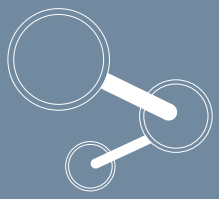
# TOWARDS SUSTAINABILITY

20 YEARS OF NSTDA : 1991 - 2011



Agriculture and Food
Energy and Environment
Health and Medicine
Technologies for the Communities

National Science and Technology Development Agency (NSTDA), Thailand

# Index

# Introduction

2011 marks the 20th anniversary of the National Science and Technology Development Agency (NSTDA). So much has happened in the last two decades in which research and innovation have shown social and economic impacts. NSTDA is now a mature organization and is reaching out to meet new challenges while getting ready to enter the ASEAN Economic Community (AEC) in 2015.

There are four national research and development centers and a fifth center dedicated to technology management under the NSTDA umbrella. They are

- National Center for Genetic Engineering and Biotechnology: BIOTEC
- National Metal and Materials Technology Center: MTEC
- National Electronics and Computer Technology Center: NECTEC
- National Nanotechnology Center: NANOTEC
- Technology Management Center: TMC

All focus on building Thailand's S&T capacities to become a knowledge-based society in which research and innovation is the foundation for our future.

Good research and innovation brings added value to existing processes, products and services while generating prosperity and improving overall quality of life. Bridging the gap between research and the market place, NSTDA along with its national centers created an alliance network of universities, industries and government agencies. This serves as a mechanism that successfully links S&T to business and to deliver research and innovations according to industrial and societal needs.

Promoting the ethos of **Thai made**, **Thai own**, and **Thai use**, NSTDA and its strategic partners make each bit truly workable. By way of turning research and innovation to sustainability, the Thai economy and its long-term economic growth will see positive impacts through the local **creation**, **ownership** and **applications**. A listing of 20 major research accomplishments commemorating the 20 years of NSTDA is intended to showcase some of the research and innovation results of these partnerships. The accomplishments also portray the role that science, technology and innovation play in buildng Thailand's regional and global competitiveness while ensuring sustainable and equitable social and economic development.

SUCCESS STORIES

# AGRICULTURE AND FOOD

# Rice – Thai Staple in World Cuisine

Jasmine rice, known to Thais as "Hom Mali" rice, is a source of national pride and is widely recognized as a Thai genetic asset. Economically, it has brought in billions of dollars to Thailand. To sustain this leadership position and to remain competitive, Thailand needs to adapt and enhance its rice agriculture and agribusiness across the entire value chain. With globalization, the Thai rice industries now face with increasing international competition. In addition, climate change has added new and unpredictable variables for rice farmers and rice industries to assimilate and to mitigate. Rice research must address these challenges.



## Rice genome

An historic moment came when a top rice exporter took the lead in sequencing chromosome 9 along with the International Rice Genome Sequencing Project. The outcome was the longest genomic sequence ever deposited by Thai scientists in the public domain. Two years later, the Rice Gene Discovery Unit (RGDU) was established as a collaboration between BIOTEC and Kasetsart University. The ultimate goal of RGDU is the innovation of rice breeding by combining genomics and molecular genetics with traditional breeding methods.

The complete sequencing and annotation of the rice genome helps uncover the whole genetic code of rice. It will also lead to the discovery of new genes and innovative new rice strains. Cloning of the aromatic gene from the Thai Hom Mali rice was the first successful map-based cloning of its kind. Subsequent development of a gene-knockout technology, an enabling technology, to convert non-aromatic rice to an aromatic one has earned Thailand a US patent and seven other patents in export targeted countries around the world. The discovery has laid out a solid foundation for breeding aromatic rice for high yielding and with resistances to biotic and abiotic stresses.

## Superior traits

To develop superior rice varieties containing various resistances and high yield with top-cooking qualities is not an easy task using conventional breeding. Marker-assisted selection and gene pyramiding are the breeding strategy at RGDU. Various functional markers have been developed for aroma, cooked rice texture, diseases, as well as submergence and salinity resistance quality. The challenging goal for Thai researchers is to come up with widely-adaptive jasmine rice. One approach is gene pyramiding designed to include all resistance traits into the Thai Hom Mali rice.

Using Thai Hom Mali rice as a platform, a new series of jasmine aromatic varieties have been created. These new rice strains have the ability to withstand flash flooding (HM80), salinity (HM81), flash flooding and brown planthopper (HM82), flash flooding and bacterial leaf blight disease (HM83), and leaf-neck blast disease (Thunya Sirin). For irrigated areas, Hom Cholasid, an aromatic rice with high yield and submergence tolerance, is popular among rice farmers in flood-prone areas in Thailand. In order to accomplish this ambitious goal, bioinformatics tools are used to assist in the finding of new molecular markers and candidate genes. One such research tool named Rice Gene Thresher is a comprehensive genome browser designed and developed to integrate catalogs from public domain databases on rice. Research and innovation is on-going to shorten the breeding cycle to one-trait-one-year.

Understanding genes one-by-one does not lead to an understanding of a complex QTL (quantitative trait locus) like that of drought tolerance. Comprehensive QTL mapping from various populations revealed five large chromosomal segments controlling more than 200 traits related to drought tolerance in rice. One hundred and four near-isogenic lines, each containing 0.7-10.7% small single segment length (CSSL) from two drought tolerance donors, were comprehensively developed. Such well-developed, genomic tiling near-isogenic lines provide a great opportunity for dissecting such a complex QTL for gene isolation to gain better understanding of drought tolerance in rice.

*Genetic variation*



## Genetic variation

The availability of genetic variation is most critical to the success of rice breeding. A large mutant library created by fast neutron radiation was developed from Jao Hom Nin (JHN), highly nutritious black rice. The stabilized mutant population consisted of 24,000 M4 lines. The mutant population is well-structured to facilitate both forward and reverse genetic discovery. Among attractive mutants, the high Fe mutant contains 28.7 ppm iron whereas high amylose mutant contains three times more amylose than its wild type.

This innovative Jasmine strain can be used as an important model for high yield development. More durable varieties are being developed in countries in the greater Mekong sub-region (GMS). Breeders from Myanmar, Laos and Cambodia have now been trained how to improve on their own favorite rice cultivars using marker-assisted selection. The collaborative breeding program called the community of practices in which RGDU played a hub role, has bred a few new rice varieties for Myanmar, Laos and Cambodia. Some varieties will soon be released by the Ministry of Agriculture of Myanmar.

## Improved performance rice mills

One important step along the rice production value chain is rice milling. A good quality small rice mill (200 kg. paddy per hour capacity) can reduce loss in value from broken rice grains. Through the collaboration and support of the Industrial Technology Assistance Program (iTAP) of NSTDA, close to a hundred rice mills have improved their production efficiency. The outputs of this collaborative project include a 3% increase of the full grain rice and a 10% increase in the milling efficiency through proper fitting of the rice hulling rubber, a critical part of the milling process. As a result, additional revenue of 508 million THB was obtained from the increased yield of the full grain rice and a 3 million THB saving from the proper fitting of the rice hulling rubber, a total benefit of 511 million THB.

## Processing technologies and rice products

BIOTEC has provided funding support to Suranaree University of Technology in their development of rice starch with resistance to enzyme digestion. The rice starch containing 39% digestive resistant starch can be used in place of commercially sold starch in cooking and baking. In addition, rice bran wax, a by-product, can be used as a coating material for oranges, lime and pomelo. The quality of the rice bran wax is on par with imported coating materials.

## Impact on environment and trade

A Life Cycle Inventory (LCI) database for rice production and rice processing has been developed by MTEC. This database contains essential information for a calculation of carbon footprints of rice products. The LCI work is a result of MTEC's collaboration with the Department of Industrial Works, the Thailand Research Fund, the Federation of Thai Industries and the Thailand Environment Institute. Important data in this database are used by Thai rice industries in their evaluation of carbon footprints. Examples of carbon footprint labeling are now seen on bagged rice and Thai food served in flights. These products have been registered for the Thai carbon footprint labeling issued by the Thailand Greenhouse Gas Management Organization.

NSTDA will continue to be part of the overall research and innovation effort to improve and sustain the high quality of Thai rice throughout the rice value chain. NSTDA will not only add quality and value to the way of life for the Thais, but will also help feed the world with pride.

# Good Crops Start with Good Seed

Another fast growing industry in the agriculture and agribusiness sector is the seed industry. It has brought in 3.1 billion THB of export value in 2010, making Thailand the 12th largest seed exporter in the world. To sustain the growth and competitiveness of the Thai seed industry and to continue to add value to its products, research and innovation to improve seeds quality is essential.



## Standards of germplasm evaluation and management

NSTDA, in collaboration with experts in plant germplasm management, has evaluated the germplasm of maize, chilies, tomatoes, cucumbers and pumpkins. The criteria are economic and quality-based. The important traits examined include resistance to diseases and pests. In addition, a germplasm database of these crops has been developed. This information is available to the public and can be accessed at **www.biotec.or.th\germplasm**

To date NSTDA has transferred more than 1,070 germplasms with outstanding quality traits and passed the evaluation to plant breeders of 15 state agencies and at least 50 companies. The recipients have signed the Material Transfer Agreement(s) with the germplasm service unit. One example is the use of chili pepper germplasm with male pollen sterility in the commercial production of hybrid varieties

## Biotechnology for breeding

NSTDA focuses its seed R&D program on breeding and varietal improvement using biotechnology. This includes development and utilization of DNA markers in plant breeding. Other examples are gene transfers (via genetic engineering technology) of the tomato yellow leaf curl and late blight resistance, as well as the chili veinal mottle resistance. Success stories include an application of the double haploid technique in the breeding improvement of chilies and cucumbers. In addition, the embryo rescue techniques have benefited a cross-hybridization of the chili varieties that resist the anthracnose infection at the stage of harvest maturity.

