COUNTRY REPORT: THAILAND

AGRICULTURAL ENGINEERING AND TECHNOLOGY FOR FOOD SECURITY AND SUSTAINABLE AGRICULTURE IN THAILAND

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Thailand is regarded as an agricultural country, and the agricultural sector has played an important role in the growth of the economy throughout Thai history. The total area of the country is 513,115 square kilometers, of which 41 percent or 21,196,571 hectares is devoted to agriculture. The latest survey shows that land under cultivation includes 51 percent for rice production, 24 percent for field crops, and 17 percent for fruit trees and perennial crops. Over the last four decades, agricultural production has increased significantly. However, increased production largely was due to the expansion of cultivated land through forest encroachment rather than increasing yield per unit area. The soil has been repeatedly cultivated without proper attention to improve its conditions, resulting in a decline in fertility. Currently, land encroachment is unacceptable if severe damage to the environment is to be avoided. In addition, existing arable land has been partly shifted to non-farm use in response to urbanization and industrialization. Land development policies therefore, are placing increased emphasis on the improvement of soil productivity, soil conservation, and land reform.

Thailand has pledged to continue exporting food at fair prices as many countries are suffering from food shortages, as non-oil producing nations are being hurt from soaring global oil prices. Thailand, the world's biggest rice exporter, has sold 6.7 million tonnes of rice so far this year, up 45 per cent from 4.6 million tonnes in the same period of last year, according to the Commerce Ministry data. The country aims to sell 10 million tonnes in 2008, slightly below the record 10.13 million in 2004 and compared with 9.5 million in 2007. Export of agricultural and food products from Thailand now exceeds over Baht 600 billion and approximately accounts for 30 per cent of total export from Thailand.

The Thai government establishes the Agricultural & Food sector as one of the country’s strategic economic sectors, and targets export value to Baht 1 trillion. Consumers especially for those in major trade partners' countries have increasing concern for safety impact in aspect of their live, health and hygiene. In addition, food production now has a more varieties and complexities in breadth and depth of product from each segment from each country; therefore, national agency in each country establishes many regulatory agency and competent authorities to closely monitor food safety measures compliance.

With soaring food prices and the rapid expansion of energy crop worldwide, the Agriculture and Cooperatives Ministry is considering re-zoning farmland. New plans would see certain areas set aside for food and others for energy. Low rice prices over the past decade have forced many farmers to consider growing other crops. At the same time, increasing oil prices have made alternative sources of bio-fuels more profitable. As a result, farmers have been switching their fields from food to bio-fuel at rate much greater than was anticipated by the authorities. Under the Thai plan, a panel would be established to develop a strategic plan for the management of food crops and energy crops. It is necessary to ensure that crops will be properly managed and any crisis averted. Thailand has about 208,000 square kilometers of farm land. About 10 per cent of this is devoted to energy crops, but this amount is growing fast.

To boost yields, the ministry plans to improve land-use efficiency while maintaining the level of energy crop. It is also looking for ways to protect farming areas under threat from expanding industry, real estate and other development. In addition, the ministry is considering doubling the amount of irrigated land in the country.

The research and development of agricultural technology in Thailand for food security and agricultural sustainable are:

Rice Cultivation by Stubble-Lodge Rice Method

This method utilizes the rice stubbles from the previous harvest, allowing the apical buds on the stubbles to develop into full-grown plants which later flower and produce seeds for another harvest. There are many positive effects of this method. There is neither the need to burn the paddy fields, re-till the soil, nor buy new seeds. It also reduces the amount of water needed and other production factors. This cuts down the costs, saves resources and conserves the environment. However, the rice plant grown in this method will be in various stages of growth, as the buds are in different stages of growth themselves thus causing the new rice plant to start growing at different times. It is then difficult to manage the rice field to produce high yields and stabilize grain quality. This method is suitable for irrigated areas where water control is possible through the set up of buns bordering leveled field. It is not suitable for primarily rain fed areas.

