CHAPTER II

THEORETICAL AND RELATED LITERATURE

Management

Management is the process of planning, organizing, leading and controlling the use of resources to accomplish performance gold. The ultimate 'bottom line' in every manager's job is to succeed in helping an organization achieve high performance by using all of its human and material resources. If productivity in the form of high levels of performance effectiveness and efficiency is measured of organizational success, managers are largely responsible for ensuring its achievement. It is their job to successfully mobilize technology and talent by creating work environments within which others work hard and perform to the best of their abilities [17].

Function of management

All managers in daily events must have the capacities to recognize performance problems and opportunities, make good decisions and take appropriate action. They do this through the process of management – planning, organizing, leading, and controlling the use of resources to accomplish performance goals. These four functions of management and their interrelationships are shown in Figure 1. All managers, regardless of title, level, type and organizational setting, are responsible for the four functions [18]. However, it is important to know that they most often do not accomplish these functions in linear step-by-step fashion. Rather, the reality of managerial work is that the functions are being continually engaged as a manager moves from task to task and opportunity to opportunity in the process of mobilizing resources to accomplish goals.

1. Planning

In management, Planning is the process of setting performance objectives and determining what actions should be taken to accomplish them. Through planning, a manager identifies desired work results and identifies the means to achieve them.

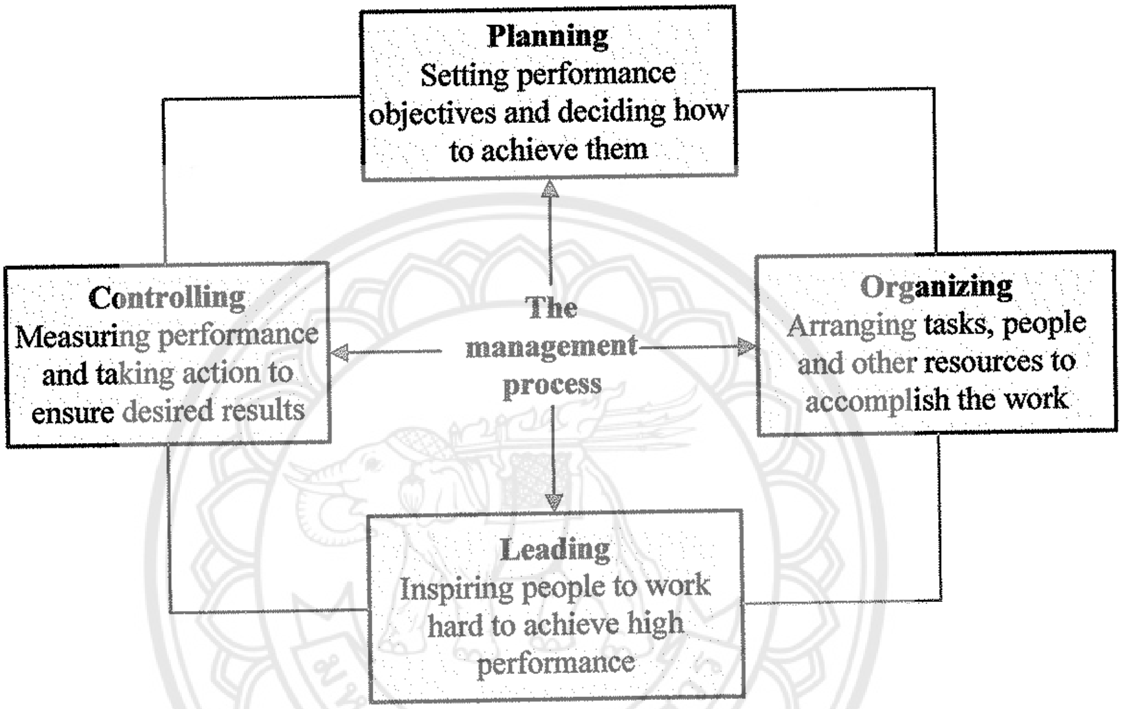

Figure 1 The four functions of management

2. Organizing

Organizing is the process of assigning tasks, allocating resources and arranging activities to implement plans. At Erst and Young, chairman Phil Laskawy believes that the best plan will fail, without strong implementation. This begins with organizing, the process of assigning tasks, allocating resources and arranging the coordinated activities of individuals and groups to implement plans. Through organizing, managers turn plans into actions by defining jobs, assigning personnel and supporting them with technology and other resources.

3. Leading

In management, leading in the process of arousing people's enthusiasm to work hard and direct their efforts to fulfill plans and accomplish objectives. Through leading, managers build commitments to a common vision, encourage activities that support goals, and influence others to do their best work on the organization's behalf.

4. Controlling

The management function of controlling is the process of measuring work performance, comparing results to objectives, and taking corrective action as needed. Through controlling, managers maintain active contact with people in the course of their work, gather and interpret reports on performance, and use this information to plan constructive action and change [19].

Risk management

Risk management objective is the reduction and elimination of certain types of risks facing businesses and other organizations. It is a scientific approach to the problem of dealing with these risks that seeks to achieve identifiable objectives by avoiding, reducing, and transferring risk. Risk management evolved from the field of corporate insurance buying.

1. The concept of risk

In its broadest sense, the sense in which we have used it thus far in our discussion, the term risk means exposure to adversity. Although our usage of the term in this loose sense has been adequate for our discussion up to this point, it is now time to define the term precisely.

The definition of risk differs from one discipline to another, and even within the same field there are sometimes contradictory definitions. Insurance and risk management are a case in point. In part because the field is relatively new and in part because risk management writers and insurance theorists have attempted to borrow the definitions of risk used in other fields, there are contradictory definitions of risk even in a field where risk is the central object of study.

2. Current definition of risk

If we were to survey the best-known insurance textbooks used in colleges and universities today, we would find a general lack of agreement concerning the definition of risk. Although the insurance theorists have not agreed on a universal definition, all the definitions share two common elements: indeterminacy and loss.

2.1 The notion of an indeterminate outcome is implicit in all definitions of risk: the outcome must be in question. When risk is said to exist, there must always be at least two possible outcomes. If we know for certain that a loss will occur, there is no risk. Investment in a capital asset, for example, usually involves a realization that the asset is subject to physical depreciation and that its value will decline. Here the outcome is certain and so there is no risk.

2.2 At least one of the possible outcomes is undesirable. This may be a loss in the generally accepted sense in which something the individual possesses is lost, or it may be gain smaller than the gain that was possible. For example, the investor who fails to take advantage of an opportunity "loses" the gain that might have been made. The investor faced with the choice between two stocks may be said to "lose" if he or she chooses the one that increases in value instead of the alternative.

3. Classification of risk

Business generally involved the environment of assets. The hope is that this investment will generate a profit. If things do not go as planned, the investor can suffer a loss, and this possibility of loss represents the risk of entrepreneurship. Businesses may fail or suffer loss as a result of a variety of causes. The differences in these causes and their effects constitute the basis for different classifications of risk. The sources of risk may be classified as dynamic or static, pure or speculative, and fundamental or particular.

3.1 Financial and nonfinancial risks

In its broadest context, the term risk includes all situations in which an exposure to adversity exists. This adversity sometimes involves financial loss and sometimes not. Some element of risk is involved in every aspect of human endeavor, and many of these risks have no (or only incidental) financial consequences.

Financial risk involves relationship between an individual (or an organization) and an asset or expectation of income that may be lost or damaged. Thus financial risk involves three elements: (1) the individual or organization that is exposed to loss, (2) the asset or income whose destruction or dispossession will cause financial loss, and (3) a peril that can cause the loss.

3.2 Static and dynamic risks

A second important distinction is between static and dynamic risks. Dynamic risks are those resulting from changes in the economy; they arise from two sets of factors. The first set is factors in the external environment: the economy, the industry, competitors, and consumers. Changes in these factors are uncontrollable, but all have the potential to produce financial loss to the firm. The other factors that can produce the losses that constitute the basis of speculative risk are management's decisions within the firm. The management of every organization makes decisions on what to produce, how to produce it, how to finance the production, and how to market what is produced. If these decisions result in provision of goods and services that the market accepts at an adequate price, the firm will profit. If not, it may suffer loss.

3.3 Pure and speculative risks

One of the most useful distinctions is that between pure risk and speculative risk. Speculative risk describes a situation that holds a possibility of either loss or gain. Gambling is a good example of a speculative risk. In a gambling situation, risk is deliberately created in the hope of gain. The entrepreneur or capitalist faces speculative risk in the quest for profit. The investment made may be lost if the market does not accept the product at a price sufficient to cover costs, but this risk is borne in return for the possibility of profit. The term pure risk, in contrast, is used to designate those situations that involve only the chance of loss or no loss. One of the best examples of pure risk is the possibility of loss surrounding the ownership of property. The person who buys an automobile, for example, immediately faces the possibility that something may happen to damage or destroy the automobile. The possible outcomes are loss or no loss.

3.4 Fundamental and particular risks

The distinction between fundamental and particular risks is based on the difference in the origin and consequences of the losses. Fundamental risks involve losses that are impersonal in origin and consequence. They are group risks, caused for the most part by economic, social, and political phenomena. They affect large segments or even all of the population. Particular risks involve losses that arise out of individual events and are felt by individuals rather than by the entire group. They may be static or dynamic. Unemployment, war inflation, earthquakes, and floods are all fundamental risks; the burning of a house and the robbery of a bank are particular risks.

4. Techniques for dealing with risk

Because risk is distasteful, we attempt to deal with it through avoidance, reduction, retention and transfer. In some cases, two of these approaches-transfer and retention- are combined to create a fifth technique, risk sharing.

4.1 Risk avoidance

Risk is avoided when the individual or organization refuses to accept it even for an instant. The exposure is not permitted to come into existence. This is accomplished by merely not engaging in the action that gives rise to risk. If you do not want to risk losing your savings in a hazardous venture, then pick one where there is less risk. If you want to avoid the risks associated with ownership of property, do not purchase the property but lease or rent it instead. If the use of a particular product promises to be hazardous, don't manufacture or sell it.

The avoidance of risk is one method of dealing with risk, but it is a negative rather than a positive technique. For this reason it is sometimes an unsatisfactory approach to dealing with many risks. If risk avoidance were used extensively, the business would be deprived of many opportunities for profit and would probably not be able to achieve its objectives.

