leads to even greater waste in the domestic water system. When it comes to the domestic heating plant, if less water flows through the system, then less energy is needed to heat the domestic hot water in the first place.

5. Insulate piping

For a domestic hot water system, clearly it is better—and now an energy code requirement—to insulate all piping and storage tanks. In many existing commercial buildings, domestic hot and hot water return piping is either uninsulated or not insulated properly. As a result, when there is a demand for hot water, the user will wait at faucets and showers for the hot water to flow, resulting in significant water waste. Properly insulating return piping also ensures that warmer water will be supplied back to the hot water plant, thus reducing the energy demand at the heating plant. By properly insulating hot water pipes, heat losses can be reduced and terminal fixture water temperatures can be effectively raised without any additional energy usage. When hot water is immediately available, the user is less likely to waste.

6. Leak proofing/leak repair

Leaking pipes can go unnoticed, sometimes for years. Water distribution piping is inevitably installed in every nook and cranny, crawlspace, and chases throughout all types of buildings. Pipes are concealed out of sight, and more times than not, leaks are not found until water damage is evident on chase walls and ceilings. Rates of water loss vary significantly depending on the type and severity of the leak. Dripping water taps and leakage from toilet cisterns can lose gallons of water per day. Proper preventive maintenance, proactive approaches, and quick fixes are necessary for water conservation, but there are steps that can be taken prior to installation that can potentially discover future leaks prior to the inevitable failure.

Design modifications that can reduce leaks or find leaks prior to waste and damage Include checking water usage through metering and submetering. Leak detection systems in critical or remote locations tied to a BAS to notify maintenance staff of water leaks ensure a quick response before building walls, ceilings, and equipment are permanently damaged. Piping dedicated lines to high-usage areas ensures that pressure is maintained at the point of use. Isolating zones in buildings also gives the end user the ability to shut down areas where leaks have occurred without interrupting the overall building usage. The fundamental idea is ease of maintenance and inspection. Leaks are inevitable, but with methods and procedures in place and—don't forget—an upfront cost, damage and water wastage can be reduced.

7. Rain sensor on irrigation

One of the quickest and simplest ways to address water conservation in irrigation systems is to add a rain sensor. Rain sensors are designed to identify when precipitation is present and lock-out a controller so it does not run its program and irrigate when watering is unnecessary. After the rain event, the sensor automatically resets, allowing the controller to resume its schedule without losing any program information.

8. Cooling tower water recovery

Cooling towers remove heat from a building's air conditioning system by evaporating some of the condenser water. Since all cooling towers continually lose water through evaporation, drift, and blowdown, they can consume a significant percentage of a building's total water usage. Towers that are in good condition, operated properly, and well maintained allow chillers to operate at peak

Water Conservation Systems

What It Is

Water is the "invisible utility", whose usage patterns are too often overlooked by companies as a cost of doing business. Water bills can account for as much as 20% of a buildings' utility cost and upwards in process applications. Compared to other countries, Canadian water prices are well below average. The cost of water is likely to rise as watersheds are depleted, water conservation and efficiency standards are legislated, and municipal governments increase rates to fund repairs to aging infrastructure.

To reduce water utility bills, building owners must find ways to limit their consumption without sacrificing occupancy comfort. There are 3 ways to mitigate water utility spending; by reducing use, reusing, and by collecting.

How It Works

- Low Flow & Waterless Fixtures - plumbing fixtures (kitchen and bathroom taps, toilets, urinals, and water fountains) account for a large portion of a buildings water use. We can reduce their water use by replacing existing toilets with specially designed 'low-flow' fixtures (such as dual flush toilets) that will use 50% less water. Traditional urinal systems have timed cycles that will constantly flush even when they are not used, by integrating water less or motion controlled units we can eliminate this waste. Sinks can be fitted with tap sets that have electronic sensors which control water flow to timed or motion activated bursts. Shower heads can be replaced with higher efficiency heads that save water while maintaining high pressure.
- Grey-water recycling – is the process of reusing water from sinks, baths, showers, dish-washing, laundromats, carwashes etc. is a practice that is becoming more popular as water utility prices increase. Here grey water is collected, filtered and stored for use as a supply for toilets and landscape irrigation. Black-water (from toilets) is the only waste water flushed down the drain. There is huge potential for water savings with these systems, and in larger buildings, they are more cost effective if the system is incorporated in new construction.
- Hydronic Cooling Water Reductions - Larger system components that use water should also be considered for replacement. Older Hydronic Cooling towers, can account for a large portion of a buildings water utility use. Towers serving old, inefficient A/C systems can easily use twice the water that a new chiller would need. Also some older buildings still operate a 'once-through' cooling system, which simply flushes water over a cooling coil and drains the water down the drain. This system costs ten times as much to operate as a modern air-cooled system.
- Rain water collection - has been done throughout history. Minimal filtering is required before storage and reuse if the collected rainwater is used for toilets, landscape irrigation and in some cases process use. More advanced filtration such as ultraviolet water purifiers may be required depending on length of time stored and desired water usage. Rain water collection is usually quite effective, because most large commercial/industrial buildings have large, flat roofs that provide lots of space for collection. Imagine collecting rainwater to water your companies rooftop garden.

Benefits

- Water utility cost reductions from 50% to 90%
- Limit the impact of budgeting uncertainties associated with large yearly water utility rate increases
- Reduces load on municipal water and sewage treatment facilities

Water conservation and rain water harvesting

Water Conservation

Water being one of the most precious and indispensable resources needs to be conserved. **Water conservation refers to any beneficial reduction of water usage, loss or waste.** It also includes the strategies and activities to manage and protect water resources to meet the demand for human consumption.

The key activities that benefit water conservation are as follows :

1. Any beneficial reduction in water loss, use and waste of resources.
2. Avoiding any damage to water quality.
3. Improving water management practices that reduce the use or enhance the beneficial use of water. (like rain water harvesting)

Goals of water conservation efforts include :

- **Sustainability** : Ensuring availability of water for future generations where the withdrawal of freshwater from an ecosystem does not exceed its natural replacement rate.
- **Energy Conservation** : Water pumping, delivery and wastewater treatment facilities consume a significant amount of energy.
- **Habitat Conservation** : Minimizing human water use helps to preserve freshwater habitats for local wildlife and migrating waterfowl.
- Water conservation also helps in reducing the need to build new dams and other water diversion infrastructure.