## Seed quality inspection

Antibodies against plant pathogens have been developed as preventive measures in varietal improvement, screening, and seed quality enhancement. One example of the developed diagnostic kits is a simple test kit to detect a rot disease in the cucurbitaceae family. Research was conducted by the Monoclonal Antibodies Unit of BIOTEC. The antibody and test kit are available for licensing.

## Seed coating

A research team at Khon Kaen University with support from NSTDA has developed a coating substrate that produces an evenly coated surface on the sweet corn seeds. These pre-coated seeds, later covered with disease preventive material, are found to have a shelf life of more than six months. This trait has tremendously given an advantage to the Thai seed industry.

The seed research program at NSTDA involves more than 70 partners from the public and private sectors. The collaborations take part along the entire seed research value chain. They are to enhance and to further develop the breeding of new varieties, boosting seed exports under Thailand's brand, and increasing the export value of Thai seed in the global markets.

# World's Most Diverse Insect Pathogenic Fungi Collection

Thailand is home to over 250,000 species of microbes. These microbes comprise algae, bacteria, mushrooms, fungi and yeasts. With their biodiversity, the exact number of estimated species on earth is still unknown. The Microbe Bank at BIOTEC contains over 40,000 samples of bacteria, yeasts and fungi and has one of the most assorted collections of species in this region, especially the fungi that infect insects. Over 400 species of the insect killer fungi are found in Thailand; 140 of these species are in the Microbe Bank at BIOTEC. Such diversity and richness present untapped opportunities for many possible applications and products in various industries.




## Service and development

More than 4,000 species of microbes found in Thailand are being preserved separately in the Microbe Bank at BIOTEC. The Microbe Bank preserves the microbes according to the guidelines of the World Federation of Culture collection with an ISO 9001 standard for service management. The microbes are frozen using liquid nitrogen or kept in a dry stage for preservation and storage of living cultures. There are on-site microbio-logists who oversee the quality, authenticity and the purity of each microorganism in the Microbe Bank.

The BIOTEC's Microbe Bank (http://www.biotec.or.th/bcc) also provides access and services to students, researchers and private organizations who wish to use microbes in research and further development for applications.

## From diversity to competitive advantage

BIOTEC researchers continue to explore for possible applications of these rich collection of domestic microbes. The work has been done with the private sectors in the areas of medicine, agriculture, environment, food, paper and textiles. This has led to a few success stories, for examples microbes as bio-catalyst in the fermentation process of food (fermented pork and fish sauce) and bioethanol production from bagasse. Another example is a discovery of an insect fungus, Beauveria bassiana BCC 2660, as a more effective pest control for aphids, mealy bugs, and brown plant hoppers than the commercial strains.

**For further information contact:**
**BIOTEC Culture Collection**
Bioresources Technology Unit
The National Center for Genetic Engineering and Biotechnology (BIOTEC)
113 Thailand Science Park, Phaholyothin Road, Klong 1, Klong Luang, Pathumthani 12120
THAILAND
Tel: +66 2 564 6700 ext. 3336
Fax: +66 2 564 6707
E-mail: bcc@biotec.or.th

# Natural Rubber
## with Greener Production Process

Another impact of globalization seen in recent years is the high demand for natural rubber. It comes with a boom in the automotive industry. Rubber is another economic crop of Thailand and is responsible for adding close to 300 billion THB to the country's GDP. With its geographic advantage, Thailand has perfect weather for rubber cultivation. With fierce competition, Thai rubber industries, both upstream and downstream, need to be sustainably innovative and produce higher quality processes and products along the value chain.



### Clean processing

The Natural rubber production's value chain comprises three stages: (1) latex production, (2) latex processing to produce crude rubbers (concentrated rubber latex, rubber sheets and block rubber) and (3) rubber product manufacturing. The traditional crude rubber production (concentrated latex and dry rubbers) is known for being environmentally unfriendly and for not producing consistent quality of latex and dry rubber.

Researchers at MTEC have found a new way to improve the latex production step in the value chain. As a result, rubber quality is improved. In addition, productivity is raised, energy consumption is reduced, and environmental pollution and odor problems are mitigated.

The research team has also developed a compound called TAPS (Thai Advanced Preservative System) for use in the rubber latex production process. TAPS is utilized to enhance the quality of latex, yet poses no harm to the environment. It replaces ammonia as latex preservative in the traditional process. Compounds called GRASS 0 and GRASS 1 (GRASS for Green Recovery Agent for Skim and Sludge), also formulated by MTEC, are being employed in place of sulfuric acid for waste rubber recovery from skim rubber latex with improved efficiency while yielding skim rubber of quality. In addition, GRASS 2 was developed to coagulate and recover rubber from washed water of centrifuging machines. Not only are the sulfate contamination problem in wastewater and the annoying odor from the hydrogen sulfide gas problems solved, these newly developed compounds have also improved quality of the natural rubber waste. This added value will be reflected in the product's higher demand and higher prices.

### Retrieving value from rubber latex sludge

In Thailand, there are more than 70 concentrated latex manufacturing plants with a total production capacity of approximately 1.1 million tons a year. The collective natural rubber latex sludge can total up to 10,000 tons a year. This sludge is mostly managed in landfills or area-fill methods. A large amount of natural rubber has become waste or fertilizer for rubber and palm plantations.

The MTEC research team has also developed the world's first process technology called GRASS 3 to effectively recover rubber from the natural rubber latex sludge. 20-30% of the sludge can be turned into reusable rubber. In addition to using fewer chemicals, the process also reduces the water usage by over 50% compared with the traditional process.

### From natural rubber to higher value-added rubber grades

In addition, the research team at MTEC has been successful in making high quality rubber products that are resistant to heat, oxygen and ozone. This will widen the applications of natural rubber. The other type of special natural rubber developed is thermoplastic natural rubber (TPNR) which can be processed like plastics such as injection molding, therefore suitable for manufacturing of rubber parts, used in automobile parts and sports equipment. Furthermore, the research team has collaborated with the Faculty of Dentistry, Mahidol University, to develop rubber bands for dental braces, made from TPNR via a process of injection molding, that cost consumers less than imported ones.

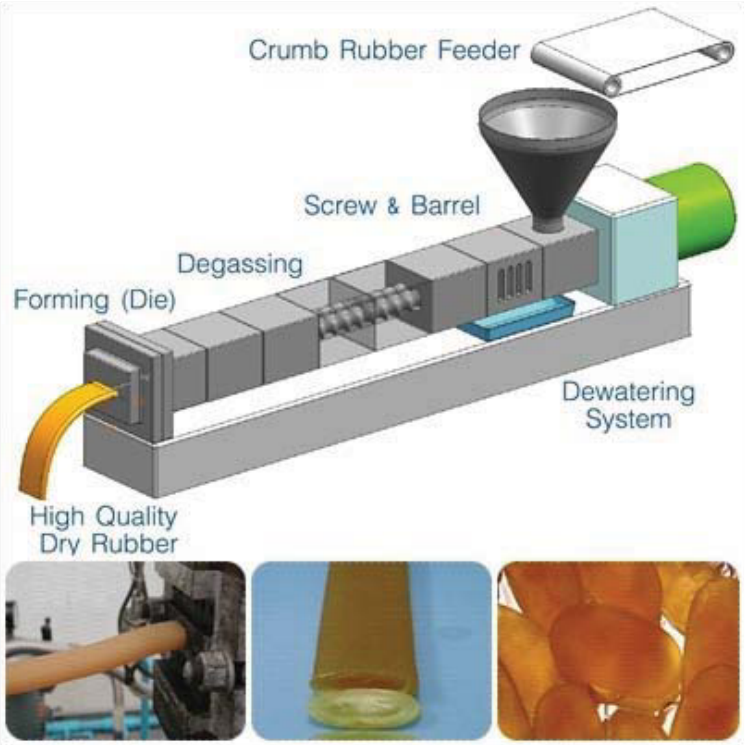
*Clean processing*



## Machine for continuous drying of rubber

The block rubber industry is the other important industry in the rubber value chain in Thailand. Block rubber is used as a raw material to produce various kinds of rubber products. However, traditional block rubber production in Thailand still depends on an antiquated production process that consumes a lot of energy and gives an inconsistent quality of block rubber.

Another research team at MTEC has developed a new technique that continuously dries natural rubber. It is done by applying the principle of twin-screw extrusion together with a special screw configuration, resulting in a compression mechanism to an appropriate degree for water and vapor removal. The rubber does not deteriorate with heat or pressure in the screw barrel. This system and controlled variables positively affect the potential of rubber dehydration, energy consumption, and quality of dry rubber produced. This leads to cost cutting, energy saving, reducing odor pollution or smoke emitted from factories, and being able to produce dry rubber with uniquely better features.




While research and innovation on natural rubber by MTEC researchers continues, the sustainable green and clean processes will serve to improve the environment and the health of the rubber planters. Thailand will not only be the world leader in natural rubber production and export, it will also be one competitive player for value-added natural rubber products in the global markets.