4.2 Risk reduction

Risk may be reduced in two ways. The first is through loss prevention and control. Safety programs and loss-prevention measures such as medical care, fire departments, night security guards, sprinkler systems, and burglar alarms are all examples of attempts to deal with risk by preventing the loss or reducing the chance that it will occur. Some techniques are designed to prevent the occurrence of the loss, whereas others, such as sprinkler systems, are intended to control the severity of the loss if it does happen. From one point of view, loss prevention is the most desirable means of dealing with risk. If the possibility of loss could be completely eliminated, then risk would also be eliminated. And yet, loss prevention can also be viewed as an inadequate approach to dealing with risk. No matter how hard we may try, it is impossible to prevent all losses. In addition, in some cases the loss prevention may cost more than the losses themselves.

4.3 Risk retention

Risk retention is perhaps the most common method of dealing with risk. Organizations, like individuals, face an almost unlimited number of risks; in most cases nothing is done about them. When some positive action is not taken to avoid, reduce, or transfer the risk, the possibility of loss involved in that risk is retained.

Risk retention is a legitimate method of dealing with risk; in many cases, it is the best way. Every organization must decide which risks to retain and which to avoid or transfer on the basis of its margin for contingencies or ability to bear the loss. A loss that might be a financial disaster for one organization might easily be borne by another. As a general rule, risks that should be retained are those that lead to relatively small certain losses.

4.4 Risk transfer

Risk may be transferred from one individual to another who is more willing to bear the risk. Transfer may be used to deal with both speculative and pure risk. An excellent example of the use of the transfer technique for dealing with speculative risk is the process of hedging. Hedging is a method of risk transfer accomplished by buying and selling for future delivery, whereby dealers and processors protect themselves against a decline or increase in market price between the time they buy the product and the time they sell it. It consists of simultaneous purchase or sale for immediate delivery and purchase or sale for future delivery, such as the sale of futures in the wheat market at the same time that a purchase is made in the spot market.

4.5 Risk sharing

Risk sharing is a special case of risk transfer; it is also a form of retention. When risks are shared, the possibility of loss is transferred from the individual to the group. However, sharing is also a form of retention in which the risks "transferred" to the group are retained, along with the risks of the other members of the group.

Risk is shared in a number of ways by individuals and organizations. One outstanding example of a device through which risk is shared is the corporation. Under this form of business, the investments of a large number of persons are pooled. A number of investors may pool their capital, each bearing only a portion of the risk that the enterprise may fail. Insurance is another device designed to deal with risk through sharing, as one of the basic characteristics of the insurance device is the sharing of risk by the members of the group [20].

Biomass

Biomass is a term for all organic materials that stems from plants (including algae, trees and crops). Biomass is produced by green plants converting sunlight into plant material through photosynthesis and includes all land- and water-based vegetation, as well as all organic waste. The biomass resource can be considered as organic matter, in which the energy of sunlight is stored in chemical bonds. When the bonds among adjacent carbon, hydrogen and oxygen molecules are broken by digestion, combustion, or decomposition, these substance release their stored, chemical energy. Biomass has always been a major source of energy for mankind and is presently estimated to contribute about 10-14% of the world energy supply [21].

1. Photosynthesis

Photosynthesis is the process by which living organism converts the energy of light into the chemical energy of organic molecules. This process exploits solar energy to provide the energy for the complex physico-chemical reactions of living organisms. Photosynthesis provides the energy for the whole of the living world.

Sunlight is the ultimate energy source for all biological processes on earth. Throughout much of biological time the exploitation of light to change matter from a lower to a higher state has been essential for life.

1.1 Photosynthesis in relation to other plant functions

If the respiratory and photosynthetic processes are compared with the starting materials on the left-hand side of equation 2.1 and the products on the right-hand side, the net result is energy conversion and closed cycles of carbon and water.

$$\text{Photosynthesis: } CO_2 + H_2O + \text{light energy} \xrightarrow{\text{biological catalysts}} (CH_2O) + O_2 \quad (2.1)$$

$$\text{Respiration: } (CH_2O) + O_2 \xrightarrow{\text{biological catalysts}} CO_2 + H_2O + \text{heat energy} \quad (2.2)$$

Net result of respiration and photosynthesis: light energy $\longrightarrow$ heat energy. Thus, photosynthesis and respiration work in opposition, forming a cyclic, closed system of matter. The physical energy of light is converted into chemical energy and ultimately heat.

1.2 Photosynthesis, plant production and environment

Photosynthetic response to the environment, with its complex diurnal and seasonal changes in weather – temperature, radiation, rainfall, etc., plus variation in other environmental condition, e.g. nutrient supply-determine the gross assimilation of carbon and nitrogen by plants. Great differences exist between environments but there is considerable flexibility in photosynthetic characteristics within and between species, for they evolved under changing conditions and have the genetic potential to adjust, at least partially, to conditions. The ecological behavior of plants is determined by photosynthetic productivity coupled with the use of the photosynthetic products in growth and development. Future increase in atmospheric CO_2 and climate change will require that species respond if they are to survive. However, the extent to which plants can adapt, and the ecological consequences, will depend on many factors, e.g. the particular combinations of CO_2, UV-B radiation resulting from ozone depletion, and temperature, that are very hard to predict. By examining the way in which photosynthetic and other processes of plant communities respond to their environment under the presence very diverse conditions, the cause of differences in production, indifferent current and future climates may be assessed.

The mass of standing vegetation in different habitats varies widely, from almost nothing in some deserts to hundreds of tons of dry matter per hectare in tropical forests, and the rates of dry matter production also differ greatly. Crops of well water and fertilized C_3 cereals in temperate zones have the potential to produce more than 25 t dry matter ha^{-1} in an 8-month growing season, and in the tropics sugar cane (C_4) forms over 80 t dry matter ha^{-1} $year^{-1}$. All organic matter is derived from photosynthesis and accumulation of inorganic matter in vegetation (usually 10 percent of dry matter) requires photosynthetic energy. Some of the distinguishing characteristics of C_3 and C_4 and crassulacean acid metabolism (CAM) are shown in Table 1 [12, 13].

Table 1 General characteristics of C_3, C_4 and CAM plants

	C_3	C_4	CAM
1	Typically temperate species.	Typically tropical or semi-tropical species. Plants adapted to high light, high temperatures and also semi-arid environments.	Typically arid zone species.
2	Moderately productive. Yields of 30 t (tonnes) dry weight per hectare (2.47 acres) possible.	Highly productive, 120 t wet weight per hectare is possible.	Usually very poorly productive.
3	Cells containing chloroplasts do not show Krane-type anatomy generally lack peripheral reticulum. Only one type of chloroplast.	Krane-type anatomy and peripheral reticulum are essential features. Often have two distinct types of chloroplast.	Lack Krane anatomy and peripheral reticulum. Only one type of chloroplast.

Table 1 (Cont.)

	C_3	C_4	CAM
4	Initial CO_2 acceptor is riburose bisphosphate (RuBP), a 5-carbon sugar.	Initial CO_2 acceptor is phosphoenol pyruvate (PEP), a 3-carbon acid.	CO_2 acceptor is PEP in the dark and RuBP in the light.
5	Initial CO_2 fixation product is the is 3-carbon acid phosphoglycerate.	Initial CO_2 fixation product is the 4-carbon acid oxaloacetate.	CO_2 fixation product are oxaloacetate in the dark and phosphoglycerate in the light.
6	Only one CO_2 fixation pathway.	Two CO_2 fixation pathways separated in space.	Two CO_2 fixation pathways separated in time.
7	Photosynthesis saturated at 1/5 full sunlight.	Do not readily photosaturate at high light.	Same as C_4.
8	Low water use efficiency and salinity (ion) tolerant.	High water use efficiency and salinity tolerant.	Same as C_4.
9	Open stomata by day.	Open stomata by day.	Open stomata by night.

2. Biomass fuel

Green wood can contain up to 50% water by weight, so its properties a widely with moisture content. Furthermore, more than 80% of the biomass is volatile. Biomass generally has very low sulfur and ash content compared to coal. Biomass comes in a wide variety of physical forms, making it necessary to tailor the shapes of the gasifier, fuel drying equipment, feed systems, and ash-removal equipment to each form. Therefore, the resulting gasifier design must be very fuel specific.

2.1 Biomass fuel analysis

2.1.1 Proximate and ultimate analysis

Two types of analyses, proximate and ultimate, are useful for defining the physical, chemical, and fuel properties of a particular biomass feedstock.

These analyses were initially developed for coal and are widely available from commercial laboratories. They are described in detail in the publications of the American Society for Testing Materials (ASTM) [22].

The proximate analysis determines the moisture content (M.C.), volatile matter (VM), ash (A), and fixed carbon content (C) of a fuel, using standard tests.

The ultimate analysis gives the chemical composition and the higher heating value of the fuels. The chemical analysis usually lists the carbon, hydrogen, oxygen, nitrogen, sulfur, and ash content of the dry fuel on a weight percentage basis.

2.1.2 Physical test

One of the most physical characteristics of biomass fuel is the bulk density. The bulk density is the weight of biomass packed loosely in a container divided by volume occupied. Clearly, it is not an exact number, depending on the exact packing of the particles.

2.1.3 Other fuel parameter

Each type of gasifier will operate satisfactorily with respect to stability, gas quality, efficiency and pressure losses only within certain ranges of the fuel properties of which the most important are energy content, moisture content, volatile matter, ash content and ash chemical composition, reactivity, size and size distribution and bulk density.

1) Energy content

The choice of a fuel for gasification will in part be decided by its heating value. The higher heating value of the fuel is determined by reacting the fuel with oxygen in a bomb calorimeter and measuring the heat released to a known quantity of water. The heat released during this procedure represents the maximum amount of energy that can be obtained from combusting the efficiency of gasification. The high heating value (HHV) is measured in this test, since liquid water is produced; the low heating value (LHV) is more relevant to the amount of energy produced, and this can be calculated from the HHV.

The heat of combustion is determined by the composition of the biomass and in fact can be calculated with considerable accuracy from

HHV = [34.1 C + 132.2 H + 6.8 S − 1.53 A − 12.0 (O+N)] kJ/g (2.3)

LHV = [146.6 C + 568.8 H + 29.4 S − 6.6 A − 51.5 (O+N) $\times 10^2$ Btu/lb (2.4)

where C, H, S, A, O, and N are the wet % of carbon, hydrogen, sulfur, ash, oxygen, and nitrogen in the fuel. The calculated value agrees with the measured value with an absolute error of 2.1% for a large number of biomass materials.

2) Moisture content

The heating value of the gas produced by any type of gasifier depends at least in part on the moisture content (M.C) of the feedstock.

Moisture content can be determined on a dry basis as well as on a wet basis.