Steps for water conservation

The following strategies can be adopted for conservation of water :

- **Decreasing run-off losses**: Huge water-loss occurs due to runoff on most of the soils, which can be reduced by allowing most of the water to infiltrate into the soil. This can be achieved by using contour cultivation, terrace farming, water spreading, chemical treatment or improved water-storage system.

- **Reducing evaporation losses**: This is more relevant in humid regions. Horizontal barriers of asphalt placed below the soil surface increase water availability and increase crop yield by 35-40%.
- **Storing water in soil**: Storage of water takes place in the soil root zone in humid regions when the soil is wetted to field capacity. By leaving the soil fallow for one season water can be made available for the crop grown in next season.
- **Reducing irrigation losses**
    a. Use of lined or covered canals to reduce seepage.
    b. Irrigation in early morning or late evening to reduce evaporation losses.
    c. Sprinkling irrigation and drip irrigation to conserve water by 30-50%.
    d. Growing hybrid crop varieties with less water requirements and tolerance to saline water help conserve water
- **Re-use of water**
    a. Treated wastewater can be used for ferti-irrigation.
    b. Using grey water from washings, bath-tubs etc. for watering gardens, washing cars or paths help in saving fresh water.
- **Preventing wastage of water**: This can be done in households, commercial buildings and public places.
    a. Closing taps when not in use
    b. Repairing any leakage from pipes
    c. Using small capacity flush in toilets.
- **Increasing block pricing**: The consumer has to pay a proportionately higher bill with higher use of water. This helps in economic use of water by the consumers.

Rain Water Harvesting

Rainwater harvesting is a technique of increasing the recharge of groundwater by capturing and storing rainwater. This is done by constructing special water-harvesting structures like dug wells, percolation pits, lagoons, check dams etc.

Objectives of rain water harvesting

- to reduce run off loss
- to avoid flooding of roads
- to meet the increasing demands of water
- to raise the water table by recharging ground water
- to reduce groundwater contamination
- to supplement groundwater supplies during lean season.

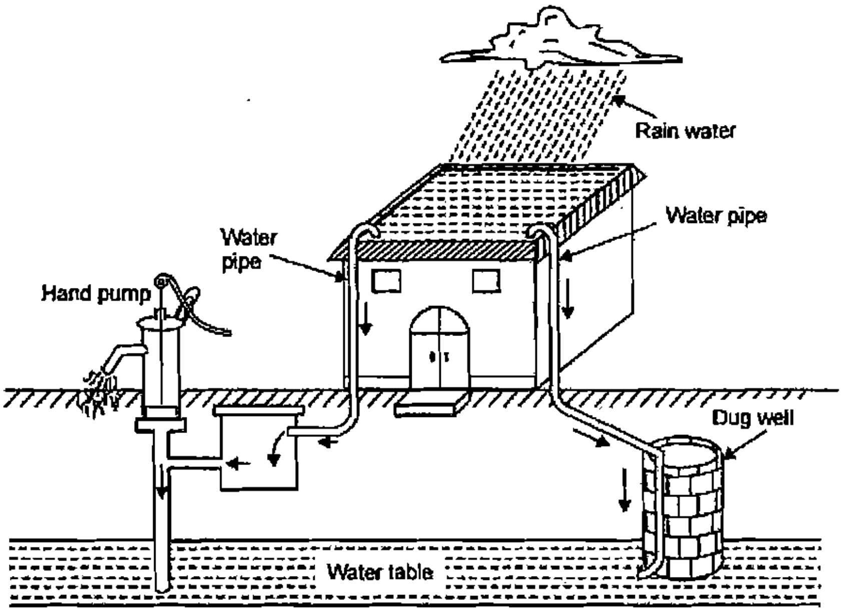
Methods of rain water harvesting

Rainwater can be mainly harvested by any one of the following methods:

- by storing in tanks or reservoirs above or below ground.
- by constructing pits, dug-wells, lagoons, trench or check-dams on small rivulets.
- by recharging the groundwater.

Roof top rain water harvesting

Roof top rain water harvesting is a low cost and effective technique for urban houses and buildings. The rain-water from the top of the roofs is diverted to some surface tank or pit through a delivery system which can be later used for several purposes. Also, it can be used to recharge underground aquifers by diverting the stored water to some abandoned dug-well or by using a hand pump.



Roof-top rainwater harvesting by recharging

(i) through hand pump or (ii) through Dug well.

Benefits of Water Harvesting:

1. It can be used for drinking.
2. It could be utilized for irrigation purposes.
3. This water increases the underwater level.
4. It keeps you urban flood.
5. Reduce sea water entrance in coastal areas

Strategic insight

1. Introduction and Global Status

Waste-to-Energy (WtE) technologies consist of any waste treatment process that creates energy in the form of electricity, heat or transport fuels (e.g. diesel) from a waste source.

These technologies can be applied to several types of waste: from the semi-solid (e.g. thickened sludge from effluent treatment plants) to liquid (e.g. domestic sewage) and gaseous (e.g. refinery gases) waste. However, the most common application by far is processing the Municipal Solid Waste (MSW) (Eurostat, 2013). The current most known WtE technology for MSW processing is incineration in a combined heat and power (CHP) plant.

MSW generation rates are influenced by economic development, the degree of industrialisation, public habits, and local climate. As a general trend, the higher the economic development, the higher the amount of MSW generated. Nowadays more than 50% of the entire world's population lives in urban areas. The high rate of population growth, the rapid pace of the global urbanisation and the economic expansion of developing countries are leading to increased and accelerating rates of municipal solid waste production (World Bank, 2012). With proper MSW management and the right control of its polluting effects on the environment and climate change, municipal solid waste has the opportunity to become a precious resource and fuel for the urban sustainable energy mix of tomorrow: only between 2011 and 2012, the increase of venture capital and private equity business investment in the sector of waste-to-energy - together with biomass - has registered an increase of 186%, summing up to a total investment of USD 1 billion (UNEP/Bloomberg NEF, 2012). Moreover, waste could represent an attractive investment since MSW is a fuel received at a gate fee, contrary to other fuels used for energy generation, thus representing a negative price for the WtE plant operators (Energy Styrelsen, 2012).

However, an increasingly demanding set of environmental, economic and technical factors represents a challenge to the development of these technologies. In fact, although WtE technologies using MSW as feed are nowadays well developed, the inconsistency of the composition of MSW, the complexity of the design of the treatment facilities, and the air-polluting emissions still represent open issues for this technology.

The development of WtE projects requires a combination of efforts from several different perspectives. Along with future technical developments, including the introduction in the market of alternative processes to incineration, it is nowadays crucial to take into account all the social, economic and environmental issues that may occur in the decision making process of this technology.