Rice Combine Harvester

The rice combine harvester had been introduced to Thai farmers for a long time. Due to its expensive cost, not suitable field conditions and high technology, the rice combine harvester was not accepted by Thai farmers. However, because of the expansion of industrial sector, labour migrated to other sectors and consequently leaving the agricultural sector short of labour especially in harvest periods. During 1985-1986, the rice combine harvester was developed by local manufacturers. There were about 1500 harvesters made by 30 manufacturers during 1990-1991. The parts of harvester were integrated among exported parts, used parts and using axial flow thresher as threshing unit. The hiring rate was about 75-90 US$/ha. The future role of rice combine harvester in Thailand was considered to be based on economic, social and agricultural production systems. For the economic aspect, the labor shortage in harvesting, the need in quality improvement of rice and cost reduction lead to the utilization of the rice combine harvester. For social aspect, due to labour migration most available labour are found to be older persons and children. For agricultural production system, the rice combing harvester was necessary for timely harvesting of upland crop planting as a second crop after rice. In terms of post-harvest loss, the use of combine harvester loss can be reduced when compared with traditional method. The use of combine harvester can be found in the intensive planting areas, from the lower part of the northern region down to the central plain region. The availability of water supply, non-photosensitive varieties, tractors and combine harvesters allow rice farmers in this area to grow 2 to 3 crops per year. There are about 3,000 units of the combine harvester being used in those areas. They operate on contract basis.

Grain Dryer

At the beginning of the introduction of the combine harvester, rice is combined at relatively high moisture, sometimes as high as 28 per cent, but the average moisture at harvest is about 24 per cent. A farmer does not dry his own paddy but sells it to the miller or the collector right away. The high moisture rice is immediately transported to the rice mill or the local collector. Most millers and collectors at that time had no mechanical dryer, with drying the high moisture rice depending mostly on sun drying. This change had created a large volume of high moisture paddy at a short period, beyond the handling capability of the millers. During 1992 – 93 farm price of paddy at that period was the lowest ever recorded. The government tried to solve the problem by, on one hand subsidizing dryers at cooperatives and farmer's groups in the major rice production areas, and on the other hand giving soft loans to millers and owners of central market for paddy to put up dryers. The Ministry of Agriculture and Cooperatives undertook the subsidizing of dryers at the cooperatives and farmers' group programme. The Ministry of Commerce undertook the soft loans provided for millers and collectors programme. The programme took place from 1995 to 1998 for cooperatives and farmer's group and until the year 2000 for millers. At present almost 90 per cent of the miller and local collector in the major rice production area own mechanical dryers.

Drying of wet paddy is done by the miller or by the collector using only dryer or both mechanical dryer and sun drying floor. Types of paddy dryer used in Thailand are cross flow, mixed flow, fluidized bed and rotary dryer. The concurrent flow dryer has not been observed. The dryers that the government subsidized to the Farmers' group and cooperatives were mostly the mixed flow type, very few were the cross flow. Drying capacity of these dryers were about 30 tons per day of paddy at initial moisture of 22 per cent dry to 15 per cent, using diesel fuel burner to generate hot air. The dryer operates as batch re-circulation at about 6 tons per batch for individual farmer to dry the wet paddy. The dryer also, was designed accommodate the harvesting capacity of a combine harvester in one day. There are about 300 units of these dryers in all parts of the country. Survey on the use of these dryers in 1998 found that about 10 per cent of them were in operation. This may be due to the system of local buying. The pricing of dry paddy in some areas was not much different from the wet paddy. Also farmers need immediate cash to pay their loan. At present none of those dryers is in operation due to the high price of diesel fuel and no incentive for drying. At the cooperatives rice mill level, the government subsidized a larger size of mixed flow dryer having drying capacity of about 60 to over 100 tons per day. Those dryers use rice hull as fuel to generate hot air through heat exchanger and they operate as batch re-circulation. Because of the cheap cost of fuel for drying and the need to dry wet paddy for milling, most of the dryers at cooperative rice mill in the central region are operating.

For the case of soft loans provided to rice millers and collectors for securing dryers and the necessary components for operating the dryers, millers mostly hire contractors to build dryers according to their own designed or in consultation with the contractors. This might be due that the mill owner sees that construction of a dryer is easy, buying it is too costly, or because there are too few dryer manufacturers as compared to the number of the millers. At present, there are only five or six manufacturers, which cannot serve over 1,000 of the millers all at once. Many of those built by the contractor, mostly are very large in size, having holding capacity of 100 tons or more at little moisture extraction rate. Some rice mills install two to three dryers of those sizes to cover the daily input. Operation of those dryers is either as re-circulation batch or continuously drying wet paddy in one passing. Some version of dryer may have four of the mixed flow type drying bins holding about 25 tons each arranged in series instead of a large drying bin. Input paddy continuously flow from one bin to the others and exit at moisture about 15 per cent. Head rice yield obtained from those dryers are higher compared to the sun drying floor method. Source of fuel used for generating hot air for drying is rice hull, and is mostly direct fire from the furnace.