Moisture content on a dry basis is defined as:

$$M.C._{dry} = \frac{\text{wet weight - dry weight}}{\text{dry weight}} \times 100\% \quad (2.5)$$

$$M.C._{wet} = \frac{\text{wet weight - dry weight}}{\text{wet weight}} \times 100\% \quad (2.6)$$

Conversion from one to another can be obtained by:

$$M.C._{dry} = \frac{100 \times M.C._{wet}}{100 + M.C._{wet}} \quad (2.7)$$

and:

$$M.C._{wet} = \frac{100 \times M.C._{dry}}{100 + M.C._{dry}} \quad (2.8)$$

High moisture contents reduce the thermal efficiency since heat is used to drive off the water and consequently this energy is not available for the reduction reaction and for converting thermal energy into chemical bound energy in the gas. Therefore, high moisture contents result in low gas heating values.

In downdraft gasifiers, high moisture contents give rise not only to low heating values, but also to low temperatures in the oxidation zone, and this can lead to insufficient tar converting capability if the gas is used for engine applications.

Because of the gas heating value (engine need gas of at least 4200 kJ m^{-3} in order to maintain a reasonable efficiency) and the tar problem, downdraft gasifiers need reasonably dry fuels (less than 25 % moisture content).

3) Volatile matter

The volatile matter content of biomass, most of which gets released when the biomass is heated from 100-500 °C consists of water vapor, tar, pyrolysis oils and gases. Most of the volatile matter is consumed in the process of gasification. Oils, tar and gases are cracked/burned in the oxidation and reduction zones.

The amount of volatiles in the feedstock determines the necessity of special measures (either in design of the gasifier or in the layout of the gas cleanup train) in order to remove tar from the producer gas in engine applications.

The volatile matter content in charcoal, however, is often underestimated and in practice may be something from 3 to 30 percent or more. As a general rule if the fuel contains more than 10 percent volatile matter, it should be used in downdraft gas producers.

4) Ash content and ash chemical composition

Ash can cause a variety of problems particularly in updraft or downdraft gasifiers. Slagging or clinker formation in the reactor, caused by melting and agglomeration of ashes, at the best will greatly add to the amount of labour required to operate the gasifier if no special measures are taken; slagging can lead to excessive tar formation and/or complete blocking of reactor. The worst case is the possibility of air-channelling which can lead to a risk of explosion, especially in updraft gasifiers.

5) Reactivity

The reactivity is an important factor determining the rate of reduction of carbon dioxide to carbon monoxide in a gasifier. Reactivity influences the reactor design insofar as it dictates the height needed in the reduction zone.

In addition, certain operational characteristics of the gasifier system are affected by the reactivity of the char produced in the gasifier. Reactivity depends in the first instance on the type of fuel. For example, it has been observed that fuels such as wood, charcoal and peat are far more reactive than coal.

It is well known that the reactivity of char can be improved through various processes such as stream treatment (activated carbon) or treatment with lime and sodium carbonate.

6) Size and size distribution

Up and downdraft gasifiers are limited in the range of fuel size acceptable in the feedstock. Fine grained and /or fluffy feedstock may cause flow problems in the bunker section of the gasifier as well as and inadmissible pressure drop over the reduction zone and a high proportion of dust in the gas. Large pressure drops will lead to reduction of the gas load of downdraft equipment, resulting in low temperature and tar production.

Excessively large sizes of particles or pieces give rise to reduce reactivity of the fuel, resulting the startup problems and poor gas quality, and to transport problems through the equipment. A large range in size distribution of the feedstock will generally aggravate the above phenomena. Too large particle size can cause gas-channeling problems, especially in updraft gasifiers.

Acceptable fuel sizes fox gasification systems depend to a certain extent on the design of the units. In general, wood gasifiers operate on wood blocks and wood chips ranging from $8\times4\times4$ cm^3 to $1\times0.5\times0.5$ cm^3 [23].

7) Bulk density

Bulk density is defined as the weight per unit volume of loosely tipped fuel. Fuels with high bulk density are advantageous because they represent a high energy for volume value. Consequently, these fuels need less bunker space for a given refueling time. Low bulk density fuels sometimes give rise to insufficient flow under gravity, resulting in low gas heating values and ultimately in the burning of the char in the reduction zone. Average bulk densities of wood, charcoal and peat are given in Table 2. Inadequate bulk densities can be improved by briquetting or palletizing. The bulk density varies significantly with moisture content and particle size of the fuel.

Table 2 Average bulk density [23]

Fuel	Bulk density (kg m^{-3})
Wood	300-500
Charcoal	200-300
Peat	300-400

Before choosing a gasifier for any individual fuel, it is important to ensure that the

fuel meets the requirements of the gasifier or that it can be treated to meet these requirements. Practical tests are needed if the fuel has not previously been successfully gasified.

Most wood species have ash contents below two percent and are therefore suitable fuels fox fixed bed gasifiers.

Because of the high volatile content of wood, updraft systems produce a tar- containing gas suitable mainly for direct burning. Cleaning of the gas to make it suitable for engines is rather difficult and capital and labour intensive. Downdraft systems can be designed to deliver a virtually tar-free producer gas in a certain capacity range when fuelled by wood blocks or wood chips of low moisture content. After passing through a relatively simple clean-up train the gas can be used in internal combustion engines [23].

3. Biomass conversion

Conversion of biomass to energy is undertaken using two main process technologies: thermo-chemical and bio-chemical. Within thermo-chemical conversion four process options are available: combustion, pyrolysis, gasification and liquefaction. Bio-chemical conversion encompasses two process options: digestion (production of biogas, a mixture of mainly methane and carbon dioxide) and fermentation (production of ethanol).

3.1 Thermo-chemical conversion

Three main processes are used for the thermo-chemical conversion of biomass, together with two lesser-used options. The main processes, the intermediate energy carriers and the final energy products resulting from thermo-chemical conversion are illustrated in the flow chart shown in Figure 2.

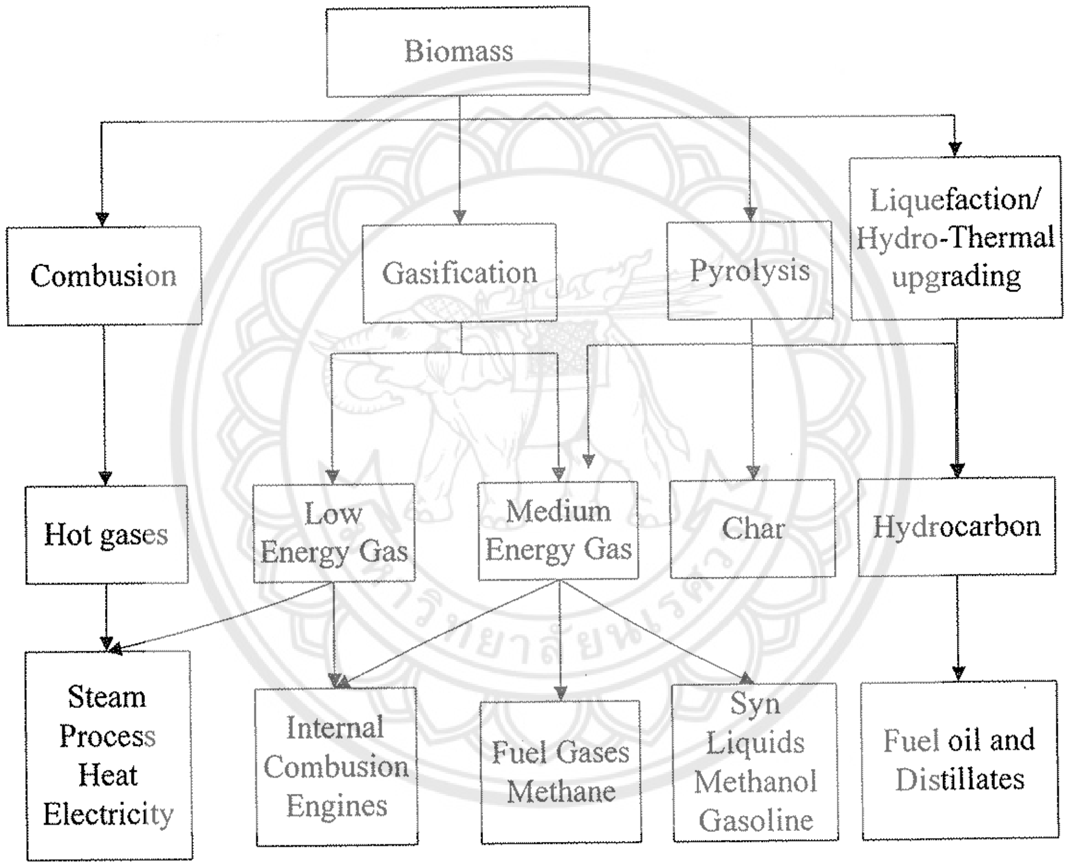

Figure 2 The three processes from thermo-chemical conversion of biomass

3.2 Bio-chemical conversion

Two main processes are used, fermentation and anaerobic digestion (AD), together with a lesser-used process based on mechanical extraction/chemical conversion.

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3.2.1 Fermentation

Fermentation is used commercially on a large scale in various countries to produce ethanol from sugar crops and starch crops. The biomass is ground down and starch converted by enzymes to sugars, with yeast then converting the sugars to ethanol. Purification of ethanol by distillation is an energy- intensive step, with about 450 L of ethanol being produced per ton of dry corn. The solid residue from the fermentation process can be used as cattle-feed and in the case of sugar cane, the bagasse can be used as a fuel for boilers or for subsequent gasification.

3.2.2 Anaerobic digestion (AD)

is the conversion of organic material directly to a gas termed biogas, a mixture of mainly methane and carbon dioxide with small quantities of other gases such as hydrogen sulphide. The biomass is converted by bacteria in an anaerobic environment, producing a gas with an energy content of about 20-40% of the lower heating value of the feedstock. AD is a commercially proven technology and is widely used for treating high moisture content organic wastes, i.e. 80-90% moisture [24].

Gasification

Gasification is the conversion of biomass to a gaseous fuel by heating in a gasification medium such as air, oxygen or steam. Unlike combustion where oxidation is substantially complete in one process, gasification converts the intrinsic chemical energy of the carbon in the biomass into a combustible gas in two stages. The producer gas can be standardized in its quality and is easier and more versatile to use than the original biomass, e.g. it can be used to power gas engines and gas turbines, or used as a chemical feedstock to produce liquid fuels.

1. Type of gasification

asifiers are of two main types, fixed bed and fluidized bed, with variations within each type. A third type, the entrained suspension gasifier, has been developed for coal gasification but the need for a finely divide feed material (<0.1-0.4 mm) presents problems for fibrous materials such as wood, which make the process largely unsuitable for most biomass materials and therefore the process is not considered further.

1.1 Fixed bed gasification

The fixed bed gasifier has been the traditional process used for gasification, operated at temperatures around 1000 °C. Depending on the direction of airflow, the gasifiers are classified as updraft [Figure 3, (a)], downdraft [Figure 3, (b)], or cross-flow.