Growing population, increased urbanization rates and economic growth are dramatically changing the landscape of domestic solid waste in terms of generation rates, waste composition and treatment technologies. A recent study by the World Bank (2012) estimates that the global MSW generation is approximately 1.3 billion tonnes per year or an average of 1.2 kg/capita/day. It is to be noted however that the per capita waste generation rates would differ across countries and cities depending on the level of urbanization and economic wealth.

Figure 1

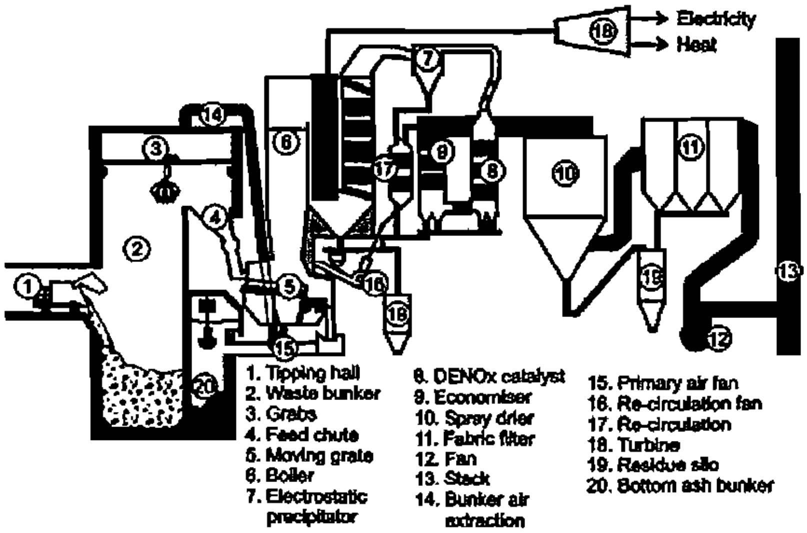


Figure 2

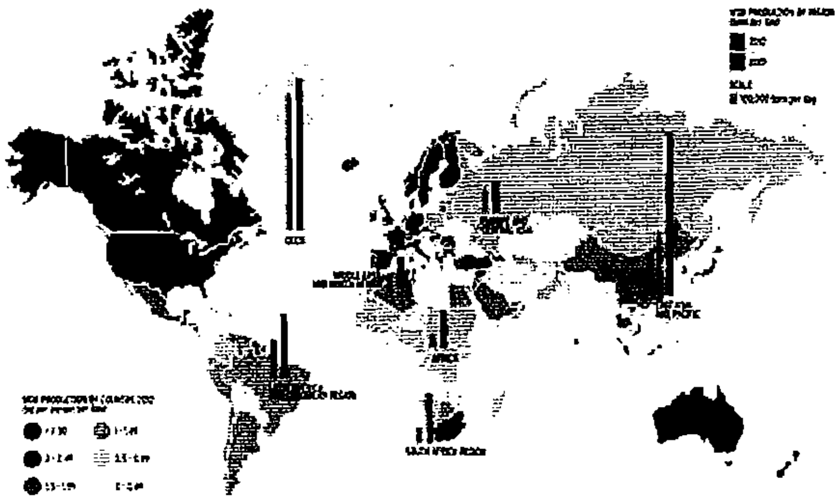
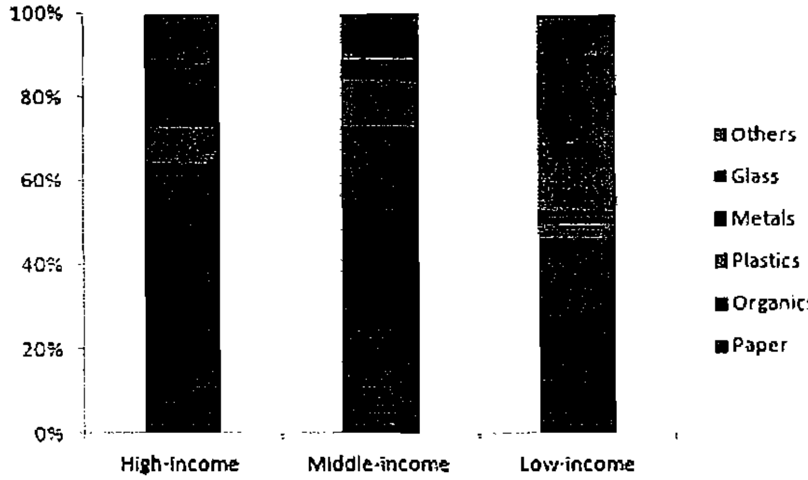


Figure 3



The amount of municipal solid waste generated is expected to grow faster than urbanization rates in the coming decades, reaching 2.2 billion tons/year by 2025 and 4.2 billion by 2050 (World Bank, 2012; Mavropoulos, 2012).

Today, the majority of MSW is generated in developed countries (North America and European Union) as shown in Figure 2. However, the fastest growth in MSW generation for the coming decade is expected mainly in emerging economies in Asia, Latin America and South Africa.

In terms of waste composition, there is a shift towards an increased percentage of plastic and paper in the overall waste composition mainly in the high-income countries, as shown in Figure 3 (UNEP, 2010). It is expected that both middle- and low-income countries would follow the same trends with the increase of urbanization levels and economic development in these countries.

2. Technical and economic considerations

WtE technologies are able to convert the energy content of different types of waste into various forms of valuable energy. Power can be produced and distributed through local and national grid systems. Heat can be generated both at high and low temperatures and then distributed for district heating purposes or utilized for specific thermodynamic processes. Several types of biofuels can be extracted from the organic fractions of waste, in order to be then refined and sold on the market.

As of today, the most common and well-developed technology is in the form of Combined Heat and Power plants, which treat Municipal Solid Waste - and possibly a combination of industrial, clinical and hazardous waste, depending on the system settings - through an incineration process. Technical and economic considerations will be therefore limited to this type of plant.

By definition, waste incineration is carried out with surplus of air. This process releases energy and produces solid residues as well as a flue gas emitted into the atmosphere (Hulgaard T. & Vehlow J., 2011). Because of emission and safety concerns, there is a certain temperature range that is demanded for this type of process. In the case of mixed waste, a furnace temperature of 1050°C is required. A generic description of an incineration process is represented in the following figure (Figure 1). As depicted in Figure 1, waste is first deposited and then extracted from a bunker, and then it is processed on a moving grate in order to achieve a correct combustion. Before undergoing the combustion phase, the incoming waste may be exposed to pretreatment, depending on its quality, composition and the selected incineration system.