Biomass energy

According to a recent study on Assessment of Sustainable National Biomass Resource Potential for Thailand, many potential biomass sources were identified, including agricultural and wood residues, wood fuels, new plantations, waste water from livestock farms and industries, and municipal solid wastes. Agriculture is a large economic sector in Thailand, generating large amounts of agricultural and wood residues. Rice, sugar, palm oil, and wood-related industries are the major potential biomass energy sources. It has been estimated that about 60 million tons of agricultural and wood residues including rice husk, bagasse, palm oil residues, and wood residues, etc. are produced each year in Thailand. Currently, about 1 million ton of rice husk is consumed in rural households and 17 million tons of bagasse and rice husk are utilized as fuel for industries' heat and power requirements. In addition, 12 million tons of fuel wood and charcoal are utilized in the rural households and mills. Consequently, biomass contributes to about one-fifth of the final energy consumption in Thailand but, in general, a lot of biomass are still disposed of through open burning or dumping and are utilized in very inefficient manners, which often cause environmental problems. The surplus availability of the residues was estimated around 40 million tons per year, which is equivalent to about 426 PJ of energy. Most of these residues are cheaply available and the price of these residues including the transportation cost ranges from 0-500 Baht/ton. The potential for exploiting biomass residues for power production and cogeneration, other than those already identified, is appreciable. Aggregate commercial power generation potential from main residues including rice husk, bagasse, and palm oil residues is estimated to be around 1,000 MW. Harnessing such potential is still constrained by factors such as inappropriate conversion technologies, high investment costs, other competitive uses of the residues, lack of information on the residues, etc. Since 1995, around 176 MW of electricity has so far been supplied to the national grid from 22 small power producers (SPP) using biomass residues. Biomass conversion technologies for power generation can be classified into three categories: traditional, state-of-the-art, and emerging technologies. Most of the existing technologies employed in Thai industries are traditional technologies which have been used for a long time without any technological barrier. System (boiler) efficiencies range from 50 per cent to above 80 per cent and have minimal environmental features to meet current environmental standards. State-of-the-art technologies which are considered more efficient and environmentally-friendly than the traditional technologies are currently available in the market, with minimal developmental barriers, although its uptake is still limited to a few industries. Thailand needs substantial support for local manufacturers for the development of high-efficiency biomass systems (including boilers and components). Boilers that are produced locally are for low-pressure operation (less than 20 bar) and thus yield low-efficiency. High-pressure boilers, turbines and biomass power equipment and components have so far had to be imported mainly from Europe and Japan. Emerging technologies are long-term technologies which require further research before commercialization. There is little information about the uptake of such technologies in Thailand on a pilot or demonstration scale.

Biogas - In addition to biomass residues, wastewater containing organic matters from livestock farms and industries has increasingly been used as a potential source of biomass energy. Biogas systems using anaerobic digestion techniques such as Up flow Anaerobic Sludge Blanket (UASB) and Fixed Film technology have substantially been established especially for pig farms and food processing industries. In general, the biogas systems can be locally produced and installed. The biogas technology has been rapidly and widely accepted particularly in both large and small-sized livestock farms chiefly because the production of biogas in the livestock farms helps alleviate not only the pollution problems but also the energy cost by substituting the on-site use of fuel oil, LPG or electricity. The production potential of biogas from livestock farms in 2000 was estimated at 560 Mm^3. According to a survey performed by Chiang Mai University in 2000, there are approximately 5.4 million pigs nationwide, 65 per cent of which are in medium and large farms. These farms have a high demand of power for various activities, such as the incubation of piglets, grinding of animal feeds, pumping of effluent etc. In 2001 the installation production capacity of biogas system using wastewater from the pig farms nationwide totaled 80,000 m^3. A total capacity of 4.6 MW of electricity can be generated from biogas produced from approximately 20 large farms. If all biogas produced from pig farms in Thailand is used for electricity generation, the power generation potential will be around 50 MW. The production potential of biogas from industrial wastewater from palm oil industries, tapioca starch industries, food processing industries, and slaughter industries is also significant. It was estimated that in Thailand a total of 440 Mm^3 of biogas could potentially be produced from wastewater from such factories. To estimate the total power generation potential from biogas produced from both livestock farms and industries, it is assumed that 1 m^3 of biogas can produce electricity at 1.2 kWh and the power generation is operated 8 hours a day. Thus, a total of 560 and 440 Mm^3 of biogas produced from livestock farms and industries respectively could potentially generate about 410 MW. There is thus a considerable potential for electricity generation from biogas from livestock farms and industries, though it is currently more likely that most farms and industries substitute biogas for the on-site use of LPG or fuel oil.