1.2 Fluidized Bed Gasification

Fluidized bed (FB) gasification has been used extensively for coal gasification for many years, its advantage over fixed bed gasifiers being the uniform temperature distribution achieved in the gasification zone. The uniformity of temperature is achieved using a bed of fine-grained material into which air is introduced, fluidizing the bed material, the hot combustion gas and the biomass feed.

Two main types of FB gasifier are circulating fluidized bed [Figure 3, (x)] and bubbling bed [Figure 3, (y)]

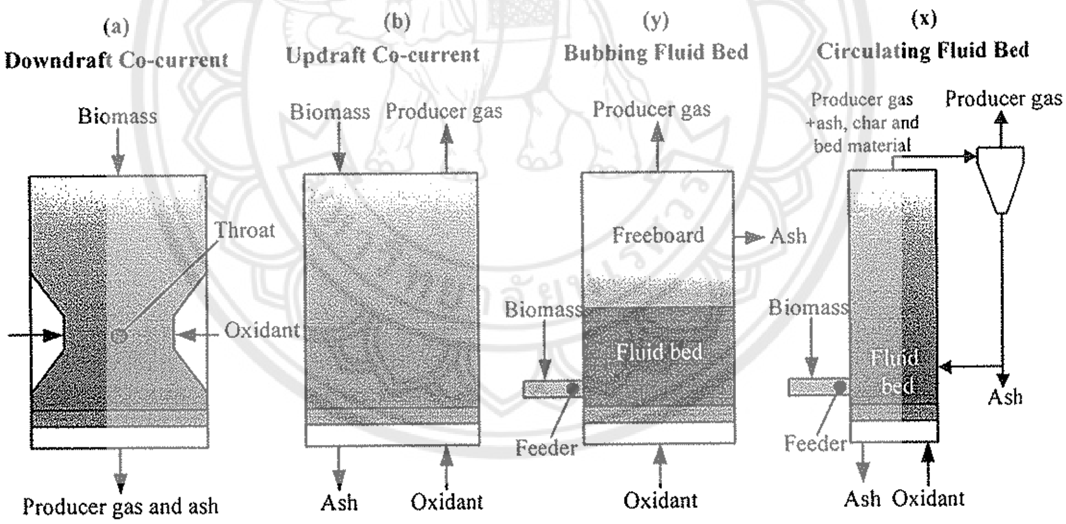

Figure 3 The main types of gasifier

A third type of FB is currently being developed, termed a fast, internally circulating gasifier, which combines the design features of the other two types. The reactor is still at the pilot-stage of development [25].

2. Chemistry of gasification

Gasifier in general has different zones in which different chemical and physical reactions take place.

Drying, pyrolysis and reduction processes are driven by heat transferred from the combustion zone (also called oxidation or hearth zone).

In the drying zone, the moisture content of biomass evaporates. In case of an updraft gasifier, this moisture leaves along with gas at the top. In case of a downdraft gasifier, this moisture passes through the combustion and reduction zones and participates in certain chemical reactions. The process taking place here is at a temperature of 25 to 150°C.

$$H_2O_{(liq)} \rightleftharpoons H_2O_{(gas)} \quad (2.9)$$

Essentially, dry biomass enters the pyrolysis zone from the drying zone. Pyrolysis converts dried biomass into char, tar vapor, water vapor and non-condensable gases. The vapors and non-condensable gases leave the gasifier at the top in case of updraft gasifier. In case of downdraft gasifier, these pass through the combustion zone and undergo further reactions. The char produced in the pyrolysis zone is probably around 15% of the original biomass by weight and passes through the combustion and reduction zones. The temperature of this zone is about 150 to 900°C and the chemical reaction taking place is

$$C_xH_yO_z \rightleftharpoons \text{Tar, oil, organic acid, char, methane, etc.} \quad (2.10)$$

In the oxidation zone, oxygen supplied for gasification first comes in contact with the fuel. In case of updraft gasifiers, the fuel is carbonized biomass, which can be regarded as consisting mostly carbon and ash. In case of updraft gasifiers, the reactions taking place in the oxidation zone are similar to those taking place in the oxidation zone of an updraft charcoal gasifier. In case of downdraft gasifier, the fuel consists of carbonized biomass plus vapors and gases formed in the pyrolysis zone. In a properly operated gasifier, the intake of oxygen is insufficient to completely burn all the vapors and gases since the oxygen/fuel ratio is too low. Instead partial combustion takes place. From these processes, some products of oxidation, such as H_2O, CO_2, etc., are formed due to combustion and thermal cracking of tar vapors. The temperature of the oxidation is in the range of 900 to 1400°C and the major reactions are:

$$C_{(s)} + O_2 \rightleftharpoons CO_2 + 406{,}042 \text{ kJ kg}^{-1} \text{ atom of carbon} \qquad (2.11)$$

$$\text{Tar, oil ...} + O_2 \rightleftharpoons \text{Mixture of } CO, O_2, H_2O, CH_4 \qquad (2.12)$$

These are also exothermic reactions.

In the reduction zone, the products of complete oxidation, e.g., CO_2, H_2O, etc., undergo reduction by the carbonized biomass. The major reaction takes place here is

$$C_{(s)} + CO_{2(g)} \rightleftharpoons 2CO_{(g)} - 159{,}905 \text{ kJ kg}^{-1} \text{ atom of carbon} \qquad (2.13)$$

The temperature is 600 to 1400°C and this is an endothermic reaction. This reaction is very important in the gasification process, where it is the main reaction to convert the major non-combustible CO_2 gas to combustible CO gas at temperatures above 900°C.

Another important reaction that takes place in both the oxidation and reduction zones is the shift reaction.

This reaction takes place at temperatures above 900°C.

$$C_{(s)} + H_2O \rightleftharpoons CO + H_2 + 118{,}045 \text{ kJ kg}^{-1} \text{ atom of carbon.} \qquad (2.14)$$

Increasing the humidity of the combustion air can improve the calorific value of the gas produced by this reaction. This reaction is important because it produces CO and H_2 which are both combustible gases.

Small amounts of CH_4 is normally found in the producer gas produced as a result of the following reaction.

$$C_{(s)} + 2H_{2(g)} \rightleftharpoons CH_{4(g)} - 88{,}324 \text{ kJ kg}^{-1} \text{ atom of carbon} \quad (2.15)$$

It is an endothermic reaction.

The final composition of producer gas depends on a number of factors, e.g., 1) operating parameters i.e. temperature and pressure, 2) composition and moisture content of fuel, 3) reactor design, and 4) air/fuel ratio [23, 24].

Combustion engine

There is a basic distinction between thermal engines with internal combustion and those with external combustion.

Engines with internal combustion are essentially the diesel engines and petrol engines. The operational principle is based on the fact that the fuel is sucked or pumped into a cylinder and burns there with extremely high intensity. This "explosive" burning sets a piston in motion, which, in turn, propels a shaft. The essential difference between diesel and petrol engines lies in that the gasoline in the petrol engines is ignited through an electrically induced ignition whereas the diesel engine fuel ignites on its own. Internal combustion requires a substantially high quality fuel. Otherwise the cylinder could easily be damaged.

Engine with external combustion are the steam engines, steam turbines and stirling engines. In the case of steam engines, water is heated up in a closed container outside the actual engine so that water vapor with high pressure develops. The water vapor is then led into a cylinder to set a piston in motion. In the case of steam turbine, the water vapor, which is under pressure, is used in order to propel a turbine. Steam engines operate with very bad efficiency and, are therefore used today only for special areas of application. Steam turbines are applicable in an economically meaningful way only in larger energy plants [26].

Applications of biomass gasified power generation system

Applications of BGPGS can be classified into three main types that are shown in Figure 4 [25]:

Stream turbine: steam turbine is an application of producer gas from biomass gasiifier (BG) as gaseous fuel to produce steam by heating steam boiler for use in a turbo-generator to produce electricity.

Gas engine: gas engine is an application of producer gas from BG as gaseous fuel for gas engine which is modified from diesel or gasoline engine in conjunction with a generator to produce electricity.

Gas turbine: gas turbine is an application of producer gas from BG as gaseous fuel for using in a turbo-generator to produce electricity.

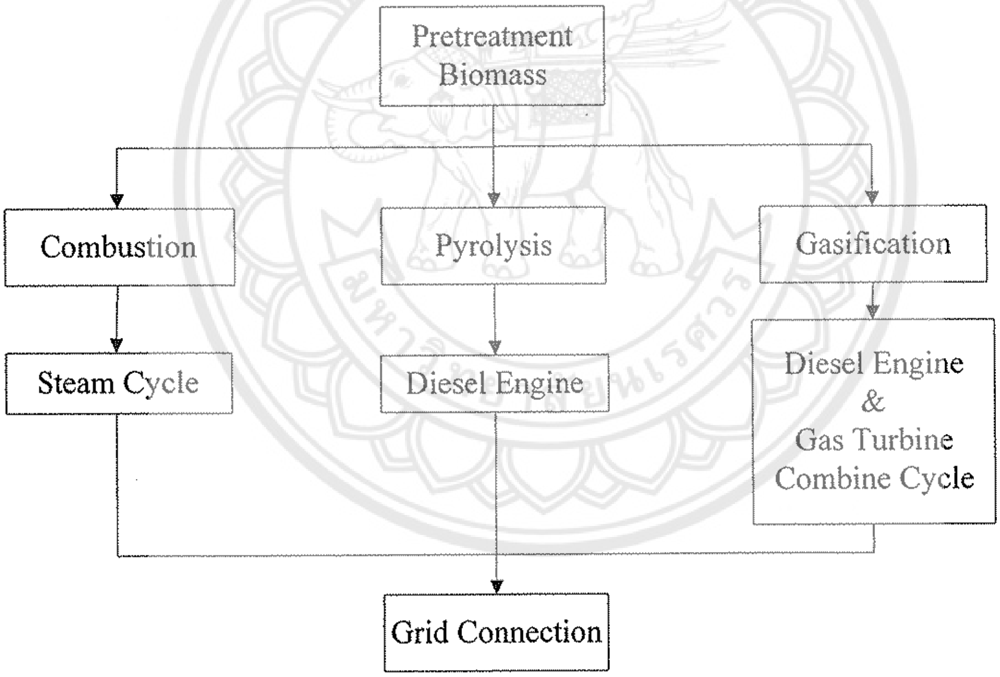

Figure 4 Applications of thermo-chemical conversion process from BG

Economic condition evaluation

To function successfully in today's complex and dynamic world, each organization engaged in economic or financial activity must plan its operations and formulate decisions in a completely methodical and expert manner. Consequently, it is mandatory that the organization be guided by individuals who possess a deep and thorough grasp of financial principles and of the techniques of economic analysis and decision making.