The combustion products (flue gases) then exchange heat in a boiler, in order to supply energy to a Rankine cycle. This cycle will then provide power and heat by activation of a turbine and by means of a heat exchanger respectively. The choice of the boiler type is strictly related to the choice of the desired final use of the produced energy.

Within the incineration plant, the flue gas cleaning system (which can be designed in different ways - from filters to electrostatic precipitators) and a series of fans ensure both a correct combustion process and controlled emissions. However, there will be a certain percentage of substances emitted into the atmosphere, depending on the MSW composition and on the type of cleaning systems used. The common pollutant particles in the flue gas are CO_2, N_2O, NO_x, SO_x and NH_3.

Furthermore, it is possible to achieve energy recovery within the cleaning system, when focusing on the flue gas flow. Apart from flue gases that are used to produce heat and power in the incineration plant, the other main product of the process consists of solid residues, mostly in the form of bottom ash or slag and fly ash; some of which can be reused in applications such as filling in the building and construction industries.

The efficiencies for the described incineration process, in terms of energy production, are typically around 20-25% if operating in CHP mode and up to 25-35% in the case of power production only. The size of CHP plants can vary significantly, both in terms of waste input capacity and of power output. A typical capacity is of one (or few) process units, each one dealing with 35 tonnes/hr of waste input (Energinet, 2012). According to the Energy Styrelsen report about Technology Data for Energy Plants (2012), the best example of available WtE incineration technology is the Afval Energie Bedrijf CHP plant in Amsterdam, in operation since 2007. It is the largest incineration plant in the world (114.2 MW) and is able to process 1.5 million tonnes of MSW per year with an electricity generation efficiency of 30%.

It is typical for the described technology to be running at full load during all operation hours, and therefore to be utilized as a base load unit within the electricity generation mix. However, especially in new plant designs, it is possible to achieve significant flexibility of operations through down-regulation, without exceeding the fixed limits for steam quality and environmental performance.

The most important economic difference between WtE technologies and other combustion-based energy generation units is strictly related to the nature of the input fuel. Waste has a negative price, which is regulated by prefixed gate-fees, and is usually considered as the main source of income for the WtE plant owners. In this sense, incineration facilities have the primary purpose of waste treatment. Generation of electricity and heat can be considered as a useful byproduct, with relative additional earnings. Furthermore, the dispatch of power from WtE units is prioritized over other generation units, thus yielding a guaranteed income form during all operations.

Regarding the technology-related costs, the initial investment costs for the construction of the plant play an important role because of the large size of these facilities and of the main installed components. Capital costs, however, can vary significantly as a function of the selected processes for the treatment of flue gases and other produced residues. Operation and maintenance costs have a lower impact on the total expenses of the facility and are mainly related to the amount of treated waste.

3. Market trends and outlook

Despite the recent economic crisis, the global market of waste to energy has registered a significant increase in the past few years and is expected to continue its steady growth till 2015. In 2012, the global market for waste-to-energy technologies was valued at USD 24 billion, an average annual increase of 5% from 2008. The waste to energy market is expected to reach a market size of USD 29 billion by 2015 at a Compounded Annual Growth Rate (CAGR) of 5.5% (Frost & Sullivan, 2011).

The main drivers for this growth could be summarized in an increasing waste generation, high energy costs, growing concerns of environmental issues, and restricted landfilling capacities. WtE would help solve these issues by reducing the waste volume and cutting down on greenhouse gas emissions. Moreover, legislative and policy shifts, mainly by European governments, have significantly affected the growth of WtE market as well as the implementation of advanced technology solutions.

Figure 4.1

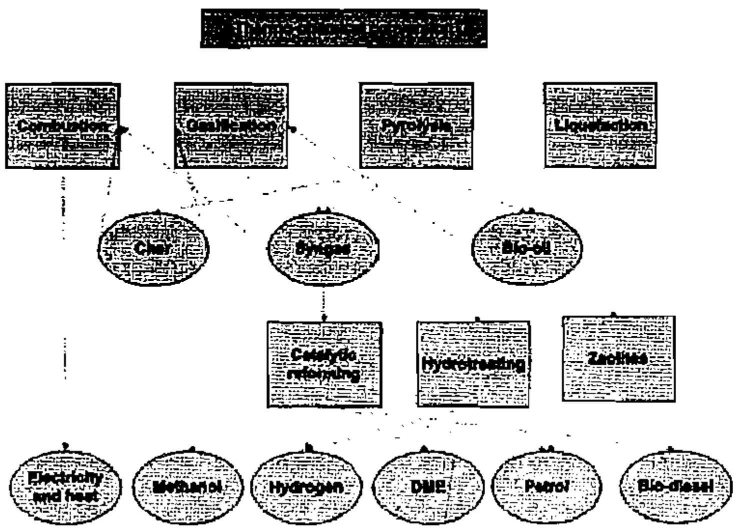
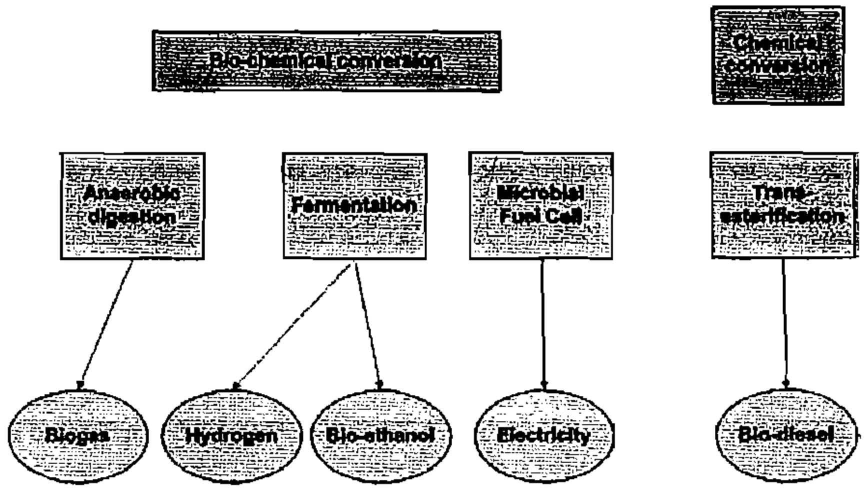


Figure 4.2



The thermal WtE segment is expected to keep the largest share of the total market (approximately 90% of total WTE revenues by 2015). This segment would be expected to increase from 18.5 to reach USD 25.3 billion by 2015 at a CAGR of 6.7%. The biochemical WtE segment would witness a rapid growth from USD 1.4 billion to USD 2.75 billion in 2015 at a CAGR of 9.7% (Frost & Sullivan, 2011).