At present, most of the pig farms and food-processing factories use modified diesel engines for electricity generation. The technology has low upfront costs but requires frequent maintenance and a major overhaul every 3-5 years due to corrosion problems that are caused by the presence of hydrogen sulfide in the biogas. More efficient and longer-lasting gas turbines technologies are available but have to be imported and cost 3-5 times more, so their adoption in Thailand is still limited. There is thus a clear need to develop biogas-fuelled generation technologies that are reliable and low-cost, and to build up local capabilities to manufacture such technologies so that the use of biogas for electricity generation can be accelerated. Estimates for the potential expansion of the biogas industry to 2011 range from 100 MW to 300 MW provided there is finance and development competence. Considerable growth appears very likely due to probable subsidies under the government programme to reach its 8 per cent renewable energy target.

In addition to the use of biomass residues and wastewater containing organic matters for energy production, several efforts have in recent years been made to investigate the potential and use of biomass as bio-liquid fuels for engines and vehicles, which can replace the use of petrol and diesel oil and thus help to reduce dependency on oil import. Interest in using agricultural products, such as cassava for ethanol production, has been given particular attention. According to the Ethanol-Biodiesel Club of Thailand, in 2001, the production of cassava amounted to 20 million tons while only 4 million tons were for domestic consumption and the rest was for export. The surplus of cassava was estimated to be 2 million tons per year which could be used for ethanol production of up to 1 million liters per day. The National Ethanol Committee of Thailand has recently approved 5 private ventures on ethanol production. A combined daily output of 875,000 liters of ethanol could be produced commercially. Raw materials to be used in the production are cassava roots and molasses. Ethanol would be used to blend with petrol at 5.5 per cent and 11 per cent, and to substitute for methyl tertiary butyl ether (MTBE), a fuel additive.

Though there are many and diverse sources for biomass that could be used for energy, in many cases the businesses with biomass residue streams are unaware of opportunities for value adding to their businesses and are understandably reluctant to invest in technologies they know little about. With commercial viability possible even without any subsidies and at capacities exceeding 2000 MW, the now-established targets and subsidies for biomass and renewable are expected to deliver at least 900 MW of new biomass capacity by 2011 (Du Pont, 2005). In a Power Development Plan report prepared for the World Bank by EGAT on the commercial viability of renewable energy technologies, technical and institutional factors were considered in order to arrive at estimates of practically achievable generation by the year 2011 from various biomass sources. The bulk of commercial biogas potential is in the cassava processing industry where there is an estimated 300 MW of possible development, but financing is appearing to be a key constraint. However, within the next 10 years it is expected that US$100 million will be invested in Thai biogas, though an additional US$200 million would be required to fully develop of the sector (Du Pont, 2005). Outside factors that could influence biogas include the export of cassava to countries where standards require a different waste water treatment process resulting in biogas becoming a direct by-product. Another influence will be the ability of the Clean Development Mechanism to be used to provide an additional revenue stream for projects.

Ethanol - The use of agricultural products, such as cassava and molasses, for ethanol production has been given particular attention since ethanol, which is 99.5 per cent pure alcohol by volume, can replace the use of Methyl Tertiary Butyl Ether (MTBE), a fuel additive, which takes a long time to degrade. Each year Thailand spends more than 2 billion baht on MTBE import. Therefore, the use of domestically produced ethanol can contribute to foreign currency saving as well as mitigation of pollution problems resulting from fossil fuel combustion. Efforts to use ethanol as alternative fuel actually commenced in 1977, but the cost of ethanol production then was much higher than oil prices. Commercial production was, therefore, not materialized. However, at present, given the continually increasing oil prices, ethanol is considered a viable alternative fuel for the transportation sector.