1. Basic principles

1.1 The decision process

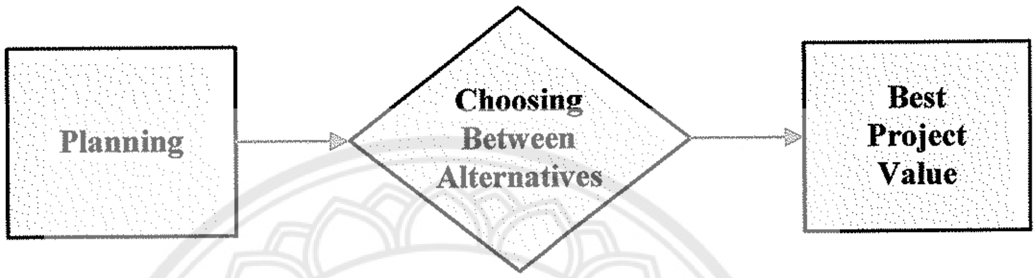

Figure 5 The decision process

Life is full of choices. In matters small and large we are constantly confronted with the need to make selections from arrays of alternative courses of action concerning how best to spend our time, where to live, which job to take, how to determine spending priorities for our money and so forth. In short, how best to invest our limited supply of resources such as time and money? The decision making process would be greatly simplified if the alternatives could be quantified objectively and some numerical value attached to each. Then the optimal return on our limited resources could be assured by simply selecting the alternative with the highest numerical value from each array of choices.

As in other areas of life, the practice of engineering requires a considerable amount of decision making. The decision making process may vary somewhat depending upon the needs of the project sponsor. Most engineering works are sponsored either by the government, as public works projects or private enterprise, as profit making ventures.

1.2 Determining public works priorities

The selection, planning, funding, construction, and operation of public works projects typically involve the following process:

1.2.1 List current and future needs of the public that can be met by public works projects.

1.2.2 List the alternative proposals for meeting those needs.

1.2.3 Compare the alternatives.

1) Quantify and numerically compare tangle values, such as the costs, benefits, effectiveness, or income of each alternative in meeting needs.

2) Compare the intangible values, such as quality, appearance, effect on neighborhood image, pride and respect, the comparative needs of the beneficiaries, and the distribution of the benefits.

1.2.4 Establish priorities based on ratios of benefits to costs or equivalents, with proper consideration given to intangibles.

1.2.5 Make recommendations for funding, and hold public hearings to obtain approval and funding.

1.2.6 Construct and operate the project. Evaluate accomplishments compared with previous estimates.

Since public works planning involves decision making in the spending of the public's tax money, it should be done with the public's sense of priority in mind. The conscientious engineer performs a valuable public service in preparing and presenting comparative numerical data for use by the public service when facing decisions between competing alternatives.

1.3 Determining private enterprise priorities

Planning for privately owned facilities differs from public works planning basically in the accountability for funds, both investment and return. In public works, the funds must be fairly distributed to reflect the needs of citizens, their sources of revenue, and other factors of concern to them. In the private sector, the investor has wide discretion concerning the allocation and amount of funds to be expended, within the broad limits set by law. Usually the private investor is primarily concerned with profit. As a result, the private investor, like the public works planner, is vitally concerned with the needs of the public, since the return on investment usually depends on the patronage of the consuming public as well as on the satisfaction of individual demands. Therefore, rather than rely on intuition and hope, planners of privately owned projects need factual numerical comparisons in order to make intelligent decisions.

Money has the capacity to generate income, and this capacity is termed the time value of money. The process of using money to generate income is termed an investment, the sum of money that is earning income at a given instant is termed the capital, and the rate at which the capital is earning income is termed the investment rate, internal rate of return, or yield. Although, the earning of income is merely a potential characteristic of money, we shall view it as actual by assuming that money is invested the instant it is received [27].

2. Tools and definitions for the economic evaluation

Two estimations have to be made, namely an effective interest rate and useful life of power plant. Normally, i would represent the effective interest rate, n the useful life of the asset, B_j and C_j the total benefits and the costs of the j^{th} year, and C_0 its initial capital cost at the year 0.

2.1 Uniform series capital recovery factor

Before seeing the different tools to evaluate a project, the uniform series capital recovery factor has to be defined.

$$CRF = \frac{i(1+i)^n}{(1+i)^n - 1} \qquad (2.16)$$

Multiplying a uniform annual cash flow by this factor gives the present worth of the cash flow. On the other hand way, we can get the annualized worth of an asset over its useful life.

2.2 Cost of energy

The cost of energy is one of the major data for a power plant because it can show the price of generated electricity. Expressed in Baht kWh^{-1}, it is the annualized cost of the power plant (taking into account the initial capital cost and the annual costs) over the annual electricity delivered to grid or to the consumers.

$$COE = \frac{\text{Annualized Cost}}{\text{Annual Electricity Production}} \qquad (2.17)$$

In the case of the CO_2 reduction price, this intensive is subtracted from the annualized costs to get a net annualized cost. This enables seeing the impact of CO_2 reduction price on the cost of electricity.

2.3 Discounted payback period

The payback period measures the time elapsed between the point of the initial investment and the point at which accumulated savings, net of other accumulated costs, are sufficient to offset the initial investment outlay.

The simple payback period is just the initial investment over the net annual savings.

$$\sum_{j=0}^{n_{sp}} B_j - C_j = 0 \tag{2.18}$$

However, it is better to use the discounted payback period.

$$\sum_{j=0}^{n_{dp}} \frac{B_j - C_j}{(1+i)^j} = 0 \tag{2.19}$$

The payback period method is widely used in financial decision making because it is easy to understand and to use. It also emphasizes a rapid recovery of the initial investment, which may be a very important objective in a variety of situations. However, all cash flows that would commonly occur after the computed payback period are neglected. Thus the payback period method makes no allowance for projects with long gestation periods.

2.4 Net present value

The difference between the present value of the benefits and the costs resulting from an investment is the Net Present Value (NPV) of the investment.

$$NPV = \sum_{j=0}^{n} \frac{B_j - C_j}{(1+i)^j} \tag{2.20}$$

The positive NPV means a positive surplus indicating that the financial position of the investor will be undertaking the project. Obviously, a negative NPV would indicate a financial loss and that the project is rejected. The NPV of Zero would mean that the present value of all the benefits over the useful lifetime is equal to the present value of all the costs.

2.5 Internal rate of return

The Internal Rate of Retern (IRR) is a widely-accepted discounted measure of investment worth and is used as an index of profitability for the appraisal of project. IRR is defined as the interest rate at which the NPV of an investment is zero.

$$NPV(IRR) = \sum_{j=0}^{n} \frac{B_j - C_j}{(1+IRR)^j} = 0 \tag{2.21}$$

IRR is widely used in the appraisal of projects because the IRR on a project is its expected rate of return. Furthermore, it employs a percentage rate of return as the decision variable, which suits the banking community. For situations in which IRR exceeds the cost of the funds used to finance the project, a surplus would remain after paying the capital.

In economic terms, the IRR represents the percentage rate of interest earned on the unrecovered balance of an investment. The unrecovered balance of an investment is the portion of initial investment that remains to be recovered after interest payments have been added and receipts have been deducted up to the desired point in time [28].

Environmental impacts

The emission of CO_2 and other greenhouse gases is one of the greatest environmental problems of our time. At the United Nations Climate Change Conference in 1997 in Japan, it was agreed that total would-wide emissions should be reduced by 5.2% by the year 2012. The European Union has undertaken the major reduction of 8% compared to the 1990 level.

Today only 6% of the European Union's consumption of energy is covered by renewable energy, but the EU Commission Renewable Energy White Paper, published in December 1997, prescribes doubling of the proportion of renewable energy by the end of the year 2010.

Biomass is the sector that must be developed the most and the fastest. It is estimated that in 2010 it should amount to 74% of the European Union' total consumption of renewable energy.

The use of biomass is based on the facts that it is CO_2 neutral, saves foreign currency, creates jobs, and utilizes waste products from agriculture, forestry, household, trade and industry.

1. Air pollution

1.1 Carbon monoxide

Most of our serious air pollution is produced directly or indirectly by the combustion of fuels. In addition to the ideal combustion process that combines carbon (C) and oxygen (O_2) to form carbon dioxide (CO_2), there can also be incomplete combustion of carbon that leads to the formation of carbon monoxide.

$$2C + O_2 \rightarrow 2CO \tag{2.22}$$

The formation of carbon monoxide takes place when the oxygen present during combustion is insufficient to form carbon dioxide. A prime source of CO is the gasoline-fueled, spark-ignited internal combustion engine, where the burning of gasoline takes place at high pressure and temperature but not in an overabundance of oxygen.

Carbon monoxide is a colorless gas that is toxic at high concentrations. Its toxicity stems mainly from its ability to form a stable compound with hemoglobin called carboxyhemoglobin. Hemoglobin is the substance in the red blood cells that carries oxygen to the tissues. Carbon monoxide has an affinity for hemoglobin 200 times more than that of oxygen. Because of this, CO tends to block the normal distribution of oxygen in the body and leads eventually to suffocation and duration of exposure. A concentration of 100 parts per million (ppm) in air for ten hours will lead to headaches and reduced ability to think clearly. Concentrations of

300 ppm for 10 hours lead to nausea and possibly loss of consciousness. At 600 ppm, after a similar length of time, death can result. At 1,000 ppm, unconsciousness occurs in 1 hour and death in 4 hours. It has not been determined if there are effects of chronic low-level exposure. There are, however, a number of people with respiratory diseases or anemia who are susceptible to even relatively low concentrations.

1.2 The oxide of nitrogen

If a nitrogen-oxygen mixture such as air is heated to over 1,100 °C, the nitrogen and oxygen will combine to form nitrogen oxide (NO). If the cooling process is slow, the reaction will reverse, and the NO will decompose back into N_2 and O_2. However, if the cooling takes place rapidly, as is the case of internal combustion engines, the nitrogen oxide will not decompose; it will remain as NO in exhaust gas. The reaction that forms NO does not depend directly on the fuel used. The vital ingredients are only the nitrogen, the oxygen, and the high temperature. The exhaust of an internal combustion engine running at high speed without emission controls will contain about 4,000 ppm of NO. The exhaust of a coal-fired steam generator will have 200 to 1,200 ppm of NO. Nitrogen oxide is a colorless gas, toxic in high concentrations, but its toxicity is generally considered to be minor compared to another oxide of nitrogen, nitrogen dioxide, NO_2.