In terms of markets, the Asia-Pacific region is the fastest growing market for WtE and should witness a significant growth by 2015 with major expansions in China and India. Many of these countries see WtE as a sustainable alternative to landfills. The European market is expected to expand at an exponential rate for the next decade with European Union's efforts to replace the existing landfills with WtE facilities. Moreover, there is a current trend with the private sector actively developing large-scale WtE projects as opposed to the traditional public sector monopoly. This would influence the future of WtE as more players would be expected to enter the market which would help decrease prices and increase technological advancements.

Currently, CHP incineration is the most developed and commercialized technology for WtE conversion. However, a number of different technological configurations are already available for this purpose and, with a constant R&D, many others are envisioned to become valuable alternatives in the future.

The following classification illustrates the possible methodologies which can be used in order to obtain energy from waste.

Thermo-chemical conversion

Looking at thermo-chemical conversion processes, in which the energy content of waste is extracted and utilized by performing thermal treatments with high temperatures, the choice of fuel strongly determines the type of process.

- **Incineration:** With mixed waste input, simple incineration is often utilized by means of the previously described CHP plant technology.
- **Co-combustion:** Co-combustion with another fuel (typically coal or biomass) is an alternative that makes it easier to control the thermal properties of the fuel; in particular the Lower Heating Value. Also, co-combustion is an attractive alternative to simple coal combustion both in terms of costs and emission levels (Rechberger H., 2011).
- **Residual Derived Fuel (RDF) Plant:** The possibility to achieve higher energy contents is the main advantage of Refuse-Derived Fuel (RDF), which can be achieved from different kinds of waste fractions. Its high and uniform energy content makes it attractive for energy production, both by mono-combustion and co-combustion with MSW or coal (Rotter S., 2011).
- **Thermal Gasification:** Thermal gasification is a process which is able to convert carbonaceous materials into an energy-rich gas. When it comes to gasification of waste fractions, it is often agreed that this technology is not yet sufficiently developed in comparison to combustion. However, this process could present many favorable characteristics such as an overall higher efficiency, better quality of gaseous outputs and of solid residues and potentially lower facility costs (Astrup T., 2011). Thus gasification, with proper future technology developments, could be considered a valuable alternative to combustion of waste.

Bio-chemical conversion

Energy can also be extracted from waste by utilizing bio-chemical processes. The energy content of the primary source can be converted, through bio-decomposition of waste, into energy-rich fuels which can be utilized for different purposes.

- **Bio-ethanol production:** Bio-ethanol can be produced by treating a certain range of organic fractions of waste. Different technologies exist; each of which involving separate stages for hydrolysis (by enzymatic treatment), fermentation (by use of microorganisms) and distillation. Other than bioethanol, it is possible to obtain hydrogen from the use of these technologies, which is a very useful and promising energy carrier (Karakashev D. & Angelidaki I., 2011)
- **Dark fermentation and Photo-fermentation producing bio-hydrogen:** Dark fermentation and photo-fermentation are techniques that can convert organic substrates into hydrogen with the absence or presence of light, respectively. This is possible because of the processing activity of diverse groups of bacteria. These technologies can be interesting when it comes to researching valuable options for waste water treatment (Angenent et al., 2004).
- **Biogas production from anaerobic digestion:** Anaerobic digestion is a biological conversion process which is carried out in the absence of an electron acceptor such as oxygen (Angelidaki I. & Batstone D.J., 2011). The main products of this process are an effluent (or digest) residue and an energy-rich biogas. The entire conversion chain can be broken down into several stages (Figure 5), in which different groups of microorgan-

isms drive the required chemical reactions. The obtained biogas can be used either to generate power and heat or to produce biofuels. The digest can also be utilized in many different ways depending on its composition. Several technologies utilizing this process have been developed throughout the years but are still considered to be immature and not economically competitive compared to other WtE technologies.

- **Biogas production from landfills:** Other than in an anaerobic digester, it is possible to extract biogas directly from landfill sites, because of the natural decomposition of waste (Tchobanoglous et al., 2002). In order to do so, it is necessary to construct appropriate collecting systems for the produced biogas. Biogas in landfills is generally produced by means of complex bio-chemical conversion processes, usually including different phases like Initial Adjustment, Transition Phase, Acid Phase, Methane Fermentation and Maturation Phase (Zaman, 2009).
- **Microbial fuel cell:** A microbial fuel cell is a device that is able to produce electricity by converting the chemical energy content of organic matter. This is done through catalytic reaction of microorganisms and bacteria that are present in nature. This technology could be used for power generation in combination with a waste water treatment facility (Min B., Cheng S. & Logan B.E., 2005).

Chemical conversion (Esterification):

The chemical process of esterification occurs when an alcohol and an acid react to form an ester. If applying this process to WtE treatment, it is possible to obtain various types of biofuels from waste. (Nic et al., 2006).