# Shrimp Cultivation

Cultivated shrimp is among the top 10 export commodities from Thailand. The country exported 407,978 tons of shrimp products in 2010 for a revenue of 96.6 billion THB, up by 9.48% from 2009. Being well located for a year-round shrimp culture, the Thai shrimp industry has a comparative advantage in becoming a global market leader. The government and shrimp industry have unified their efforts to promote the sustainable growth of the shrimp enterprise with minimal negative impact on the environment as well as developing domesticated broodstock in captivity.



### Research for sustainability and competitiveness

NSTDA has given special attention to shrimp aquaculture research for the past 20 years. Its active contribution is in the biotechnology for shrimp breeding, feed development and supplementation, disease control, waste treatment and recovery. One example is seen during the WSSV (White Spot Syndrome Virus) outbreak in 1994-1995. WSSV was discovered in 1994 in Thailand through a BIOTEC supported project before it became problematic in farms in late 1995. The export of farmed shrimp dropped from 220,000 to 160,000 metric tons that year (60,000 tons or 27% reduction from the preceding year) in 1995. Diagnostic reagents were quickly developed by BIOTEC and the technology was rapidly transferred to the shrimp industry. As a result, the Thai shrimp industry did not suffer the same catastrophic market collapse seen in others countries in the region, who faced a massive loss of 170,000 metric tons (i.e. 77% of the previous year's production)

### Pathogen prevention and shrimp feed

Several DNA probes have been developed by NSTDA for the rapid detection of major shrimp pathogens such as WSSV, YHV, HPV and MBV. These probes are essential for the development and monitoring of certified shrimp broodstock and fry. Monoclonal antibodies (MABs) were also developed in an easy-to-use rapid test strip to detect, verify and monitor specific shrimp diseases such as WSSV, YHV, GAV, TSA and Vibriosis. The latest technology being used today is the Loop Mediated Isothermal Amplification (LAMP), a specific and sensitive technique proven to be a useful tool in undetermined specimens. In addition, research has been done on a highly effective maturation diet based on the nutritive value. A new artificial food formulation has given promising results for the ovarian and sperm development of shrimp. The potential use of microbes as nutrition sources in place of synthetic nutrients is also being investigated.

### Domesticated shrimp stocks

In 1996, a government joint venture company called Shrimp Culture and Research Company Limited (SCRD) was established with focus on the development of sustainable shrimp aquaculture. SCRD plays an important role in the domestication and genetic improvement of shrimp stocks and provides domesticated stocks to the industry. To strengthen this infrastructure, NSTDA and partners created the Nucleus Breeding Center (NBC) in southern Thailand to facilitate the breeding of domesticated broodstock and genetic improvement program. It is a research site where shrimp are raised under a biosecurity system for healthy shrimp with desirable economic traits. NBC will then supply these to the Broodstock Multiplication Center for multiplication and distribution to the hatcheries.


*Pathogen prevention and shrimp feed*



## Shrimp genome

Thailand took a leadership role in initiating the Asia-Pacific Shrimp Genome Consortium in 2004. All genomic libraries are developed from the DNA of domesticated shrimp stock in Thailand. Important discoveries coming from this research include the identification of genes from different tissues of the black tiger shrimp - under normal, infection or stress conditions - to identify those responsible for infection and stress. Other genes selected are those related to commercially important traits such as disease and environmental resistance, and reproductive and growth efficiency. As of today, the shrimp EST (expressed sequence tags) database has assembled almost 40,000 shrimp uni-genes and is ready for the gene-functional study. From this database, the identification and characterization of marker-assisted selection (MAS) responsible for disease resistance, stress response and fecundity can be undertaken. The molecular markers and related data will help improve the efficiency and effectiveness of the selection and genetic improvement of the strains suitable for cultivation.

## Farm management

NSTDA supports and promotes research for environmentally friendly water treatment systems used in aquaculture, for example the treatment of nitrates used in aquaculture. Research is conducted to help the shrimp industry build up competency to compete in quality, not in price. Examples of research output include the development of strong domesticated black tiger shrimp broodstock, of pathogen-free domesticated seed stock, of a disease-prevention diet, and of aquaculture animal welfare. These are critical issues for shrimp growers. The impact from NSTDA's shrimp research and innovation is best seen in the past 5 years when Thailand overcame the non-tariff trade barrier problems that other shrimp exporting countries experienced.

# Smart Farm

Agriculture and the Thai way of life are synonymous in many senses. The demands for Thai agricultural goods in domestic and international markets has seen steady growth. But with climate change, the agricultural sector is now faced with tough challenges from unpredictable and severe weather, extremes of temperature, as well as floods and drought. These problems are exacerbated by the fact that many farmers are choosing to leave farming and head to the city for work in the hopes of making a better life for themselves and their families.

How can technology help with sustainable agricultural development in Thailand? NSTDA recognizes the complexity of the problems. This has led to the Smart Farm initiative which aims to find guidelines to support and be part of the solution using research and innovation. The key matters concern cultivation, seeds selection, soil condition, farm management, harvesting, processing and logistics.



## Biotechnology

Biotechnology plays an important role in plant breeding for a stronger and better harvest. An excellent example is seen in the development and application of DNA marker technology for strains improvement. DNA markers are also used in the prevention of plant diseases. Gene transfer technology is implemented for the protection of tomato yellow curl leaf, tomato leaf spot, and chili veinal mottle disease. Other techniques employed include the double haploid for strain improvement for chili and cucumber and embryo rescue for cross-breeding to prevent anthracnose in chili. Other developments are seed coatings. These technologies have now been transferred to farmers and industries.

## Materials technology

Greenhouses are gaining popularity and acceptance among farming communities in Thailand. With the hot and humid climate, there is a need for the climatic control inside the greenhouse to prevent overheating. A combination of technologies can help mitigate the pressures of uncertain weather caused by climate change. Equally important, it decreases the use of chemicals and insecticides. The integrated technologies NSTDA has supported are:

- **Greenhouse design**: Research is done on airflow inside the greenhouse using the simulation technique to create a design with effective ventilation. For the greenhouse structure, the materials chosen have the parameters of local climate and environment included in the design and selection process. It is found that the smart greenhouse has added 40% more value to the seed industry, while reducing the usage of pesticides and imported chemicals by 30-50%.
- **Greenhouse covering**: The plastic covering developed by MTEC and Poly Plastic Company can reduce the temperature inside the greenhouse by 1-3 ˚C. This plastic covering is designed to allow only certain wavelengths of light needed by the plants inside the greenhouse to pass through. At the same time, it can block UV rays from entering. It appears that the seasonal growth period has shortened while the yield has increased inside this greenhouse. This observation is seen in vegetables and small crops. The yield with high quality also improves by 25% compared to those greenhouses using regular plastic covering. In addition, plant diseases can also be prevented in this smart greenhouse; the use of pesticides has decreased by 80%.
- **Monitoring and control**: Although technologies are available to help with heat reduction, there is a supported need for the monitoring and control systems inside the greenhouse. Systems needed are for fog sprays, air ventilation and roof openings to obtain an optimal condition inside the greenhouse while conserving energy.

## Environmental monitoring station

Environmental information can help farmers plan for their crops effectively. A small environmental monitoring station built by NECTEC contains electronic equipment, sensors and communication systems. The station monitors and collects remote meteorological data. It can measure relative humidity, air temperature, rain volume, wind velocity and direction, atmospheric pressure and sunlight intensity. These are parameters that affect agriculture. This database can be analyzed to create a warning system. It can also be used to predict future productivity, and it is, therefore, an important assessment tool for effective farming management. These technologies have been transferred to farmers and farming industries around the country.



### Automated fertilizer mixer

An automated mixer can precisely produce an optimal recipe for nutrients needed by crops. This will prevent an over-usage of fertilizer as previously practiced using pre-mixed ready-made fertilizer. Today, this prototyped automated fertilizer mixer is being employed by sugar cane farmers in Buri Ram province.

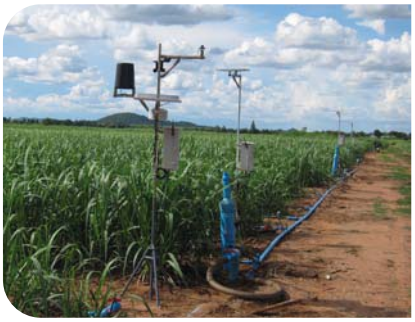
### Controlled operation

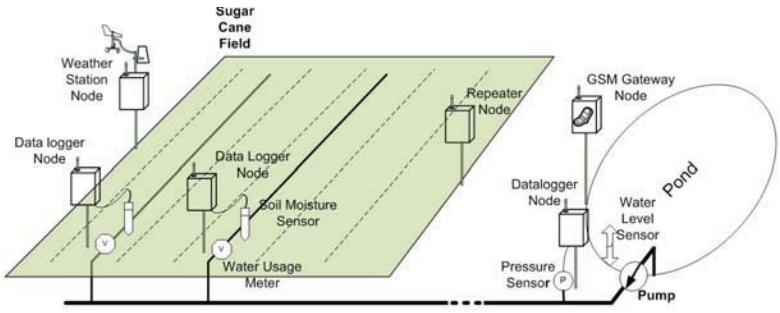
One specific example developed by scientists at NECTEC is a temperature and humidity controlled, automated oven for drying longan. It is a done without human intervention. The product has high quality and in good demand by the markets.
This technology has been licensed to a private company to mass-produce and distribute to farmers and agribusiness.