Nitrogen dioxide is produced in the same manner as nitrogen oxide, although for most combustion processes, NO is much more prevalent. Nitrogen dioxide is also produced, however, when NO is released into the atmosphere. In one process, NO reacts with ozone, O_3, and becomes NO_2. After about 10 hours, 50% of the NO will have been converted to NO_2. Because of its greater toxicity compared with NO, NO_2 is of much greater importance environmentally, although frequently the nitrogen oxides are treated together as NO_x. Nitrogen dioxide is a reddish-brown gas that accounts for the brownish color of the familiar smog in cities.

Nitrogen dioxide can be smelled at about 0.5 ppm in air, and at 5 ppm it begins to affect the respiratory system. At concentrations of 20 to 50 ppm, there is a strong odor, one's eyes become irritated, and damage to the lungs, liver, and heart has been known to occure. At 150 ppm, serious lung problems occur with 3 to 8 hour exposures. Many feel that chronic lung damage will occur at concentrations as low as

5 ppm for day-long exposures. The National Air Quality Standard is 0.05 ppm annual arithmetic mean.

1.3 Hydrocarbon emissions

As the name implies, hydrocarbon molecules are made up of atoms of hydrogen and carbon, but atoms of oxygen and chlorine may also be involved. In a study of the Los Angeles air, 56 different species of gaseous hydrocarbons were identified, but apparently the number observed is limited only by the sensitivity of the analytical techniques used.

The various hydrocarbons enter the atmosphere from a number of different sources. Some of the most important are:

1. Auto exhaust and partially unburned gasoline.
2. Gasoline evaporated in various steps in production, refining, and handling.
3. Organic solvents used in manufacturing, dry cleaning fluids, inks and paints.
4. Chemical manufacturing.
5. Incineration of various materials, industrial dryers and ovens.

Once the hydrocarbons are liberated into the atmosphere, they can combine with atomic oxygen or with ozone formed by the interaction of sunlight with nitrogen dioxide, as described previously. These reactions result in the formation of complex molecules of hydrogen, carbon, oxygen, and nitrogen , known as peroxyaccyl nitrates, abbreviated PAN. The PANs are strongly oxidizing and account for many of the harmful properties of smog.

1.4 Sulfur dioxide

Sulfur dioxide, SO_2, is an important atmospheric pollutant. When fossil fuel is burned, the various sulfur compounds in the fuel are conversed to SO_2, a colorless and flammable gas. The automobile is not the major source of this pollutant. The largest SO_2 sources are stationary, particularly coal and oil-burning electric power plants. The next most important sources are industrial processes, with the smelting of copper, zinc, and lead being the leading contributor. The sulfur content of coal and petroleum varies widely, but it is generally in the range of one-half percent to a few percent by weight.

It is difficult to separate the effects of SO_2 from those of H_2SO_4 (sulfuric acid) that results from SO_2. When sulfur dioxide enters the atmosphere, it is oxidized to sulfur trioxide, SO_3, in a relatively short time (a few days), and the SO_3 can then combine with moisture to form H_2SO_4 or sulfate salts. The local effects of SO_2 are somewhat intermixed with those of H_2SO_4, but both substances are known to be irritants of the respiratory system. In combination with particulates, measurable increases in the rate of illness and death have been observed in cities where the SO_2 concentration is around 0.1 or 0.2 ppm. Concentration of 0.01 ppm for a year, ranging to concentrations of a few ppm for 30 seconds, are thought to affect the health of people, particularly through the respiratory and cardiovascular systems. The experience in the Netherlands has been that there is a definite increase in the mortality rate from lung cancer and bronchitis at SO_2 concentrations of 0.04 ppm. It is hard to isolate the effects directly due to sulfur dioxide, however, because particulates and moisture are usually present in the same environment and they play a synergistic role.

1.5 Particulates

Particulates are very different in nature from the gaseous air pollutants we have discussed. The particulates can be solids or liquids, and as such, they can have a certain size as well as a chemical composition. The term aerosol is often used to describe either solid or liquid matter suspended in the atmosphere; however, we shall use the term particulates. There are a number of natural sources of particulates, such as salt from ocean, dust from fields, volcanic ash, and forest fires. Worldwide, the natural sources produce about 14 times as much particulates as are produced from man-made sources.

In addition to their effects on human health, particulates in the atmosphere can scatter and absorb an appreciable amount of sunlight. It is known that the volcanic ash put into the atmosphere by the eruption of Tambora in the Dutch East Indies in 1815 resulted in a general lowering of the global temperature for several years afterward. In one year during this period, there was frost every month in New England; there was no real summer. On a more local level, cities now receive about 20% less sunlight than do areas with less industry and fewer power plants. Coupled with this is a general reduction of visibility and enhancement of fog formation. In addition to the soiling of clothing and buildings by the deposition of particles of soot, corrosion of metals and degradation of other materials are caused by particulates that have had sulfuric acid and other corrosive liquids condensed on them. Paint, masonry, electrical contacts and textiles are all affected [29].

2. Noise

The noise limits vary with various types of area. The ambient noise standards of Pollution Control Department, Ministry of Natural Resources and Environment, Thailand will be shown in Table 3.

Table 3 Ambient noise standards of Pollution Control Department, Ministry of Natural Resources and Environment, Thailand. [30]

Ambient noise standards	
Standard	Calculation
1. Maximum sound level (L_{max}) should not exceed 115 db(A)	Equivalent Sound Level (L_{eq}) from Fluctuation Noise
2. A weighted Equivalent Continuous Sound Level (L_{eq}) 24 hours should not exceed 70 db(A)	Equivalent Sound Level (L_{eq}) from Steady Noise

The noise of biomass power plant comes primarily from engines, pumps, fans, air inlets or exhaust systems, as well as from other machines (compressors, cranes, belt conveyors, screw conveyors, and hydraulic systems) and from all traffic on the plant sites. For most areas, the noise limit is lowest during the night, and it will therefore normally be this limit that will form the basis of the dimensioning. However, the delivery of biomass fuel often gives rise to problems, although it takes place during the day if the driveway of the plant is inexpediently located [31].

3. Waste water

During the gasification of wood and/or agricultural residues, ashes (from the gasifier and the cleaning section) and condensate (mainly water) are produced. The latter can be polluted by phenolics and tar.

The ashes do not constitute an environment hazard and can be disposed of in the normal way. For the tar-containing condensate, the situation is different, and disposal of these from a large number of gasifier can have undesirable environmental effects. No hard data are available on the bio-degradation of the phenolic and tarry constituents of the condensates, and the problem of disposal needs careful study. Therefore, the waste water cannot be permitted to drain to environment [31].

Review related literatures

Eric D. Larson [32] reported that gasifying biomass to produce a combustible gas provides the possibility for much more efficient overall conversion of a given biomass resource into electric power than was possible with traditional combustion-based technologies. In particularly, gasified biomass could be used to power internal combustion engine (ICEs), gas turbines, and fuel cells, all of which were able to produce electricity at considerably higher efficiency than boiler/steam-turbine systems of comparable size. In addition, ICEs, gas turbines or fuel cells coupled with biomass gasifiers had the potential for considerably lower capital investment requirements than comparably-sized boiler/steam turbine systems. In the size range below 5 MW_e, spark-ignition or compression-ignition engines were the technologies of choice for gasification-based power generation from biomass.

P.R. Bhoi [33] reported the performance evaluation of open core gasifier on muti-fuels that Sardar Patel renewable energy research institute (SPRERI) had designed and developed open core, throat-less, downdraft gasifier and installed it at the institute. The gasifier was designed for loose agriculture residues like groundnut shells. The purpose of the study was to evaluate the gasifier on multi-fuels such as babul wood (Prosopis juliflora), groundnut shell briquettes, groundnut shell, mixture of wood and groundnut shell in the ratio of 1:1 and cashew nut shell. The gasifier performance was evaluated in term of fuel consumption rate, calorific value of producer gas and gasification efficiency. Gasification efficiency of babul wood (Prosopis juliflora), groundnut shell briquettes, groundnut shell, mixture of wood and groundnut shell in the ratio of 1:1 and cashew nut shell were 72%, 66%, 70%, 64%, 70%, respectively. The study revealed that babul wood (Prosopis juliflora), groundnut shell briquettes, groundnut shell, mixture of wood and groundnut shell in the ratio of

1:1 and cashew nut shell were satisfactorily gasified in open core downdraft gasifier. The study also showed that there was flow problem with groundnut shells and thereby provided uniform response over a wide range of operating conditions.

R.O. Williams [34] described the modification of a standard diesel engine to convert it to dual fuel operation on producer gas. A 6-cylinder, 4 stroke, direct-injection diesel engine with 8.7×10^{-3} m^3 of displacement and a compression ratio of 14.5 was used. It was turbo-charged intercooled, had a power ratting of 202 bhp intermittent, 172 bhp continuous variable speed governor. The engine was coupled to a 100 kW alternator.

Fossum M. Barrio [35] described the gasifier in detail at 500 mm height and 100 mm diameter. One of the singularities of the gasifier design was that it allowed for variation of the point of air injection and that air preheating was also possible. The gas engine was originally a diesel engine but it had been modified for producer gas and/or natural gas operation. These changes mainly affect the compression ratio and the fuel injection system. The paper described the gas engine and explained the modifications. Experiments had been performed of gasification of wood pellets. The feeding rate was about 5 kg h^{-1}, giving and effect of 30 kW. The amount of air supplied to the reactor had been varied in the experiments, in addition to the location of the supply. The fuel gas composition had been measured with a gas chromatography. The amount of producer gas obtained 12.5 Nm^3 h^{-1} and had a heating value of 4.9 MJ Nm^{-3}. From these data the power produced by the gas engine was expected to be about 5 kW. The gas engine would be operated with mixtures of synthesis gas and natural gas and detailed measurements of cylinder pressure, compression ratio and heat released by the engine were planned, in addition, to emission measurements of CO, unburned hydrocarbons and NO_X. The dependency of the results on the ratio of synthesis gas/natural gas would further be evaluated.

Ulrik Henriksen [36] presented the Two-Stage Gasifier which was operated for more than 2000 h. The first tests (465 h) would be focused in his study. During these tests the gasifier was operated automatically unattended day and night, and only small adjustments of the feeding rate were necessary once or twice per day. The operation was successful, and the output as expected. The engine operated well on the gas production, and no deposits were observed in the engine afterwards. The bag house filter was an excellent and well operating gas cleaning system. Small amounts of deposits consisting of salts and carbonates were observed in the hot gas heat exchanger. Analysis showed that the metal part of the reactor, where the char bed was located, was not corroded. The top of the reactor had to be reconstructed in some other material.