Figure 5

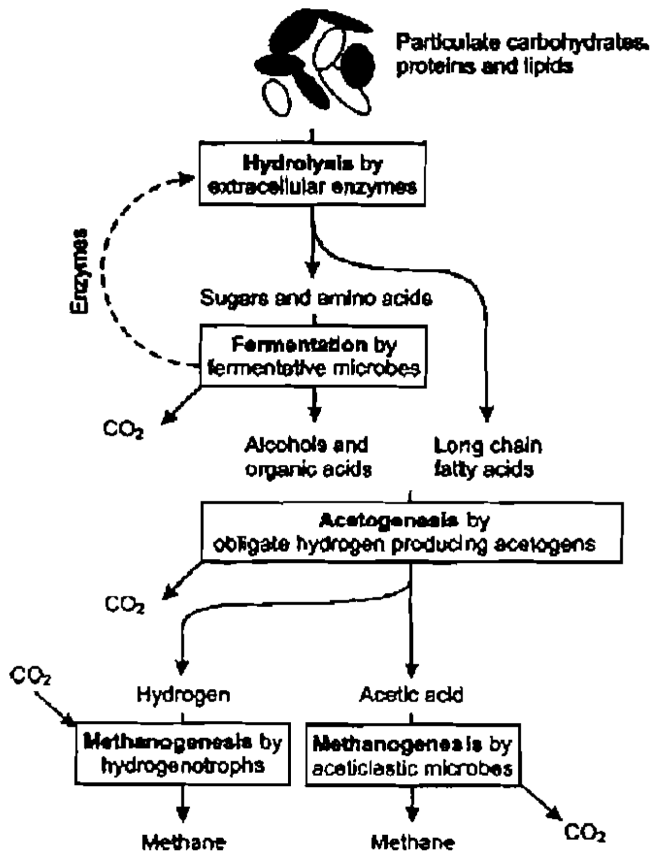


Figure 6

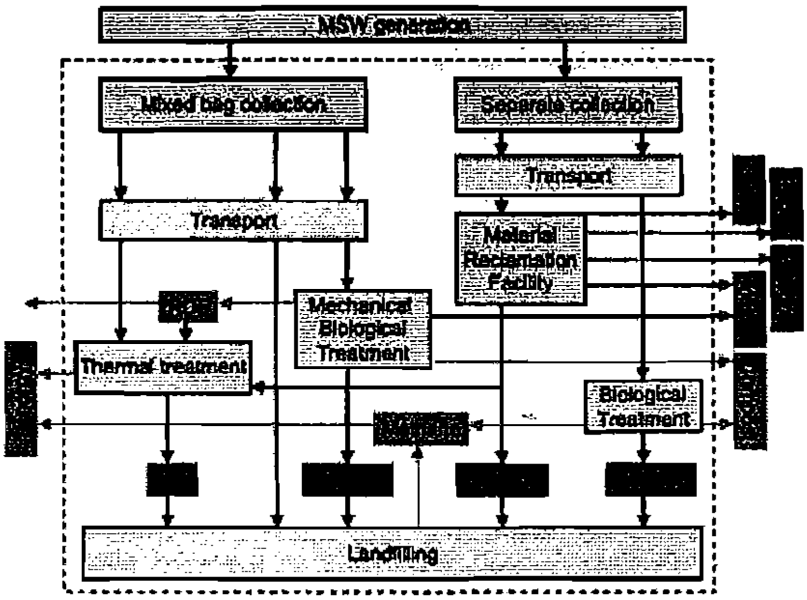


Figure 7

	Low Income Countries	Lower Middle Income Countries	Upper Middle Income Countries	High Income Countries
Income (GNI/capita)	<$876	$876-3,465	$3,466-10,725	>$10,725
Waste Generation (tonnes/capita/yr)	0.22	0.29	0.42	0.78
Collection Efficiency (percent collected)	43%	68%	85%	98%
Cost of Collection and Disposal (US$/tonne)				
Collection[1]	20-50	30-75	40-90	85-250
Sanitary Landfill	10-30	15-40	25-65	40-100
Open Dumping	2-8	3-10	NA	NA
Composting[1]	5-30	10-40	20-75	35-90
Waste-to-Energy Incineration[4]	NA	40-100	60-150	70-200
Anaerobic Digestion[5]	NA	20-80	50-100	65-150

NOTE: This is a compilation table from several World Bank documents, discussions with the World Bank's Thematic Group on Solid Waste, Carl Bartone and other industry and organizational colleagues. Costs associated with uncollected waste—more than half of all waste generated in low-income countries—are not included.

The current WtE market is continuously under development and these and other new technologies are likely to play an important role in the foreseeable future, as long as they can prove to be sufficiently competitive with the more traditional Incineration process from a technical, economic and environmental perspective.

LCA, including current costs, efficiencies and emissions & water for each phase: extraction, transport, processing, distribution, use

In the development of WtE projects, the consideration of the environmental implications is playing an increasingly important role. The Life Cycle Analysis (LCA) approach is more and more used as a support tool in strategic planning and decision-making process of WtE projects (Christensen et al., 2007). However, dealing with a general Life Cycle Analysis for MSW WtE systems could be a challenging task. The inputs and outputs of the WtE systems could markedly vary from project to project: in fact, the composition and cost of the waste strongly depend on the location of the project. Efficiencies and emissions can vary significantly by the WtE plant design and waste composition; so does the size of the markets for products derived from WtE facilities (Mendes et al., 2004).

Zaman (2009) presents a comparative LCA study among four of the main WtE technologies from energy generation perspective. The considered technologies are: 1. Landfill gas production; 2. Incineration; 3. Thermal Gasification; 4. Anaerobic Digestion. The study also includes the environmental impacts associated with the emissions of the analysed systems.

The cradle-to-grave life cycle of a WtE technology (Figure 6) begins with the waste generation e.g. when the owner of a product discards it in the waste collection trash cans. Then, depending on the country and/or regional laws, the waste is collected either via mixed-waste bags or via separate collection; in both cases a dedicated infrastructure for the collection is required (e.g. dedicated bins, dedicated collection vehicles, storage units, etc). The next stage is the transportation of the collected waste to the waste treatment facility: the mixed-waste bag reaches the WtE facility/plant (landfill gas production, incineration, pyrolysis-gasification, anaerobic digestion), whilst the separated waste goes to the Materials Reclamation Facility (MRF). The next stage of the life cycle is then the processing of the waste inside the WtE plant: energy in the form of heat, electricity and fuels are produced, as well as residues and ashes.

Regarding the collection, storage and transportation of the MSW, LCA studies show that the door-to-door collection system has a higher environmental impact than the multi-container collection system (Iriarte et al., 2009). Moreover, the bring systems (where individuals physically bring the waste to the collection points), although widely used in modern waste collection schemes, have higher overall environmental impacts than the curbside collection, where the collection of waste is centralised (Beigl & Salhofer, 2004). Eventually, it is believed that using bigger high-density polyethylene (HDPE) bins in the collection systems will yield a lower environmental impact than if using smaller HDPE bins (Rives et al., 2010). The costs associated with the collection and disposal of the MSW depend, of course, on the considered country. An overview of the estimated solid waste management costs by disposal method is shown in Figure 7 below.

Concerning the WtE processing, LCA studies demonstrate that landfill gas production has the highest emissions of carcinogenic substances among the considered technologies. It has respiratory effects of organic solvent exposure and presents a higher level of toxicity and an overall higher impact on climate change (Zaman, 2009). As reported by Abeliotis (2011) landfills represent the worst management option from a waste management point of view (Miliute & Staniskis, 2010; Cherubini et al., 2009; Wanichpongpan & Gweewala, 2007; Hong et al., 2006; Mendes et al., 2004). Incineration, on the other hand, has a high impact on climate change and acidification and presents respiratory effects of organic solvent exposure. The Thermal Gasification and Anaerobic Digestion processes have significant lower environmental impacts than other considered WtE options (Zaman, 2009). The LCA simulation conducted by De Feo & Malvano (2009) of 12 different MSW WtE scenarios with 16 management phases for each scenario, clearly shows that following the 11 considered impact categories, there is a different "best scenario" option for each category: the MSW WtE management options should be evaluated case-by-case.