### Traceability system

The traceability system keeps track of agricultural products from seeding, to processing, and up to consumers' tables. This is to ensure that consumers have access to products of high quality and food safety. The system uses RFID (radio frequency identification) tags, a reader and a data management system. It contains details of products such as breed, feed, diseases, etc. Being able to trace this information, product management becomes more effective. Rising problems can be taken care of quickly. At present, Silicon Craft Technology Co., Ltd., has received technological support from the NSTDA in their manufacturing of the RFID tags and readers.

The collected technological developments in this Smart Farm project are NSTDA's contribution to Thai farmers and Thai agricultural industries. The ultimate goal is a better way of life for Thai farmers and the sustainability of Thai agriculture.





# Pre– and Post–Harvest Plastics

Thailand, renowned for its "Kitchen of the World", produces abundant vegetables and fruits for domestic consumption and exports. High quality produce can also command premium prices in the market place. This implies a blemish free appearance, excellent texture and outstanding taste. For those high value vegetables and fruits, special care should be given at the pre-harvest stage. Since loss of freshness and nutrition promptly begins the minute vegetables and fruits are harvested, post-harvest technologies can help deter these losses. Pre- and post-harvest technologies, packaging in particular, in addition to logistic management, is vital to the agricultural produce industries.



## Extending shelf life

MTEC, in collaboration with Kasetsart University, has developed a film that controls permeability of oxygen, carbon dioxide and water vapor optimal for different types of fresh vegetables and fruits. The film is being used as packaging that extends shelf-life of fresh vegetables, fruits and cut flowers with different respiratory rates. Having suitable gas permeabilities, this film can create equilibrium modified atmosphere (EMA) with an optimal mix of oxygen and carbon dioxide inside the package; therefore effective in reducing the respiration and undesirable physiological changes of the fresh produce. The extended shelf-life of 3 to 5 times is observed, as compared to conventional package. Developed EMA films are now commercially available. Other prototyped plastic films, such as ethylene absorbing film, micro-perforated film and high gas permeable film with controlled gas selectivity, have been further developed to extend the films' applications to a vast variety of fresh fruits and vegetables as well as to the premium fresh-cut (ready-to-eat) produce. Research on fresh produce packaging at MTEC has also been directed towards bio-based and biodegradable plastics.

EMA packaging with gas control function, one class of the active packaging technology, has enhanced the plastic film properties currently produced by the Thai packaging industry. This packaging film together with proper post-harvest management of fresh agricultural produce, such as a cold chain system, can reduce industrial losses of fresh vegetables, fruits and cut flowers by 10-15%. This will provide an excellent boost for exports of fresh vegetables, fruits and cut flowers. In addition, this Thai-made film can be used in place of expensive, imported plastics and can cut investment cost up to 3-7 times. With the growing demand for Thai fresh-cut vegetables and fruits (annual 15-20% growth rate), the film will be used for more products and will serve expanded markets.

## Pre-harvest protection for Thai mangoes

MTEC, in collaboration with the INNOGROW Co. Ltd., has developed and launched a pre-harvest protective bag for mangoes, Thai fruit with a high demand for export. The protective bag, named PolyTech Plastic bag, is intended is to be a substitute for imported bags. These protective mango bags can be reused up to 3-5 times. More mangoes are found to meet export standards using these protective bags. This alone has reduced losses in export values, in addition to cutting back in the use of imported bags. Thailand currently imports about two billion of these bags each year (cost more than 2.7 billion THB). The price of the PolyTech Plastic bag is 1 time less expensive than the imported version; therefore a tremendous saving for the industry.

*Extending shelf life*

*Pre-harvest protection for Thai mangoes*

These PolyTech Plastic bags allow light at suitable wavelengths for the physiological development and ripening process of mangoes to go through. The specific selection enhances growth of mangoes and increases the weight of the fruit by 10-15%. The fruit skin will appear golden, smooth and blemish free. The taste is also found to be sweeter than mangoes wrapped in imported bags. In addition, the micro-porous PolyTech bags allow a high rate of 70% transmission of carbon dioxide while maintaining suitable moisture content inside the bag. As a result, the mangoes grown inside these bags are bigger and glossier.

The pre- and post-harvest technologies invented by Thai researchers are important advances in the Thai agricultural and related industries. It will not only add value but further raise the competitiveness of Thai agricultural produce in the global markets.

# Animal feed

A sustainable livestock business and animal feed industry must take into account a long term view of the impacts on both animal welfare and consumers. These industries are an important part of the long value chain of the agriculture and food sector of Thailand which is the largest employer in the country. For Thailand to stay competitive, research and innovation must continue to add value to the sector. To enhance the quality of meat, the quality of the animal feed must be improved. Using more natural products in combination with biotechnology would help the animal feed industries increase their competitiveness in global markets.



## Thai animal feeds industry

A non-tariff barrier has been imposed on imported meat contaminated with leftover chemicals and antibiotic residues. In addition, consumers today have a growing demand for meat from animals raised with good welfare. The Thai livestock industry is responding to these changing market conditions by using more natural products as animal feed ingredients. Biotechnology is also commonly employed in breeding improvement, growth stimulation, reduction in the use antibiotics and chemicals, more effective feed digestion, and waste reduction. The Thai livestock industry is using microbes and enzymes in animal feed, especially for economic livestock. Over 1 million THB worth of enzyme for animal feed is imported. Today, Thailand has developed the domestic capability to produce enzymes at an industrial scale that can compete with the quality of imported enzymes.

## Improved animal feed

The management and utilization of the bioresources program at BIOTEC has its focus on research, development, and application of domestically found microorganisms. The scope of the program involves surveying, classifying, and collecting strains of microorganisms from various natural sources in Thailand. These strains have been kept in the BIOTEC Culture Collection (BCC) since 1996. NSTDA encourages and promotes the use of these bio-resources among Thai industries for maximum added value.


*bacteria*


*yeast*


*fungi*


*fungi*


*actino*

FD storage

LN storage



## Enzymes in animal feed industry

NSTDA's support for the animal feed industry through the application of biotechnology can be seen in these examples.

- BIOTEC in collaboration with Asia Star Animal Health Co., Ltd. has undertaken research on the production of an enzyme named pentosanase from Aspergillus sp. BCC 7178 on solid feed at an industrial pilot scale. Scaling up was done with relative ease while yielding an enzyme of high quality and consistency. This has led to the successful commercial production of this enzyme. The pentosanase enzyme is widely used as a supplement in animal feed to boost effective digestion in pigs and chickens. It enhances digestibility and nutrients' absorbability. The results are seen in higher feed conversion rates, better overall animal health with fewer occurrences of illness and lower feed costs. Having domestic production of this enzyme at a lower price compared to imported products has added significant competitiveness to the Thai animal feed industry.

- A team of researchers from BIOTEC and KMUTT (King Mongkut's University of Technology, Thonburi) joined Microinnovate Co., Ltd. to screen and select microorganisms registered in the BIOTEC Culture Collection that have the potential to be animal feed supplements. The established production procedure of the selected domestic microbe (for fermentation of animal feed) has led to a cost cutting from expensive import. Today NSTDA has co-invested with S.P.M. Feedmill Co., Ltd. the first fermentation plant for animal feed in Thailand.

## Utilization of bio-resources

NSTDA continues to promote research and innovation for the utilization of domestic bioresources with potential benefits to both the public and private sectors. It has been proven that bioresources are an integral and important part in the value chain of the country's overall development of the livestock and the animal feed industry, thus leading to long term sustainable and competitive development.

# Sustainable Living
## for Rural Communities

Sustainable living for rural communities is illustrated well at Huay Nam Pak and Ban Bor Muang Noi villages, Saeng Pha district, Na Haeo, Loei Province. Ban Bor Muang Noi and Huay Nam Pak are new communities along the border between Thailand and Laos. 150 families are under the care of the 2nd Region and 3rd Region Thai Army Divisions. Each family has been given 1.6 hectares of land on which to make a living. The terrain is mainly comprised of jungle and mountains at 650 meters above sea level with a cool climate and with no public transportation. The majority of people are farmers. Rice is the main crop grown for human consumption. Maize is grown for animal feed and trade.



### S&T: where the end justifies the means

NSTDA, in collaboration with the 2nd Region Thai Army Division and other agencies, sees an opportunity to illustrate the importance of S&T as a means to enhance the lives and well being of the people the region.

In 1996, the researchers of BIOTEC and KMUTT (King Mongkut's University of Technology, Thonburi) collaborated to demonstrate to farmers in these remote communities a pilot plot of integrated, sustainable strawberries farming. There are total of 12 growers who have planted strawberries on their 1.28 hectares of land. They were able to produce 1,200-1,500 kilogram of strawberries for each 0.16 hectare, with a total value of 70,000 THB in 2010.

### Add value with processing

Applying an agricultural process combined with good hygiene in food production to raise standards of product quality and safety have enabled Ban Bor Muang Noi village to register as a Community Enterprise with 14 members. Examples of products include strawberry juice, strawberry jam, passion fruit juice, roasted macadamia nuts, chocolate coated macadamia nuts, macadamia bars, and macadamia oil. The products provide 35,000 THB to each member per year. In addition, this value chain also generates income for 22 labor workers, each receiving 10,000 THB per year. This means a total cash flow of 2.7 million THB per year for this community.