The annual production of cassava in Thailand is estimated at 18 million tons while only about 4 million tons are used for domestic consumption and the rest will be exported. To increase added value of cassava, about 2 million tons per year can be used for ethanol production of up to 1 million litres per day.

Gasohol - Gasohol is an alternative fuel for vehicles. It is a mixture of ethanol and regular gasoline at the ratio 1:9. The properties of derived gasohol are the same as Octane 95 gasoline. However, the use of gasohol will not only reduce oil consumption and air pollution from vehicle exhaust but also help farmers through the purchase of agricultural products, i.e.

sugarcane and cassava. In order to support and promote the production and use of ethanol and gasohol, the government has approved in principle the exemption of excise tax imposed on the ex-plant ethanol and on the ethanol mixed with gasoline, the deduction of contribution rates to the Oil Fund and to the ENCON Fund for gasohol; and the pricing of gasohol to be cheaper than that of Octane 95 gasoline within a range of not exceeding one baht per litre.

Moreover, the government has approved several supportive measures. For example, a policy will be established for government agencies and state enterprises to give priority to gasohol for their vehicle fleets. Promotion and support will be made to enhance preparedness of the automobile and oil refining industries to accommodate the production and use of fuel ethanol, by provision of tax privileges, for instance. Besides, potential SME practitioners and farmer organizations or entities will be encouraged to establish ethanol producing plants so that production of ethanol from agricultural products could be distributed across the country. Such measures as provision of financial assistance, in the form of concessional loan or soft loan, and provision of technical assistance from the government agencies will also be introduced for this purpose.

Biodiesel or Ester - Biodiesel, or ester, another alternative fuel for vehicles, can be produced from oil plants such as coconut, soy bean, palm and sunflower via a chemical process (Transesterification or Alcoholysis), using alkaline as a catalyst to transform fatty acid into ester or biodiesel, which has similar properties to those of diesel oil. In Thailand, biodiesel standards are yet to be established. The current mixtures vary, for example, between diesel and ester extracted from palm oil, diesel and ester extracted from coconut oil, or diesel and ester extracted from used cooking oil.

There are several factors encouraging research on biodiesel and its development in Thailand. These include: 1) problems of oil price hikes that Thailand, being an oil importing country, has been facing; 2) continuous price drops of agricultural products causing troubles for farmers; 3) increasing transportation costs of agricultural products due to increasing prices of diesel; and 4) the environmental impact resulting from diesel combustion. In 2001, His Majesty the King Bhumiphol of Thailand graciously took out a patent for the use of pure palm oil as fuel for diesel engines, with PTT carrying out the research and development.

Currently, several institutes have undertaken studies and development of the quality of biodiesel and "blended oil" (a mixture of diesel and crude plant oil or that of diesel and refined plant oil without any chemical process) compared with the specified diesel standards.

It has been reported that blended oil has advantages over diesel in that it contains lower sulfur content and helps with lubrication; however, the quality of different bulks of blended oil varies although it is sold at the same distribution station. Research is being carried out on biodiesel production from crude coconut oil ("cocodiesel") and on the impact of cocodiesel utilization on the environment.

Similar to the promotion and support to ethanol and gasohol, ester can be mixed with diesel, at a ratio no greater than 1:9, and the excise tax and the contribution to the Oil Fund are exempted for the portion of ester produced from plant oil and mixed with diesel. As a long-term measure, through use of the ENCON Fund, the government will continue supporting R&D to improve biodiesel efficiency as well as research on other oil plants to diversify sources of production; the standards for engine adjustment to enable them to run on biodiesel will be established.