References

Angelidaki I. & Batstone D.J. (2011) "Anaerobic digestion: process" in *Solid waste technology & management*

Angenent, L.T., Karim, K., Al-Dahhan, M.H., Wrenn, B.A., Domíguez-Espinosa, R., 2004. Production of bioenergy and biochemicals from industrial and agricultural wastewater. "Trends in Biotechnology" 22, 477-85.

Astrup T. (2011). "Pyrolysis and Gasification" in *Solid waste technology & management*

Beigl P. & S. Salhofer (2004). Comparison of ecological effects and costs of communal waste management systems. *Resources, Conservation and Recycling, 41, 83-102.*

Cherubini, F., Bargigli, S., & Ulgiati, S. (2009) Life cycle assessment (LCA) of waste management strategies: Landfilling, sorting plant and incineration. *Energy, 34, 2116-2123*

Christensen, T.H., G. Bhander, H. Lindvall, A.W. Larsen, T. Fruergaard, Anders Damgaard, S. Manfredi, A. Boldrin, C. Riber and M. Hauschild, 2007. Experience with the use of LCA-modelling (EASEWASTE) in waste management, *Waste Management and Research, 25: 257-262.*

De Feo, G., & Malvano, C. (2009) The use of LCA in selecting the best management system. *Waste Management, 29*, 1901-1915

Energy Styrelsen, Dansih Energy Agency, Energinet.dk (2012): Technology Data for Energy Plants: Generation of Electricity and Distric Heating, Energy Storage and Energy Carrier Generation and Conversion

Eurostat (2013): http://epp.eurostat.ec.europa.eu/portal/page/portal/waste/introduction/

Frost & Sullivan (2011). Key opportunities in waste to energy plant market (technical insights).

Hong, R.J., Wang, G.F., Guo, R.Z., Cheng X., Liu Q., Zhang P.J. & Qian G.R. (2006). Life cycle assessment of BMT-based integrated municipal solid waste management: Case study in Pudong, China. *Resources, Conservation and Recycling, 49, 129-146*

Iriarte, A., Gabarell, X., & Rieradevall, J. (2009) LCA of selective waste collection systems in dense urban areas. *Waste Management, 29, 903-914*

Hulgaard T. & Vehlow J. (2011). "Incineration: process and technology," in *Solid waste technology & management*

Karakashev D. & Angelidaki I. (2011) "Emerging biological technologies: biofuels and biochemicals" in *Solid waste technology & management*

Konstadinos Abeliotis (2011). Life Cycle Assessment in Municipal Solid Waste Management, Integrated Waste Management - Volume I, Mr. Sunil Kumar (Ed.), *ISBN: 978-953-307-469-6*

Mavropoulos, Alexandros (2012). International Scenario in Waste and e-Waste Management,D-waste.

Mendes, M.R., Aramaki, T., & Hanaki, K. (2004) Comparison of the environmental impact of incineration and landfilling in Sao Paulo city as determined by LCA. *Resources, Conservation and Recycling, 41, 47-63*

Miliūtė J., & Staniškis, J. K. 2010. Application of life-cycle assessment in optimisation of municipal waste management systems: the case of Lithuania. *Waste Management & Research, 28, 298-308*

Min B., Cheng S. & Logan B.E. (2005). "Electricity generation using membrane and salt bridge microbial fuel cells"

Münster M. (2009). "Energy Systems Analysis of Waste-to-Energy technologies"

Nic, M.; Jirat, J.; Kosata, B., eds. (2006–). "esters". *IUPAC Compendium of Chemical Terminology* (Online ed.). doi:10.1351/goldbook.E02219. ISBN 0-9678550-9-8.

Pike Research (2012). Waste to energy technology markets. Renewable power and heat generation from Municipal Solid Waste: market outlook, technology assessment and capacity and revenue forecasts.

Rechberger H. (2011). "Incineration: Co-combustion" in *Solid waste technology & management*

Rives, J. Rieradevall, J., & Gabarell, X. (2010) LCA comparison of container systems in municipal solid waste management. *Waste Management, 30, 949-957*

Rotter S. (2011). "Incineration: RDF and SRF - Solid waste from fuels" in *Solid waste technology & management*

Tchobanoglous, George and Kreith, Frank, 2002. Handbook of Solid Waste Management, 2nd Edition, McGraw-Hill, ISBN: 9780071356237

The Economist (2012). A rubbish map. The Economist online.

UNEP (2010). Trends in solid waste management : issues, chamllenges and opportunities. International Consultative Meeting on Expanding Waste Management Services in Developing Countries. Tokyo,Japan.

UNEP / Bloomberg New Energy Finance (2012): Global Trends in Renewable Energy Investment 2012. Frankfurt, Germany.

Wanichpongpan, W., & Gheewala, S.H. (2007) Life cycle assessment as a decision support tool for landfill gas-to energy projects. *Journal of Cleaner Production, 15, 1819-1826*

World Bank (2012). What a waste: a global review of solid waste management. Urban development series knowledge papers.

Zaman, A.U. (2009) Life Cycle Environmental Assessment of Municipal Solid Waste to Energy Technologies. EESI, School of Architecture and the Built Environment, KTH Royal Institute of Technology, Stockholm, Sweden, *Global Journal of Environmental Research 3 (3): 155-163, 2009*

Luca Lo Re L
General Manager France, BNL Clean Energy
Gianmarco Piamonti
Sustainable Energy Engineer, BNL Clean Energy
Mohamad Tarhini
Business Manager, BNL Clean Energy