The NSTDA and KMUTT team went on to develop an oven for macadamia nuts for the community using macadamia nutshells as fuel in place of natural gas. This alternative fuel source has cut the fuel cost from 120,000 THB per year to only 15,000 THB per year.

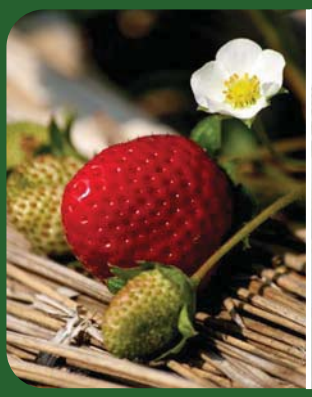
### Agricultural tourism

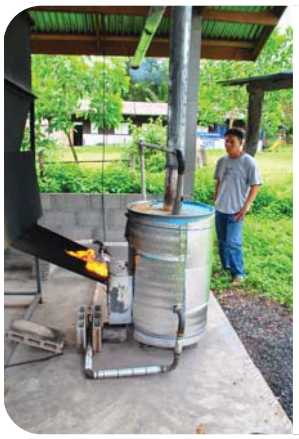
Being located in the Phu Suan Sai national park, this gives a geographic advantage to these two villages. The natural beauty and scenery combined with their well known cultivation and high quality agricultural products have attracted tourists to the region.

### Science for life for the young

To promote the Science for Life concept, Bor Muang Noi village has set up four science camps per year for the young. These camps consist of a range of activities and experiments designed to demonstrate to young villagers the value of science and technology to daily life. Camps that have been arranged include a strawberry camp, energy camp, environment conservation camp and food processing camp. Fifty students from 7 schools have participated in these camps each year. In addition, a learning center was built for the community of Bor Muang Noi and is intended to be a place where mentors and the young interact on a regular basis. It is a mechanism for building future leaders for the community.

Since its inception, these operations have earned the community an average annual income of 3 million THB. The process also has produced community leaders who are role model farmers, and community advocates who promote their local agricultural products to external markets. They give advice and act as consultants to other farmers, and are also strong activists in exposing the young to science as part of their daily life. In time, these sustainable practices will be replicated and expanded to other remote farming communities.






*Add value with processing*


*Agricultural tourism*


*Science for life for the young*

SUCCESS STORIES

# ENERGY AND ENVIRONMENT

# Zero Waste Discharge
## in Cassava Starch Manufacturing

Cassava is one of the most cultivated and important commercial crops in Thailand. Being one of the top growers and exporters of cassava in the world, Thailand has gained tens of billions THB annually from cassava export for more than 40 years. There are more than 3 million cassava farmers on more than 1 million square kilometers land. About 40 percent of the cassava produced in Thailand is processed into cassava starch, for which the domestic demand is as high as 1.3-1.7 million tons per year. Manufacturing processes with better efficiency in cassava starch production are needed. The desired technologies must reduce loss of cassava starch, and they should use less water and energy while minimizing waste. Clean technologies with a concept of Zero Waste Discharge have been implemented in cassava starch production factories.



### From lost starch to biogas

Inspection reports (by King Mongkut's University of Technology, Thonburi, Thailand, in 2003) of cassava starch factories have indentified their production efficiency at only 70-80%. Losses have occurred at different stages in the production process, for example, 17% in starch separation and dewatering and 5% during dehydration. In addition, these factories produce a large amount of wastewater that contains a starch content waste from processing plants. It is a rich source for microorganisms and creates foul-smelling gasses that disturb local residents. Production of biogas will not only be a wastewater treatment process but also a source of heat energy for drying starch.

### Increasing productivity while reducing resources consumption

The processes in cassava starch production comprise five stages: (1) raw material preparation, (2) rasping of cassava roots, (3) starch extraction, (4) drying process, and (5) packaging and storage. In collaboration with the German Society for Technical Cooperation (Deutsche Gesellschaft für International Zusammenarbeit: GTZ), NSTDA has provided funding support for development of Zero Waste Discharge technologies for Thai cassava starch manufacturing factories. Higher productivity with less consumption of water and energy are the goals of this project, with less waste produced. Participating factories have been able to cut costs from the Zero Waste Discharge concept by 112 million THB per year.

### Concept of zero waste discharge

A zero waste discharged industry has waste minimization concept via three processes:

1. **Reduce** - by using less energy and resources, lowering release of waste and minimizing polluted emissions with controlled and improved production processes that maximize efficiency.
2. **Reuse** - by recycling waste back into usable raw materials or products.
3. **Replenish** - by avoiding unnecessary consumption of resources, especially harmful chemicals, or finding ways to recycle waste into alternative raw materials.

Waste minimization means costs reduction, especially in energy and resources. This could also lead to revenue gained from turning waste into re-usable raw materials, energy or new products while reducing pollution emissions to the environment.

### Savings outcome

The participating cassava starch factories have increased their productivity by 13-27% after completing this project. 30% less water was consumed. The starch separation process' efficiency has increased from 88.2% to 95.4%. Earning was higher by 1.12 million THB more per month. The production capacity went from 47.2 to 59.9 cubic meters per hour while reducing loss of starch from 0.4 tons to 0.06 tons per hour. The total savings is reported to be over 19.9 million THB per year.

While the zero waste can represent an economical and environmental alternative to waste systems, the clean technologies will add sustainability and competitiveness to the cassava starch production manufacturing and related industries.

# Biogas

Biogas is a valuable by-product of wastewater treatment in the food processing industries and is now playing an important role in Thailand as a sustainable alternative source of energy in the manufacturing industries. These industries can reap tremendous benefits from this "turning-waste-into a high-valued-product". Biogas, as an alternative energy source, and treated water, for reuse in irrigation of farmlands, create a synergetic and impactful system for industry that produces not only cost savings, green practices, and a cleaner environment, but is also self-sustaining.



### Agricultural waste and wastewater

There are over 10,000 agricultural processing factories across Thailand. Over the years these factories have faced problems of waste treatment inefficiency and foul odors from stagnant wastewater due to a lack of a proper wastewater treatment system.

### Biogas from closed-type anaerobic reactor

The research team at the Excellent Center of Waste Utilization and Management (ECoWaste) of BIOTEC has developed a technology to treat wastewater while producing biogas in return. ECoWaste was established in 2005 under a cooperative program between BIOTEC and King Mongkut's University of Technology Thonburi (KMUTT). After more than 20 years of fine tuning the technology, a highly effective Closed-type Anaerobic Reactor has seen widespread adoption in the agricultural processing industries. It has advantages over the older treatment methods by requiring an installation area only one fifth the size of that required for the open wells system. It also produces biogas that replaces fossil fuels (including natural gas) for heat and electricity. It presents an attractive business model that is sustainable and competitive for agriculturally related industries.

### Fixed Film Reactor

An anaerobic treatment technology called Fixed Film Reactor is found to be most suitable for treating waste in food processing factories. The microbes are fixed onto the surface of the netting medium (which prolongs the life of these microbes) in the reactor tank. This system is found to be 80% effective and works best with wastewater that has high content of floating matter without pre-cleaning. The process is so effective that it also reduces foul odor. The treated water is usable for irrigation since no chemicals were used in the process.

### Real impact

To illustrate the real impact of these technologies, two Thai fruits processing factories have built their biogas system using a fixed film anaerobic waste treatment model. The highly effective fixed film system can treat wastewater at a rate of 2,000-4,500 kilograms per day and produces biogas of 200,000-600,000 cubic meters per year (at 200 working days per year). This translates into an energy savings of 720,000 unit per year; a fuel savings of 99,450 liter per year; an electricity savings of 300,000 THB per month; and a chemicals (for water treatment) reduction of 300,000 THB per month. The companies have saved 3.6-4.05 billion THB in energy costs.

### Wastewater treatment in palm oil factories

In oil palm extraction and manufacturing, a popular wastewater treatment technique being employed is anaerobic digestion. This is a highly effective method for reducing high organic content in wastewater while using little energy. This process also produces high quality methane gas that can be used as an alternative source of energy. The hybrid system using anaerobic digestion can effectively treat high organic content (200-450 cubic meters per day) wastewater. In addition to eliminating foul odors from wastewater, the treatment produces biogas that can save a company more than 13 million THB per year.

With the magnitude of impact, the process is considered one of the most innovative in the country. NSTDA and KMUTT have transferred this technology to several companies in the processed food industries.

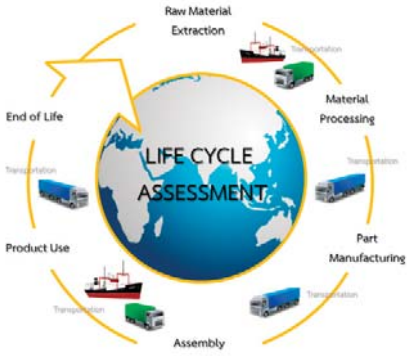
# Carbon Footprint
## and Green Practice

In this decade, we can expect to see consumers comparing products or services with their carbon dioxide emissions or green labels before making a purchase decision. This awareness among consumers about the impact that their buying decisions have on the environment is a growing trend globally. The Carbon footprint of product is a measure of the total greenhouse gas (GHG) emissions throughout the life cycle of that product and is measured in terms of tones (or kg) of carbon dioxide equivalent ($CO_2$-e). Many products in the market today have their carbon footprint labeled. However, tracking the carbon footprint is an unattainable task without the proper assessment tools and databases in place.