Phongjaroon Srisovanna [4] presented about Thailand's Biomass Energy and showed that four major agro-industries that had commonly utilized biomass as fuel for co-generation in Thailand were sugar, rice, palm oil and wood industries. Despite the current use of biomass as fuel in co-generation, there is still much to be harnessed in the agro-industries giving a clear picture of potential of biomass for co-generation. Total installed capacity of co-generation in these agro-industries is over 700 MW. The estimated surplus power generation capacity generated from biomass in sugar, rice, palm oil mill and wood mill were 240, 486, 115 and 118 MW, respectively.

N.H. Ravindanath [37] presented the performance and impact of decentralized biomass gasification system in unelectrified village such as in Hosahalli village, Karnataka, India, where lighting, drinking water, irrigation water and flour-milling services are provided by using power derived from the gasifier-based power generation system. The system consists of a 20 kW gasifier-engine generator system with all the accessories for fuel processing and electricity distribution. The biomass power system has functioned for over 14 years (1988-2004) in Hosahalli Village. Lighting and piped drinking water supply using biomass electricity was provided for over 85% of the days during the past six years. The fuel operation and maintenance cost ranged from 5.85 Rs kWh^{-1} at a load of 5 kW to 3.34 Rs kWh^{-1} at a load of 20 kW.

Kakali Mukhopadhyay [38] evaluated the socio-economic and environmental impact of the Biomass Gasification based power plant (BGBPP) in Chottomollakhali Iislands of Sunderbans. Four villages of Chottomollakhali Islands were benefited with electricity from the power plant, which served 225 consumers comprising household, commercial and industrial sectors. A simple cost benefit analysis had been used to estimate the impact of BGBPP. The findings of the study indicate that BGBPP had made a very positive impact on the life of the villages of Chottomollakhali Islands. This had led to increased economic activities and more profitable turnover for the commercial consumers and improved quality of life for the household sector. All of them had showed willingness to pay a higher price to get 24 hours of power supply. From the cost benefit analysis, it had been found that the benefit cost ratio, internal rate of return and pay back period of the project were 1.68, 19% and 7 years, respectively, However, environmental awareness was very poor among the villagers.

J. Kaew-on [39] presented biomass gas engine system for power generation which is applied in the production process of small-scale community industry. Results showed that the system should be composed of imbert-type gasifier of 1 m^3 with screw pressed fuel feeding, cyclone, ash hopper, wed scrubber, volatile matter bank, gas cooling system, gas filter, gas engine of 1,425 cc and generator of 10 kW_e.

Suppawit Lawanaskol [40] described a charcoal gasifier engine for electricity generation that was designed, fabricated, and gasification tested. The system consists of a gasifier unit, purification system (cyclone, filter and cooler), electric generator (2.2 kVA), small internal combustion engine (6.5 HP), and water pump. The gasifier was fixed base downdraft batch-type consisting of a 10 mm thickness with a unit of sheet iron walls. It had a total height of 900 mm found to be 1 kW_e for lighting, water pumping at flow rate 10 m^3 h^{-1} and charging 40 ampere-hour battery. Charcoal consumption rate was at 3 kg h^{-1}.

Weerachai Arjharn [41] reported the study of a small scale biomass power plant for rural communities developed by using the downdraft biomass gasification technology. The power plant consisted of three major parts including 1) reactor, 2) gas cleaning system, and 3) engine-generator set. The objectives of the study were to evaluate the electrical production efficiency and their pollutions using 10 types of biomass fuel such as rice husk, corn cop, cassava rhizome, cassava bark, coconut shell, palm branch, wood (Krathin Yank and Eucalyptus), Eucalyptus bark and sappanwood of Para rubber. The study procedure was comprised of three steps: 1) analysis of the biomass properties such as physical, proximate and ultimate properties, 2) evaluation of power production capability and efficiency and 3) investigation of waste and pollution produced by the power plant which include ash, waste water and exhaust gas emission. The result showed that all selected biomass could be used as fuel using gasification technology for electricity production. The ash which was generated by the power plant had a high calorific value so it could be used as charcoal for household cooking. In addition, there was no waste water discharge because the system for water treatment was a closed-looped. The exhaust gas emission quality showed an acceptable value compared to Thai's emission standard of the power plant. This study tacitly suggested that a small scale biomass power plant could be used as a substitute electricity production for every rural community in Thailand.

Kiatkri Ayuwat [42] presented the development of gasification in community level project. The technology is a thermal conversion where a solid fuel is converted into a combustible gas by using the limitation of air. Rice husk gasification technology in this project was designed as a two-stage gasifier which the pyrolysis and the gasification processes were separated into two different units. Gas which was produced in this gasifier was used as fuels instead of diesel oil in 20 kW for generating the electricity. Moreover, this gas had the negligible amounts of tar. From more than 360 hours testing, the results showed that at 25 kg h^{-1} of rice husk and 60 m^3 h^{-1} of gas flow rate, the amount of tar was less than 25 mg m^{-3} and the average of heating value was 5,000 kJ m^{-3}. It was also observed that there was 70% replacement of gas in diesel engine and the efficiency of this technology was about 83%.

Anant Oonsivilai and Boonruang Marungsri [43] reported the evaluation of biomass gasification system for internal combustion engine used in distribution power plant: A case study of the demonstration biomass gasification power plant at Tabsakhae district, Prachuapkhirikhan province, Thailand. This project was conducted by the electrical and energy systems research unit, school of Electrical Engineering of Technology, Suranaree University, under assignment of the Department of Energy Development and Energy Conservation, Ministry of Energy, Thailand. The demonstration biomass gasification power at Tabsakhae district, Prachuapkhirikhan Province, was constructed by using the budget from the year 2004 of the Department of Energy Development and Energy Conservation. The evaluation was conducted by using dual fuel, diesel and biomass gas, for internal combustion engine. The plant was operated for 1,200 hours using different kinds of biomass, i.e. pine wood, para rubber wood, coconut wood, white popinac wood and cassava rhizome, compared with 1,200 hours of plant operation using coconut shell as biomass. Furthermore, the effects of demonstration biomass gasification power plant to communities, economy, and environment, were studied and analyzed. The results denote the effectiveness of each kind of biomass.

Sasirot Pitakrattanachote [44] presented an economic feasibility study of bio-power plant using rice husk as fuel in selected areas of the country. It employed a lot of secondary data from various involved agencies to investigate production status and utilization of rice husk as well as electricity production technologies. The concept of financial and economic feasibility studies were then applied to the case studied power plant using rice husk at 22 MW in Roi-Et Province. The key indicators including NPV, BCR and IRR were used as justification of economic feasibility. Cost structure in this study included mainly environment, investment, operating and maintenance, transport and opportunity cost of rice husk and land. On the other hand, benefits included avoiding costs from typical electricity production, indirect benefit of ash sale and environmental benefit from CO_2 reduction. Findings revealed that rice husk from processing of paddy varied according to supply of paddy and type of millers. Rice husk could be used as fuel and other purposes such as fertilizer and soil improvement materials. Investigation in electricity production technology found that thermo-chemical process through suspension firing technique appears to be relatively most effective due to minimum rate of fuel use and maximum quality of ash. Both financial and economic analysis of the feasibility was described that many factors were assumed varied. The study concluded that electricity production using rice husk as fuel was considered financial and economic feasibility. Interested public and private sectors should then pay attention to such investment as an alternative source of energy now and in the future. The ultimate goal of this study then was to justify that any domestic resources of the country should be further explored and utilized to maximize benefit to the society.

Dithaporn Thungsotanon [45] reported an experimental study of influences of wavy surfaces of a fluidized bed on rice husk combustion characteristics. The experiments were made in 3 types of the fluidized bed: the conventional fluidized bed with a constriction, the fluidized bed with wavy surface at the top, and bed with wavy surface at the bottom. Each type of the beds was tested for the same air flow rate at 95 kg h^{-1} and mass flow rates of rice husk ranging from 10 kg h^{-1} to 15.5 kg h^{-1} or for the percent of excess air between 15% and 75%. Temperature distributions inside the bed were measured at selected locations and fly ash, smoke and exhaust gas emissions were observed and measured by a gas analyzer. Effects of heat exchanger installed along the center of the combustion chamber on thermal behaviors were also studied. In addition, sand used as bed materials was tested for the excess air of 30% and 45%. The experiment showed that wavy surface at the bottom part could improve combustion performance and yield better combustion than the others for all test runs. From experimental results, maximum flue gas temperatures for each bed were found to be between 573 °C and 746 °C and the maximum temperature of the combustor was about 979 °C. From exhaust gas emission measurements, it was found that CO was in a range of 605 ppm to 3,864 ppm, NO between 171 ppm and 367 ppm and combustion efficiency ranging from 83.9% to 92.5%. For the heat exchanger with air as a working fluid, the bed with wavy surface at the bottom provided a maximum heat output at 8.16% of input loads. When using sand as bed material, it was found that especially at 45% excess air, the combustion of rice husk with sand could be improved and stabilized better than that without sand.

Wannee Ekasilp [46] reported the possibility of using co-generation system in the rice mill in Thailand. The results of the analysis showed that the total electrical energy consumption; milling process, drying process, improving and packing process, office and boiler in the white rice mill was approximately 190 MJ t^{-1} paddy and 238 MJ t^{-1} paddy in par-boiled rice mill. In the white rice mill and the par-boiled rice mill, the thermal energy was found to be 242 MJ t^{-1} paddy and 1,019 MJ t^{-1} paddy, respectively, the heat to power ratio was found to be 1.3:1 and 4.3:1, respectively. Gasifier with internal combustion engine co-generation system was used with capacity of 160 kW $unit^{-1}$. The electrical power generated from 260 kW white rice mills was therefore 112 MW, of which 87% was used within the rice mills and 13% was left. The thermal energy generated from the drying process could use 50% of paddy for milling process, and 52 par-boiled rice mill was therefore 32 MW, of which 88% was used within the rice mills and 12% was left. The thermal energy generated from the drying process could use 90% of paddy to milling process. Condensing steam turbine co-generation system, the electrical power generated from 260 white rice mills was

150 MW, of which 60% was used within the rice mills and 40% was left. The thermal energy generated from the drying process could use 50% of paddy to milling process, and 52 par-boiled rice mill was therefore 29 MW of which 97% was used within the rice mills and 3% was left. The thermal energy was generated from the heat process. Currently, the government encourages private sectors to generate electricity by using biomass fuels, i.e. husk and sell back to EGAT. CO_2 caused by biomass fuels could be recycled, and the tree use CO_2 through plant photosynthesis process. Therefore, CO_2 does not accumulate in the atmosphere. From the analysis, the cost of the reduction of CO_2 resulted from electricity generation by forestation 0.0152 US\$ kWh^{-1}. Cost of the reduction of SO_2 resulted from electricity generating by flue gas desulfurization 0.006 US\$ kWh^{-1}. At present, the price of electricity bought by EGAT does not include additional price of the reduction of CO_2 and SO_2. It is recommended that EGAT raise additional price of 0.0152 US\$ kWh^{-1} or 0.0212 US\$ kWh^{-1} to purchase electricity generated by using biomass from private sector to avoid conservation cost of the environment.