Reserves and production

Table 1
Municiple Solid Waste reserves and production

	Quantity raw waste			Yield of solid fuel	Electricity Generation Capacity	Annual Electricity Generation	Direct Use from Combustion	Total Energy Production
Country	TJ	TTOE	million tonnes	GJ/tonne	kW	TJ	TJ	TJ
Albania		405						
Algeria			5					
Australia			6.9	9	11.4			
Austria			2.4				16421	30270
Belgium			1.1		76600			1765
Botswana							1420	
Brazil			40		41870			2311
Canada			11.856		211187		1.688	
Croatia			1.5		2000	0.0144		
Czech Republic			0.24		3000	42	1966	2008
Denmark	40051					6718		
Egypt			2.4					
Estonia			0.569					
Finland			2.2			2160	2380	4610
France		2394			772800	13586	27209	40795
Germany			0.94		852000	11200		
Greenland				10.5			83	
Hong Kong			7.7					
Hungary			0.2	12.5		1504	28093	62993
Iceland					831	15	56	71
Ireland								1085
Israel			5					
Italy						619475	5602	
Japan			0.601		2230000			
Jordan			2		1000	5142 MWh	5142 MWh	
Korea (Republic)							21153	
Latvia					9400	106		
Lebanon			1.44					
Mexico			37.59			820		
Netherlands						10296	1085	11381
New Zealand					37800	726	280	
Philippines						6		
Poland							675	
Portugal			1		90000	7652		
Romania		545						
Senegal					20000			
Serbia			2.8					
Singapore					135000	3994.68		
Sweden					282	4990		

Switzerland			3316		13562
Syria	4				
Taiwan		583.8	27128.9		
Thailand		5000	94.63		
Turkey		59.65	220		
Ukraine	19.57				
United Kingdom	3.8	375900	7061	2108	9169
United States of America	254	2669000	54255	20833	75088
Uruguay		1000			

County notes

Country Notes for Waste Chapter of the World Energy Resources report are currently being compiled as a subset of the Bioenergy Chapter.

What is Waste-to-Energy?

Waste to Energy refers to a family of technologies that treat waste to recover energy in the form of heat, electricity or alternative fuels such as biogas. The scope of the term 'Waste-to-Energy' is very wide, encompassing a range of technologies of different scales and complexity. These can include the production of cooking gas in household digesters from organic waste, collection of methane gas from landfills, thermal treatment of waste in utility size incineration plants, co-processing of Refuse Derived Fuel (RDF) in cement plants or gasification. This guide takes a very broad understanding of Waste to Energy, referring to large scale plants at the municipal level (i.e. utility size) using the technologies of incineration, co-processing, anaerobic digestion, landfill gas collection and pyrolysis/gasification.

https://www.eia.gov/energyexplained/index.cfm?page=natural_gas_home

Waste to Energy – Solution for Tomorrow's Energy:

In a growing world, where the conventional forms of energy are fast moving towards extinction as well as are contributing generously to global concerns like the **greenhouse effect and global warming,** the need to innovate and employ alternate or unconventional **energy sources** has become crucial for the existence of a future. Waste-to-Energy, also widely recognized by its acronym WtE is the generation of energy in the form of heat or electricity from waste. (The process is also called Energy from waste to EfW). Using developing technology, these various methods aim to compress and dispose waste, while attempting the generation of energy from them.

Each month millions of tons of waste is produced. Either they become a part of landfill or are exported to third world countries. This causes huge environmental impact in terms of wildlife, ecosystems and to human health. Keeping this in mind, many new waste treatment plants have come up and have developed new ways to generate energy from landfill waste.

Energy from waste offers recovery of energy by conversion of non-recyclable materials through various processes including **thermal and non-thermal technologies**. Energy that is produced in the form of electricity, heat or fuel using combustion, pyrolization, gasification or anaerobic digestion is clean and renewable energy, with reduced carbon emissions and minimal environmental impact than any other form of energy.

How to Produce Energy from Waste:

The most common and popular method for waste to energy generation is **'Incineration'**. Incineration is also a very highly debated technology, due to the concerns it raises regarding safety and environmental impact. In simple terms it stands for a type of waste treatment process, where the organics from the waste collected are burnt at high temperatures. Waste treatments that are conducted involving high temperatures are called Thermal treatment. The heat generated from this thermal temperature is then used to create energy.

Several countries in the world, especially in Europe are experimenting with Incineration as an alternate means of energy production; Sweden, Germany and Luxembourg to name a few.

Thermal technologies:

Depolymerization uses thermal decomposition where in the presence of water, the organic compounds are heated at high temperatures. This process of thermal decomposition is called Hydrous Pyrolysis in scientific terms.

The process without the use of oxygen is called Pyrolysis. Derived from greek it is literally the synthesis of the terms, Fire and Separating. The process usually takes plastic and bio-mass as their primary ingredients. The rest works as a thermo chemical decomposition. This is again conducted at high temperatures and involves parallel changes of the chemical composition and physics.

Often said to be a replication or representation of the conditions under which fossil fuels were created, Depolymerization has its own sets of benefits and limitations.

Gasification is another developing process employed for waste to energy generation. Gasification converts carbonaceous substances into carbon dioxide, carbon mono oxide and some amount of hydrogen. This process like incineration employs high temperatures to obtain results, however the major difference is that combustion does not occur over her. Steam and/or oxygen is also used in this procedure where usually fossil fuels or organic substances are used. The gas that is produced from the whole procedure is called Synthesis gas and is considered as a good means of alternate energy. Syngas is there after used for heat and electricity production primarily among other uses.

Pyrolysis is another waste to energy process, used majorly in industrial processes. Pyrolysis is just like Hydrous pyrolysis, without the use of oxygen. Pyrolysis employs agricultural waste or organic waste from industries.

Plasma arc glasification as the name suggests uses plasma technologies to obtain syngas or synthesis gas. A plasma torch is used to ionize gas and there after obtain synthesis gas. The process generates electricity while compressing the waste.

Non-thermal technologies:

Fermentation is also being developed as a form of waste to energy management.

Anaerobic digestion is a slow process. Here in micro organisms are used to destroy the biodegradable content. No oxygen is present during this procedure. It is used both domestically and even on a commercial level to tap the release of energy during the process and use it. Anaerobic technologies are seen as good agents to reduce the green house gases from the atmosphere and also as a worthy replacement of fossil fuels. The process works as a boon for developing countries for creating low energies for cooking and lighting in homes. Both China and India have mastered the usage of this technology, employing it as a part of their respective development schemes and investing in it. Bio gas is used to run a gas engine, and energy is created for small scale use.

Waste to energy is an emerging innovative set of technologies aimed at better sustenance of the environment, with minimum damage to the ecosystems. With these technologies developing by day and their acceptance increasing amongst households and industrial set-ups worldwide, waste to energy is seen as a development tool for emerging countries. The MBT technology stands for Mechanical Biological treatment. The technology uses domestic waste as well as industrial and commercial waste to generate products.

Waste to energy or energy from waste, is a conscious attempt to equalize the patterns of our planet and save our ecological cycles. The energy generation from these technologies are small scale right now and their employment for domestic and industrial use is sparse, however they are seen as the emerging solutions for tomorrow, that are set to affect the world immensely.