### Life Cycle Inventory (LCI) and Life Cycle Assessment (LCA)

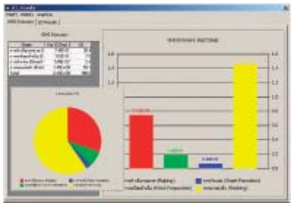
The LCI database and LCA are essential tools that assist manufacturers in their development and utilization of environmentally friendly technologies. The LCI database contains various input and output data of the entire product life cycle, including the extraction of raw materials, design, production, packaging, distribution, utilization, maintenance, reusing, recycling and disposal. LCA is a technique used in assessing the potential environmental impacts associated with a product, process or service. This can be done by: (i) compiling an inventory of relevant inputs and outputs of a system of interest; (ii) evaluating the potential environmental impacts associated with those inputs and outputs; and (iii) interpreting the results of step (ii) in relation to the objectives. The technical assessment, focusing on GHG, is summarized into a tag called carbon footprint label. This label shows how much $CO_2$-e is produced from its product life cycle.




### Thai LCI through R&D partnerships

In 2005, the National Metal and Materials Technology Center (MTEC), under the National Science and Technology Development Agency (NSTDA), initiated a project on the Thai Life Cycle Inventory Database of basic materials and energy with technical support from the Japanese government through the Green Partnership Plan. In 2007, this project was expanded into a national program through the collaboration of 5 strategic partners: MTEC, the Ministry of Industry (MOI), the Thailand Research Fund (TRF), the Federation of Thai Industries (FTI), and the Thailand Environment Institute (TEI). To date, over 600 data sets have been generated covering various categories of basic materials, infrastructures and energy, of the country, such as petrochemical, diesel, basic chemicals, textiles, construction materials, agricultural products, transportations, industrial water and waste management.


*Opening Page and Component of ThaiLCD System*

*GHGs+ Software*

### First in ASEAN

The Thai Life Cycle Inventory Data Management System (ThaiLCD) and Thai GHGs$^+$ Software have been developed by a team comprising researchers from MTEC. The system and the software were introduced to the public in January 2011, and are based on the standards of International Life Cycle Data System (ILCD) and ISO 14048. The system is being used to manage and handle Thailand's national LCI database while the software is used to analyze the carbon footprint of products and the environmental impacts in the category of climate change. Both the system and the software are the first of their kind in Thailand and in ASEAN.



## Carbon footprint of product

In 2009, MTEC and the Thailand Greenhouse Gas Management Organization (Public Organization), or TGO, teamed up to bring the concept of carbon footprint labeling into practice. They successfully launched a national campaign called Promotion of Carbon Footprint on Products. The carbon footprint label is intended to be a communications tool between carbon-conscious companies and their consumers, both locally and globally.

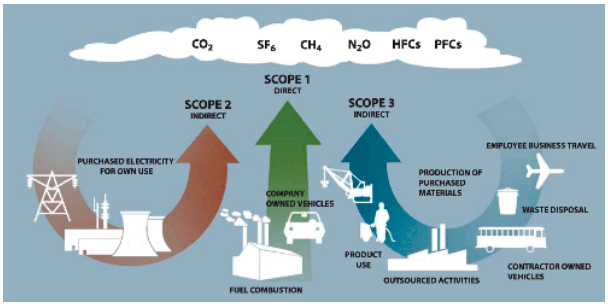
*CFP Logo of Thailand*
*[Source: http://thaicarbonlabel.tgo.or.th/]*

*Example of CFP Pilot Products*

The national CFP guidelines have now been established based on the outcomes of this pilot project. 43 products have now been monitored and certified under the Carbon Footprint Label. This is very significant step in Thailand's efforts to contribute towards a future low carbon economy and society and a greener planet. As of October 2011, a total of 295 products were certified under the CF label.

## Carbon footprint for organization at NSTDA

In November 2010, MTEC collaborated with TGO to initiate the pilot project of Carbon Footprint for Organization (CFO). Twelve groups, including government agencies (NSTDA and TGO), educational institutions, and companies, participated voluntarily in the evaluation of the carbon footprint of their operations.




*Overview of scopes and emissions across a value chain*
*[Source: WRI/WBCSD, 2004. The Greenhouse Gas Protocol: A corporate accounting and reporting standard (revised edition)]*

The CFO assessment of NSTDA covered 9 sub-organizations under the NSTDA umbrella. **The total greenhouse gas emission, including both the direct and the indirect emissions, was approximately 22,000 tons $CO_2$-e/year in 2010** (scope I - direct emissions: 10%; scope II - indirect emissions from electricity consumption: 79%; and scope III - other indirect emissions: 11% of total greenhouse gas emissions). In addition to recognizing the carbon footprints caused by the various activities of NSTDA, an awareness of the importance of the environment has been raised. NSTDA will use this crucial information in its future directives to reduce the greenhouse gas emissions from their operations. This will be a significant contribution by NSTDA towards the reduction of Thailand's global greenhouse gas emissions.

SUCCESS STORIES

# HEALTH AND MEDICINE

# Thai Human Variome

Following the success of the Human Genome Project, many countries have made use of the genome information to identify genetic variations (Human Variome) specific to their ethnicities. Crucial and important information is gained with applications seen in the medical areas.
In general, all individuals share 99.9% of the underlying DNA material. The remaining 0.1% makes us different from each other. Such variations, if found in more than one percent of the general populations, would be called genetic polymorphism. The polymorphisms can be in various sizes and formats, e.g., single nucleotide polymorphisms (SNPs), minisatellites, microsatellites, copy number variations (CNVs), etc. Since the most abundant form of polymorphism is SNP, many researchers have collected SNPs and organized them in the form of SNP databases for future use.



## Thai SNP database

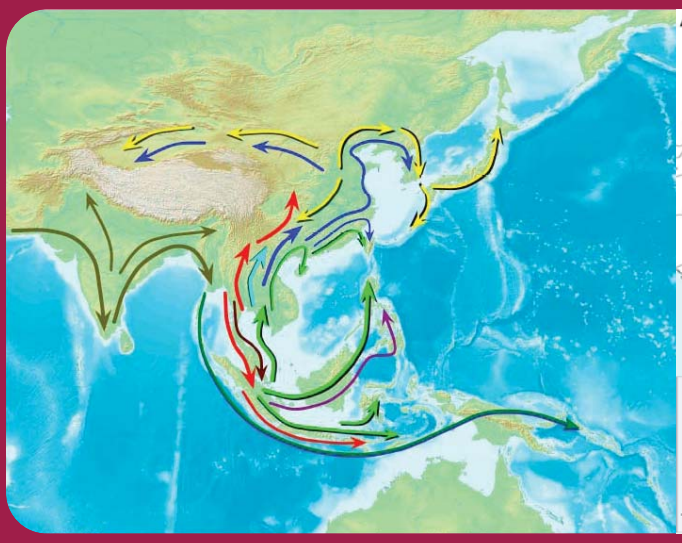
At present, a public SNP database, such as the SNP database (dbSNP) at the National Center for Biotechnology Information (NCBI) curates SNPs non-specific to Thais. BIOTEC recognizes the importance of the SNP database for medical and public health applications in Thailand. A team of researchers from BIOTEC collaborated with researchers from the Centre National de Genotypage (CNG) in Evry, France and researchers from Thai academia and hospitals - Rajanukul Institute, Mahidol and Chulalongkorn Universities - to conduct the Thailand SNP Discovery project. By genotyping SNPs of 32 randomly selected volunteers (anonymized) from the central region of Thailand, the Thai SNP Database (ThaiSNPdb) was constructed as a central SNP repository for Thais. On-going research includes investigation of Thai population genetics, and it assists researchers to identify SNPs that are associated with specific common complex diseases in Thailand. More recent data were added to the Thai SNP database, including genotyping information from two genome-wide association studies of the two burden diseases, namely Beta-Thalassemia/HbE (by Mahidol University) and depression (by Rajanukul Institute). Visualization enhancement was added to the database to graphically and comparatively present Thai specific SNP information along with other SNPs from different ethnicities.

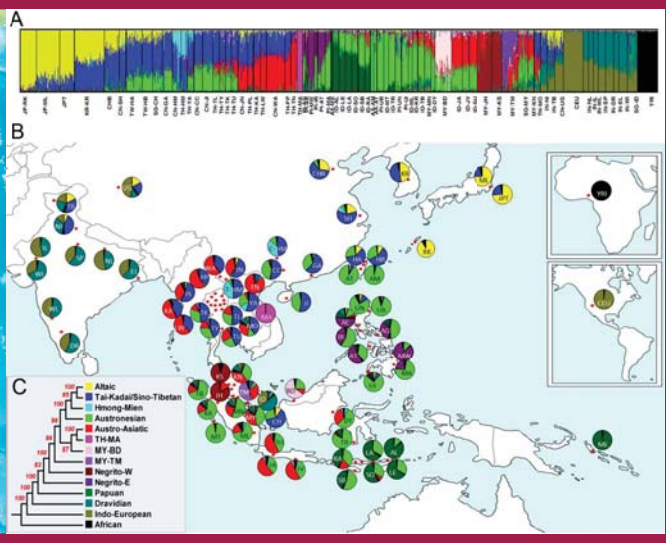
## Mapping Human Genetic Diversity in Asia

Thai researchers from BIOTEC, Chiang Mai University and Mahidol University joined the Pan-Asian SNP Consortium to conduct the Mapping Human Genetic Diversity in Asia project. The joint effort was orchestrated to derive the ethnic diversity from human genetic variations collected together with background checks and linguistic information from 73 different lineages (1,928 individuals) of Pan-Asian countries. The study elucidated that there was once a major migration into Southeast Asia prior to migration to North Asia. This is presented as an alternative theory of a series of small migrations from both the South and the North of Asia, as previously suggested. Furthermore, the genetic origin of a population is highly related to characteristics of ethnicity and to the commonly-used language. This finding was published in Science on December 10, 2009. The genotyping information from this project was deposited in the Pan-Asian SNP database (PanSNPdb), which was recently reported in PLoS ONE.