Solar energy and its applications including in the food industry

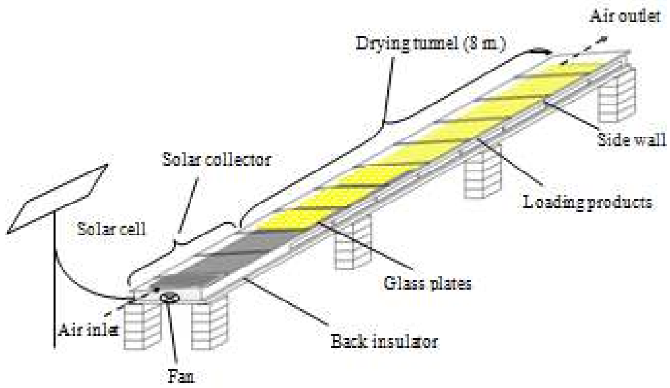
Thailand is endowed with solar energy all year long. According to the Solar Map carried out by the Department of Energy Development and Promotion (DEDP) and Silpakorn University in 1999, most areas in Thailand received maximum energy from the sunlight in April to May, ranging from 20-24 $MJ/m^2/day$. The Northern region and part of the central region of Thailand annually received the most intensive energy with an average of 20 $MJ/m^2/day$. These areas accounted for 14 per cent of the country's total area. In addition, about half of the total area received 18-19 $MJ/m^2/day$. For the whole country, the average energy from the sunlight amounted to 18 $MJ/m^2/day$. The potential for exploiting solar energy in Thailand is thus considerable. Solar energy can be used in the form of thermal energy, via the use of solar collectors, and electricity, via solar cells or photovoltaic (PV) cells. For solar thermal energy, approximately 50,000 m^2 of solar collector surface areas have so far been installed. An average increase of 2,500 m^2 is expected annually. The solar water heating industry has been commercially established, with more than ten manufacturers in the market. During 2002-2006, it is expected that solar water heaters can be installed for 10,000 households, 20 hotels and 20 hospitals. Promotion will be made on the use of solar dryers for 50 factories in the vegetable/food drying industry to reduce fuel oil or electricity consumption in the industry. With regard to the PV technology for power generation, up to now about 5.5 MW PV for stand-alone and grid connected applications have been reported. Most of them (95 per cent) are in remote areas and are off-grid, such as solar cell battery charging stations and PV pumping for village water supply. There are projects also demonstrating integrated systems of PV/wind turbine/diesel engine for power generation in national parks and wildlife sanctuaries. PV rooftops and grid supports are listed in the grid-connected category. Although the PV technology has proved to be environmentally friendly, one major barrier to wider PV utilization is its high investment costs, about 4-5 times more expensive than the present average generation cost since most of the PV system components have to be imported.

However, with the government support, coupled with worldwide stimulus for cleaner energy technologies, the future role of PV in power supply, especially in off-grid rural areas, is promising. At present, no less than 10 local companies are known to have activities or keen interest in PV-related business, such as module fabrication, system design and installation, local representatives of imported items, etc. And one company, Thai Photovoltaic's Ltd., is setting up Thailand's first solar cell production plant using thin-film technology, and plans to begin its commercial operation in 2003 with a target of producing 20 MW/year of electricity producing modules. During 2002-2006, it is targeted that 20 MW of the PV system will be installed. Of this, 8 MW is expected to be stand-alone systems in remote areas for water pumping, mini-grid for primary schools and public health facilities, and traffic lights. Another 3 MW for factories, buildings, private homes and government buildings for on-site consumption and for selling excess electricity back to the utilities' systems, where a grid system exists. The remaining 9 MW will be grid support.

Solar dryer - The solar dryer in Thailand was employed many years ago but it has not been disseminated widely due to lacking of technology transfer to farmers. In addition, most research work has been focused on industrial scale with high capital cost, which obstructs most farmers who have low capital income. There are a number of solar dryer projects operative in Thailand at present. Some of these projects are as follows:

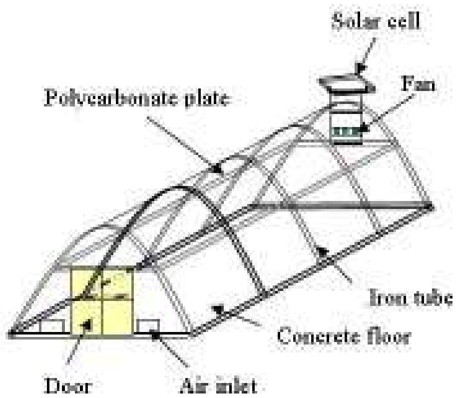
Solar tunnel dryer

The first version of the Silpakorn Type solar-tunnel-dryer has been developed in 1992. In 2005 it has been deployed to 14 locations in the north of Thailand (Royal project). Currently, five more systems are demonstrated in many parts of the country. It has been found that the solar tunnel drier can be used to dry up to 150 kg of fresh fruits and leather. In all the cases, the use of the tunnel drier led to considerable reduction in drying time in comparison to that of sun drying, and the products dried using this drier were of better quality as compared to their sun-dried counterparts. The drier can be easily constructed and it can operate with a photovoltaic module independent of electrical grid. The photovoltaic system has the advantage that the temperature of the drying air is automatically controlled by the solar radiation. The photovoltaic-driven solar tunnel drier must be optimized for an efficient operation.