Sunthorn Laaongnaun's [47] experiment was carried out to receive the fundamental data on parameters that characterize the combustion of bagasse in a fixed bed reactor, that composed of flame propagation velocity and combustion rate. The experiments were performed as batch and bagasse was used as fuel. The variable investigations were air to fuel ratio, input air speed and temperature of primary air. The various conditions were operated as follow: total air supply in rates of 200, 300 and 400 LPM having air primary speed of 188, 282 and 377 mm s^{-1}, respectively. In addition to ambient temperature of combustion air that was supplied to the bottom of the bed, temperature of primary air input was also heated by air heater before entry to the furnace at the temperature of 100, 150 and 200°C. Axial temperature along the bed height and continuous monitoring of gases emission were recorded. These results were conducted to calculate the parameters concerned as mentioned earlier. The results disclosed that bagasses combustion at ambient temperature (non-preheat of primary air) was governed by volatile combustion with char combustion. The combustion rate varied from 0.044 to 0.338 g s^{-1} and flame speed from 1.59 to 2.87 mm s^{-1} depending on speed and volume of air. Combustion rates were 0.076, 0.188 and 0.338 g s^{-1} and flame speeds were 1.86, 1.71 and 1.69 mm s^{-1} for total air of 200, 300 and 400 LPM, respectively. When primary air velocities were reduced, combustion rates reduced to be 0.044, 0.085 and 0.177 g s^{-1} whereas flame speeds increased to be 2.87, 1.94 and 1.59 mm s^{-1} for the velocity of 94, 141 and 188 mm s^{-1}. When the primary air temperature was increased, the range of combustion rate and flame speed changed to be 0.017 to 0.114 g s^{-1} and 2.46 to 5.55 mm s^{-1}, respectively. Depending on volume of air and primary air of velocity with total air was 200, 300 and 400 LPM and primary air, velocity was 188, 282 and 377 mm s^{-1} which resulted combustion rates of 0.036, 0.051 and 0.077 g s^{-1} and flame speed of 4.37, 3.72 and 3.50 mm s^{-1}. When primary airdrop was 0.094, 0.141 and 0.188 m s^{-1} the resulting combustion rate was 0.028, 0.56 and 0.076 g s^{-1} and flame speeds increased to 5.43, 5.55 and 5.30 mm s^{-1}. However, with increasing total air and primary air temperature, non-combustion rate increased from bagass combustion at ambient temperature.

Solot Suwannayuen [48] reported on the heat generation system from rice hull, namely Fluidized bed combustor and Moving-bed Gasifier, which were studied in order to find the suitable range of operating conditions and relevant performance data. The results of rice hull combustion in Fluidized bed furnace showed that the combustion efficiency at constant bed temperatures of 700 and 750 °C and excess air of about 22% was in the range of 96-99%. The external heat transfer coefficient of tubes immersing in the bed and of convective tube bank over bed were in the ranges of 130 to 360 and 60 to 185 W m^{-2}-K, consecutively. In the rice hull gasification study for the moving-bed system, the results showed that the producer gas contained 16 to 24% CO and some amount of CH_4 and H_2. Producer gas with highest heating value of 3.347 kJ m^{-3} at STD. and 24% volume of CO was obtained using air fuel ratio of 1.7. The heating value did not include the heat of tar which had already been condensed out. The fluidized bed combustion system which produces heat from rice hull seemed to give higher energy conversion efficiency than the moving-bed gasifier. Gasifier might be more suitable for energy generation system that utilized gaseous fuels. For actual application, the economic of the entire system and other relevant factor had to be considered in the selection of suitable heat generation system.

Kasame Thepnoo [49] presented the chemical compositions and physical properties of rice husk ash (RHA) generated from three different combustion technologies of biomass power plants. Additionally, the potential of utilizing RHA for brick making, substrate culture for flowers and export trading were investigated in terms of technical and economic analysis. The results of technical analysis showed that RHA (fly ash) obtained from fluidized bed combustion of Biomass power plant gave the highest silicon up to 90 wt% which was capable of brick making. Mixing of 3 wt% fly ash with clay exhibited the highest compressive strength of 101.86 Kg cm^{-2}, specified by the Thai Industrial Standard. The RHA (bottom ash) produced from traveling grate stoker of Bua Sommai power plant was suitable for use as a substrate culture for flower due to its low salinity and optimal media shrinkage under moisture saturation. The RHA (ash mixed between fly ash and bottom ash) generated from inclined grate stoker of power plant contained less than 5 wt% of carbon content, less than 1 wt% of moisture and less than 250 kg m^{-3} of bulk density. There measurements were required for exporting as a raw material to produce refractory materials. The economic analysis of three possible alternatives determined the shortest discounted pay back period of 1.36 years for export trading, followed by 1.60 years and 2.18 years for brick making and substrate culture for flower, respectively.

Prapa Tumsri [50] reported the objective of her thesis was to study the appropriate systems for controlling the manufacturing process within rice husk fuel power plants so that it could be the guideline to decide which system would be feasible to invest and to operate. The research was conducted by comparing, in terms of economics, the effects of introducing controlling system to the plant. The systems used in this research were the conventional control systems that were widely used in these types of plants, and the field bus control systems which transfered information from process devices to control system (DCS) in digital signal format. The purpose of processing this research was composed of 3 particulars: 1) to be applied to the future plant operation 2) to replace the conventional control system, and 3) to study the advantages of field bus technology for improvement of preventive maintenance. This research considered the costs involved and the system investment that resulted different long-term operating costs. The research also compared the maintenance costs for both systems. This part of the study was used for calculating the present worth on incremental investment. The study included the advantage of the maintenance improvement especially in preventive maintenance point of view. This ultimatum could be used when selecting the system for the plant. It should be concluded that the increment of the efficiency was the result of preventive maintenance that could combine the unplanned outage costs by 2,108,000 baht. This information supported that the field bus had feasibility for investment and operation. However, the weakness of single cable of the field bus that may reduce the reliability of control system should be taken into account when selecting.

Tanet Thanmatikornkun [51] presented that Surat Thani Province ranked second in the production of palm oil in Thailand after Krabi. In 2006, Surat Thani's production of palm oil totaled 1,530,896 tons. Biomass from palm oil production left about 649,254 tons which could be used as raw material in the production of electricity for about 66.89 M $year^{-1}$. Generally, the production of electricity from biomass employs thermo-chemical methods which can be divided into two types: direct combustion and gasification. At present, besides using biomass in producing electricity, there is a co-generation method producing both heat and electricity. The study determined the rate of return within twenty-five years of project initiation, beginning with the two-year construction of the Electricity Generating Plant. This plant had the capacity to sell generated electricity to the electricity purchasing system, its average net producing capacity was 10 MW or approximately 10,000 kW h^{-1}. The economic assessment used the net present value (NPV), the benefit cost ratio (BCR) and the internal rate of return (IRR). Research was the sufficiency of raw materials or biomass taken from palm oil production in Surat Thani Province. Such biomass included the palm bunch, which was the main raw material used in the production of electricity, as well as other biomass found in Surat Thani Province. The data for this research involved both primary and secondary data. The primary data was collected from interviews conducted to determine local opinions. The secondary data was collected from websites, journals, annual reports, government documents, seminar materials, and other resources regarding biomass energy. The findings indicated that the NPV of the project was 762,292,416.54 baht. The BCR was 1.371353958 and IRR was 24.1144451%. The findings also indicated that the investors received a rate of return rendering it worthy of investment and showed that the project is suitable for further investment.

Rungrat Ruangsung [52] reported the financial rate of return on the electricity generation investment of Dan Chang Bio-energy Co.Ltd., a small power producer using agricultural wasted raw materials such as bagasses, paddy husk, wood bark and other, to produce the electricity by co-generation system with the full capacity of 53 MW, for serving the 27 MW of power demand to the EGAT on the contractual basis of 21 years. The financial rate of return analysis was determined by various kinds of indicators such as IRR,NPV,BCR as payback period analysis based on the same period of 21 years as the contract term and the discount rate of 7.25% per year. The study showed that the constructional cost of Dan Chang Bio-energy Co.Ltd. was 2,752 million baht with an annual return of 676.58 million baht. The financial rate of return in terms of NPV was 1,753.37 million baht, BCR of 1.24 and IRR of 19.91%. The study also showed, from the switching value test, that the project would be able to accept an increase in cost not exceeding 19.53% of the total cost and the decrease of benefit not exceeding 24.26% of the total benefit. Besides, the sensitivity analysis was also conducted, taken into account of the increase of biomass fuel price at 30%, the decrease quantity at 30% and without any subsidiary of power value. The result of the analysis indicated that the project was still profitable and worthwhile for investment.

S-N Kriengsak, et al. [53] described that high temperature steam gasification offered significant advantages for clean conversion of wastes and low grade solid fuels to clean syngas. High temperature steam gasification of paper, biomass and coal was examined at gasification temperatures of 700 to 1200°C. Hydrogen yield of over 60% has been achieved, on a dry basis, at high gasification temperature. The results showed that both hydrogen and carbon monoxide increase while carbon dioxide and methane decrease with the increase in gasification temperature. A tenfold reduction in tar residue was obtained at high temperature steam gasification, as compared to low temperatures. The produced syngas can be further processed to produce pure hydrogen.

Somas Kaewluan and Suneerat Pipatmanomai [54] presented that an atmospheric bubbling fluidized bed gasifier was designed and constructed during this study for the purpose of simulating the conditions under which biomass and wastes undergo inside the commercial fluidized bed gasification system. The main characteristic of the gasification system was the feeding system capable of 30-100 kg h^{-1} of fuel and also allowing fuel to be tested without the need of fuel size reduction. Fuel particle size of up to around 25 mm can be used. Temperatures, product gas composition and tar concentration were also measured. The minimum fluidization velocity, U_{mf}, was experimentally determined at 0.19 m s^{-1} at 1,000 K. Preliminary tests with biomass were carried out using wood shaving with a plant for rubber wood chip and eucalyptus bark. In addition, the effect of the critical parameters, including air to fuel ratio, moisture content in fuel, etc, on the gasification behavior and its product characteristics would be investigated.

The related literature and researches it could be considered that BGT was suitable for decentralized power generation for community due to many advantages as described above.