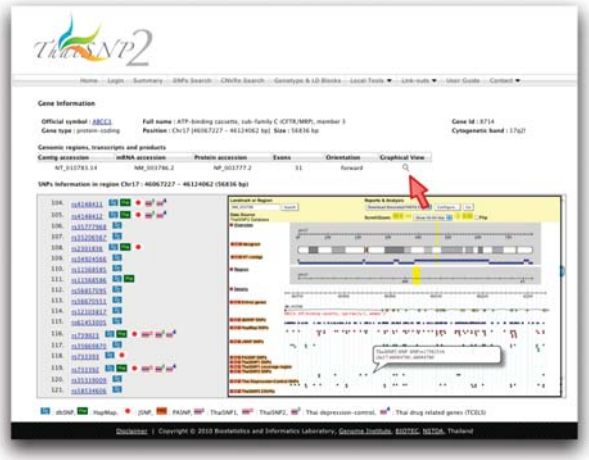
## Specific research benefits

ThaiSNPdb provides important infrastructure for genetic research in Thailand. It helps researchers select Thai specific SNPs for their studies such as disease association studies, pharmacogenetics, population genetics and forensic investigations, etc.





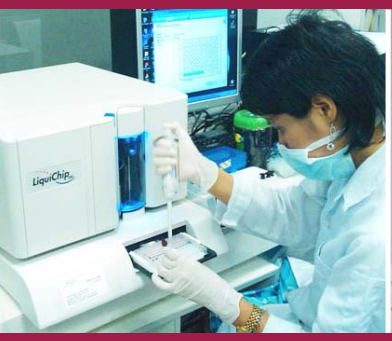





## Personalized medicine

Modern medicine is now shifting more towards preventive measures rather than just treatement. A patient can choose to be diagnosed for the risk of having some burden diseases, and identification of associated genetic markers is the key to this revelation. These kinds of markers can be put in a genetic test kit, given that the prediction accuracy is acceptable. Using this kit can give us an early warning to avoid any potential exposition that would lead to the development of diseases, and in some cases this can lead to the prescription of more effective treatments. Though it is still futuristic, it will not be long before personalized medicine becomes more common in practice. We are now seeing drug labeling with cited genetic information. This means the patient's risk profile from having an adverse drug reaction (ADR) could be improved through the inclusion of genetic information. There will be tremendous benefits to knowing one's own genetic profile in terms of understanding risk factors early, and later on in terms of prescribing the right drug(s) at an optimal dosage.

## Thai-made
# Diagnostic Test Kits





*The sample of microtube gel test kit*

Medical testing today is fast and precise. Technologies lend a helping hand to physicians in their accurate diagnosis of the cause of disease so that proper treatments can be provided to their patients. A number of Thai-made, inexpensive, rapid and accurate diagnostic medical test kits have been developed with funding support from NSTDA. They reduce the dependency of public health systems on imported technologies.



### Public health benefits

Most test kits available in the Thai market are imported and are for diseases prevalent in developed countries. NSTDA recognizes a real need for domestic development of these test kits. Targeted R&D areas supported by NSTDA include immunology, molecular biology and biosensors as they are key components in research for rapid diagnostic test kit development. Some of the medical kits which NSTDA has supported the development of include:

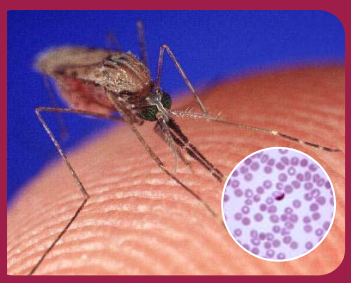
1. **Blood matching diagnosis** (Microtube gel test)
   Through NSTDA research funding, a research team at Khon Kaen University has successfully developed a test kit that identifies whether the blood of a donor and of a recipient would match. Traditionally this process requires expertise and experience, and is time consuming. The 'Test Kit for Antigen-Antibody's Reaction on Red Blood Cells' developed with NSTDA support consists of three different microtube gel tests: neutral gel , antiglobulin gel and specific gel. They test for the reaction between antibody and antigen on the surface of red blood cells. The microtube gel test provides fast, accurate results and at a fraction of the cost of imported kits. Mass testing can also be performed with precision. As a result, blood matching testing is now a routine procedure in which it is easier to determine matches correctly. Currently, the technology has been licensed for commercial distribution. The kit is now being used by blood banks and hospitals throughout Thailand.

2. **Tuberculosis diagnosis** (PCR technique)
   There is a signficicant rise in tuberculosis (TB) infected patients each year in Thailand (eight million per year). 30-40% of HIV/AIDS patients also have develop TB. The urgency brought about by this rise in TB infected patients prompted a need to develop locally diagnostics and measures to handle TB. With NSTDA's funding support, a research team at Siriraj Hospital, Mahidol University has developed a fast, accurate TB diagnostic test kit. This kit helps identify new TB patients for the earliest intervention of treatment to break the cycle of the disease. The key feature of this kit is Property-R; it detects TB bacteria from given samples. This newly developed procedure is four times cheaper than imported TB test kits. In addition, this diagnosis takes less time and the TB disease can be detected from a relatively small sample size. The technology has already been licensed for commercial distribution.

3. **H5 avian flu virus diagnosis**
   The recent emergence of H5 avian influenza has prompted a need for a diagnostic tool that can simultaneously detect both influenza and H5 avian flu. The test kits previously used could detect for either influenza or H5 avian flu, but not together. Through the funding support of NSTDA, the research team at Chulalongkorn University has successfully developed diagnostic techniques called Multiplex RT-PCR and Multiplex PCR that separate the influenza type A (subtype H1, H3 and H5) from B, and, therefore can tell if the virus is an H5 avian flu virus or not in just 2-6 hours.

NSTDA will continue to provide R&D support in the field of medicals and public health that will lead to new technologies for highly effective disease diagnosis and treatments for Thais. In addition to the test kits, technology development for public health, expertise and capacity-building have also been strengthened.

# Anti-malarial Drugs
## for Everyone

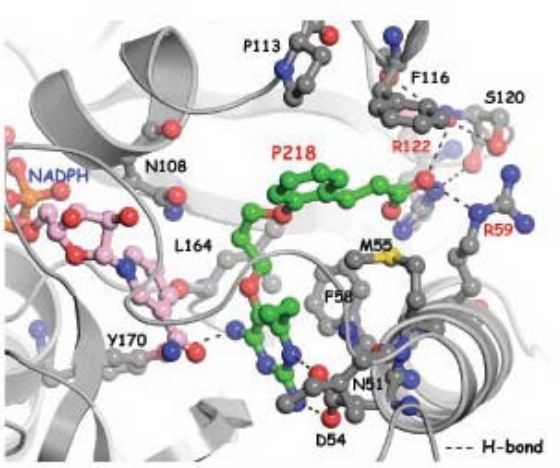


Malaria continues to be an infectious disease scourge in Thailand and is most prevalent along the porous borders with neighboring countries. Malaria is a mosquito-borne disease affecting more than 500 million people annually; making it one of the most common fatal infectious diseases worldwide (others are tuberculosis and AIDS). Malaria caused nearly 1 million deaths in 2008, mostly among African children under the age of 5 and pregnant women. One of the most difficult problems in treating this disease is the growing resistance of parasites to anti-malarial drugs. The Protein-Ligand Engineering and Molecular Biology Group in BIOTEC is engaged in malaria research covering drug targets, mechanisms of drug resistance, synthesis and validation of new drugs effective against drug-resistant parasites.



### Malaria and drug resistance

The World Health Organization (WHO) considers that approximately half of the world's population is at risk of malarial infection. It is generally accepted that drug resistance is the most important problem in fighting the disease. In Thailand, around 32 million people are at risk of malaria. All the five types of malaria are prevalent in the country. The border areas with Myanmar and Cambodia are the worst affected. Non-immune migrant workers employed in gem mining in forests, logging, agriculture and construction are the most vulnerable to the disease. High mobility of migrant and cross-border populations also encourages the spread of multi-drug resistant P. falciparum malaria from the Thai-Cambodia border to the Thai-Myanmar border, posing more difficulties for malaria control. Growing resistance to antimalarial medicines has spread very rapidly, undermining malaria control efforts.