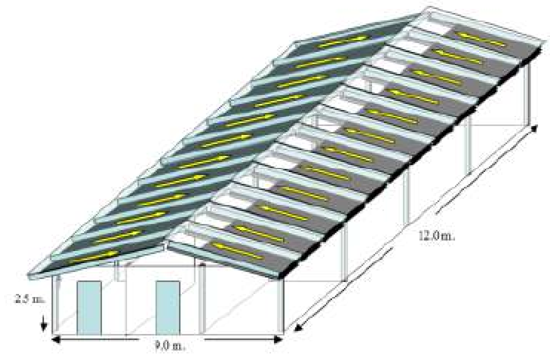
Greenhouse dryer

Solar Drying Silpakorn Type Solar Greenhouse Dryer have been developed of five years and now used in 8 locations in Thailand and one location in Africa (Sierra Leone). The dryer has a concrete floor, on which the solar radiation is absorbed. The dryer is covered by polycarbonate plates. The plates are fixed to iron square-tubes. This makes the structure of the greenhouse simple with sufficient strength to resist tropical storms. Moist air in the dryer is sucked out to the environment by three dc-fans powered by a 50-watt solar cell module. To investigate its performance, the dryer was used to dry three batches of rattan. It was found that the dryer can be used to dry 240 kg of rattan with an initial moisture content of 60 per cent db to a final moisture content of 12 per cent db in 5-7 days compared to 10-12 days needed by natural sun drying. The rattan in the dryer was completely protected from rain and it was of high quality in terms of color and texture.



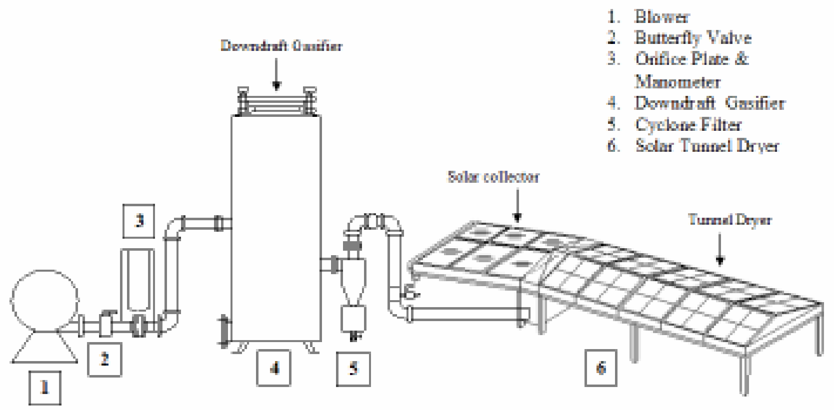
Roof integrated solar dryer

The roof-integrated collector consists of an absorber plate and a transparent cover. Solar radiation passing through the cover and heats the absorber. Ambient air is sucked through the collectors form the bottom to the top (yellow arrows). While passing through the collectors, the absorber heats up the air to high temperature. The heated air has a low humidity and can be used for the drying applications. In contrast to other technologies like the flat plat collectors and vacuum tubes the Roof integrated solar dryer is far more economical.



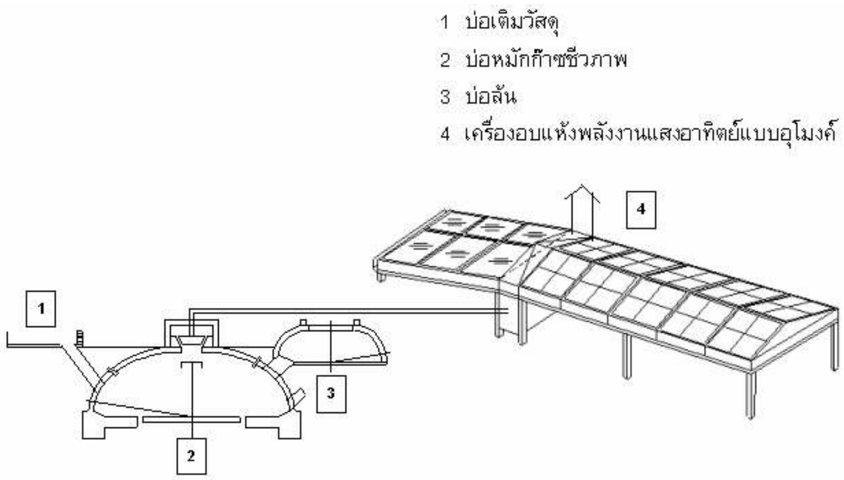
Solar Tunnel Dryer for Agricultural Products Combined with Biomass Gasifier

The solar tunnel dryer has low capital cost with less complicated construction. The study using of solar tunnel dryer for agricultural products (Banana, chilly and mango) combined with biomass gasifier. The outdoor testing was investigated at the School of Renewable Energy Technology (SERT), Naresuan University. The results showed that the efficiency of solar tunnel dryer from drying agricultural product was 42.8 per cent, 13.8 per cent and 76.9 per cent respectively and testing the biomass gasifier by used corncob material combined solar tunnel dryer, results showed that the average temperature within tunnel dryer (below level) was 57.8 ^{O}C, the average temperature within tunnel dryer (medium level) was 57.9 ^{O}C, the average temperature within tunnel dryer (top level) was 58.2 ^{O}C and the average ambient temperature was 34.9 ^{O}C that the temperature in each level of tunnel dryer non different which was suitable for drying of agricultural products. In conclusion, the biomass gasifier can be combined with the solar dryer.



Solar Dryer Combined with Biogas

The study and development of the high thermal efficiency solar tunnel dryer combined with a biogas system were tested, product are banana, chilly and glace mango. Solar tunnel dryer consists of 3 parts; (1) Solar collector (2) Tunnel dryer and (3) Auxiliary heat (Biogas System). Products in tunnel dryer can receive solar energy in two ways; (1) the solar energy can strike the drying product directly from transparent roof and (2) heated air from the solar collector passing through drying product which mass flow rate was controlled by blowers. Moreover, the dryer can operate both solar depletion and rainy day that the biogas was employed as an auxiliary heat source passing through heat exchanger. This system can be operated both daytime and nighttime. The results showed that the efficiency of solar collector was 54.6 per cent, the efficiency of solar tunnel dyer system by using banana, chilly and glace mango as drying product was 42.8 per cent, 33.4 per cent, and 76.9 per cent, respectively. The temperature in drying chamber can be adjusted, which is appropriate to disseminate to farmers. This leads to increase value added of agricultural products.



Wind energy

According to a report on wind resource assessment of Thailand done by the Department of Energy Development and Promotion (DEDP) in 2001, there are good wind areas with an annual average wind speed of 6.4 m/s or higher at 50 m height . These areas are influenced by the monsoons and are located along the eastern coastline of the southern part of the Gulf of Thailand and in the mountains of the west and southern regions of Thailand. The fair wind areas with an annual average wind speed of 4.4 m/s or higher are mainly located on the west side of the Gulf of Thailand. At its present situation with limited potential and associated high investment costs, wind energy is unlikely to be a major potential source of energy for Thailand. There are currently two main types of windmills used in Thailand, according to their applications one is for water pumping for household uses in remote areas and the other is for electricity generation. So far, only 192 kW of electricity produced from windmills has been installed in Phuket Province in the South of Thailand. Support from the government will be given to research and development on equipment and materials related to wind energy and to develop appropriate types of wind turbines that are simple to operate. There is considerable potential for large scale wind energy in Thailand, especially in the centre and western regions. A wind atlas has been created for Thailand. However, there are some constraints affecting wind energy in Thailand. These are summarized as:

- The absence of specific financing schemes designed to support wind energy development;
- The absence of grid for connection in many rural areas;
- The lack of wind data which is sufficiently accurate and industry standards to allow wind site identification;
- The fact that some existing wind turbines are not functioning, which provides a negative reinforcement of the effectiveness of wind installations;
- A low level of technology capacity in wind energy and no local manufacturing or distribution capacity.

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