Binding of P218 to PfDHFR

When treated with an artemisinin-based monotherapy, patients often discontinue treatment early following the rapid clearance of malaria symptoms. This results in a partial treatment while patients still have parasites in their blood. Without a second drug being given, these artemisinin tolerant parasites survive and can be passed on to a mosquito and then to another person. Monotherapies are therefore the primary force behind the spread of artemisinin resistance. If resistance to artemisinins develops and spreads to other large geographical areas, as has happened before with chloroquine and sulfadoxine-pyrimethamine (SP), public health will be adversely impacted as a consequence, as no alternative anti-malarial medicines are available now, or in the near future.

### New antimalarial drugs development at NSTDA

Since its establishment, the Protein-Ligand Engineering and Molecular Biology Group in BIOTEC has become Thailand's main unit for research on molecular biology and biotechnology with applications to malaria. The research team employs basic biochemistry and medical biotechnology with special emphasis on the rational discovery and development of new drugs for malaria.

The main goal of the research program is to develop anti-malarial drugs to overcome multi-drug resistant malaria. The main strategies revolve around rational drug design and the synthesis of the new effective anti-malarials based on the structures of the drug targets. The unit also conducts basic research to understand the mechanisms of anti-malarial action, drug resistance and validating new targets for drug discovery.

A recent major achievement includes the development of P218, an effective compound that can kill both wild type and antifolate-resistant P. falciparum parasites, with good pharmacokinetics and no toxicity in experimental animals. The compound is in the preparation stage for advanced pre-clinical and early clinical trial with the hope that it will be a member of the next generation of anti-malarial drugs.

# One Vaccine for Dengue Viruses


Dengue is classified by the World Health Organization (WHO) as a neglected tropical disease with a tendency to become a major international public health problem. It is transmitted by several species of mosquitoes within the Aedes genus. WHO estimates that there are 50 million dengue infections in more than 100 countries every year. Dengue is found in tropical and subtropical regions, and in urban and semi-urban areas. Most deaths occur in Southeast Asia. A vaccine with the potential to provide blanket immunity from all serotypes of Dengue viruses has been developed by Thai researchers. This approach involves genetic modifications of the genome of one of the four viruses that cause the disease.



## Dengue epidemics

In Thailand, dengue hemorrhagic fever (DHF) was first reported in 1949. During the first outbreak in 1958, 2,158 cases were infected and 300 deaths occurred. The country also experienced two major dengue epidemics in the recent past. In 1987 174,285 cases were reported, and in 1998 there were 129,954 cases. The majority of cases was reported in children below 14 years of age and dengue has now become a leading cause of hospitalization and death among children.

Outbreaks of dengue infection continue to be reported every year in Thailand. For the last 10 years, the case load has been consistently above 10,000, but the fatality rate has remained below 1%. The maximum transmissions of dengue are found during July-September each year. Dengue treatment is expensive, costing an average of $1,394 for every hospitalized patient.

## Dengue viruses

Dengue is caused by four single-stranded RNA viruses, dengue serotypes 1-4, which are spread primarily through the A. aegypti mosquito. These four viruses are distinct, yet closely related. Recovery from an infection by one provides lifelong immunity against that serotype but provides only partial and brief protection against subsequent infection by the other three. There is good evidence that sequential infection increases the risk of more serious disease, known as dengue hemorrhagic fever (DHF) or dengue shock syndrome (DSS). The pathogenic processes of DHF/DSS are complex and are still not well understood.

## Dengue Vaccine Development

In 1994, NSTDA funded the establishment of the Medical Biotechnology Research Unit which supports the collaborative effort between BIOTEC (National Center for Genetic Engineering and Biotechnology) and the Faculty of Medicine, Siriraj Hospital, Mahidol University. Over the years, this research unit has expanded to include three affiliated laboratories located at the Faculty of Medicine, Siriraj Hospital (Mahidol University), Department of Microbiology, Faculty of Medicine, and the Department of Clinical Immunology, Faculty of Associated Medical Sciences (Chiang Mai University). Research on dengue vaccine is one leading investigation conducted at these facilities.

## Dengue Vaccine

The research team at Department of Microbiology, Chiang Mai University, first generated the DNA equivalent, generally called "infectious clone", of a strain of dengue virus serotype 2. The strain was obtained through a process called "serial passage" to repeatedly infect new cells to alter the genetic make-up of the viruses. The research team found that the genome modification of the serotype 2 strain eased the virus's virulence. Starting with the non-virulent form of serotype 2, the research team was able to modify the viral genome to produce three additional "chimeric" viruses. The researchers replaced regions of the genome coding for the production of proteins responsible for initiating the infection of new cells in serotype 2's genome with similar regions from genomes of the other three serotypes. The mixture of all 4 modified dengue serotypes has led the research team to the development of a comprehensive vaccine for dengue. The prototyped vaccines are effective and safe in activating the immune responses to all four common types of the dengue viruses.

## Producing dengue vaccine commercially

A licensing agreement was announced in February 2011 involving Chiang Mai University, the National Science and Technology Development Agency (NSTDA), Mahidol University and BioNet-Asia. Once commercially available, the dengue vaccine is expected to be available to Thais, the ASEAN markets, India and China.

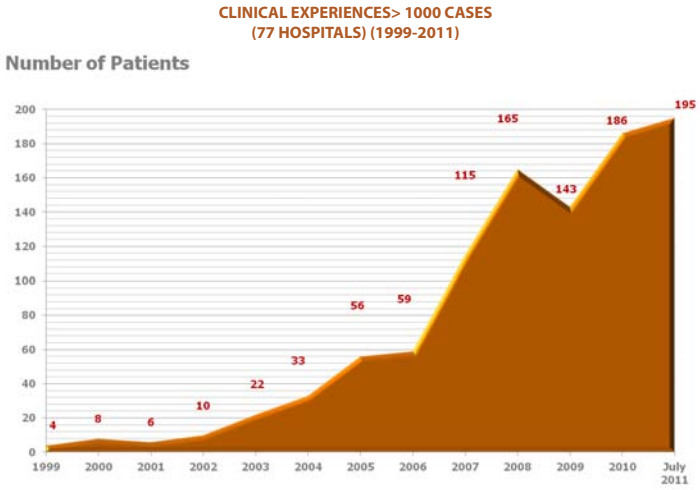
# Medical Rapid Prototyping Technology

The human body is an intricate work of art, a system that fundamentally relies on the complex process of specific organs and other body parts working together for proper function and appearance. What happens when mother nature goes awry or when a person has an accident? Defects with severity ranging from mild discomfort to serious debilitation can occur. Surgery to repair the problem depends on the severity of the defect. For the case of a cleft lip, the defect can range from very minor to the complete split of the lip up to the nostril. In some cases, several corrective or reconstructive surgeries are needed. They must be done properly as a mistake can lead to a permanent disfigurement or disability. Surgeons use art and science in their diagnosis and treatment planning. With rapid prototyping technology today, corrective surgery is done with accuracy, ease and speed.



## Traditional corrective surgery

For the corrective surgery of skull, facial, jawbone, orthopedic and dental abnormalities, a surgeon initially would base his diagnosis on a 3D image generated by a CT scan or MRI to determine the specific treatment plan. In cases where scan results are unclear, especially for complicated operations, the treatment plan might suffer from a lack of precision. This could lead to delays. The patient may need additional operations. In the case of cranio-maxillofacial operation, the surgeon has to mold an implant material by hand using only his imagination in the implant's construction. The outcome of the surgery, which depends on the skill and artistic ability of the surgeon coupled with the fast-setting limitation of implanted material, often leaves room for improvement.




## First medical application of rapid prototyping in Thailand

MTEC has set up Thailand's first medical rapid prototyping laboratory to develop medical rapid prototypes, devices and implants for corrective surgeries. This technology has tremendously enhanced the precision, accuracy, speed and safety of the surgical procedures. It also reduces risks and time required in complex cases. Computer modeling and rapid prototyping helps surgeons in their design of implant parts and positioning the parts for a perfect fit. They also help a surgical team plan the surgical procedure ahead of time and during the actual surgery. This technology has increased the confidence level in operation procedures.

In 2006, NSTDA signed a memorandum of understanding (with Chulalongkorn University, Khon Kaen University, Prince of Songkla University, and Chiang Mai University) to establish three regional centers for medical technology dissemination to local hospitals. These three regional centers have an ambitious goal of becoming international centers of excellence in rapid prototyping.

The rapid prototyping machine being developed uses Selective Laser Lithography (SLL) technology. It was capable of producing high quality polymer implants with complex details to serve over 900 patients in 77 hospitals throughout Thailand during the period 1999-2010. Rapid prototyping implants can be tailor-made with different polymers. This invention has enhanced operation efficiency and shortened the time of surgery. The corrective procedure using this new technology often results in a higher level of patient satisfaction. Patients also recover faster. This means less expense for both patients and hospital. The quality of life, therefore, improves.

In addition to the Thai-made medical rapid prototyping machine, the implant materials are also made domestically - a tremendous saving for patients from imported implants.

SUCCESS STORIES

# TECHNOLOGIES FOR THE COMMUNITIES

# Rain Warning System

Traffic jams brought about by heavy rain are one of the most stressful problems that city dwellers have to face. Being notified of the chance of heavy rain, people can prepare to deal with the likelihood of the increase in traffic more easily. With the **Rain Forecast and Warning System via Mobile Phone** that the Asian Institute of Technology (AIT) has been developing since 2004, a rain forecast notification system is within reach. The system analyzes the direction of the movements of rain clouds from radar and provides registered members with alert that are sent to their mobile phones free of charge.

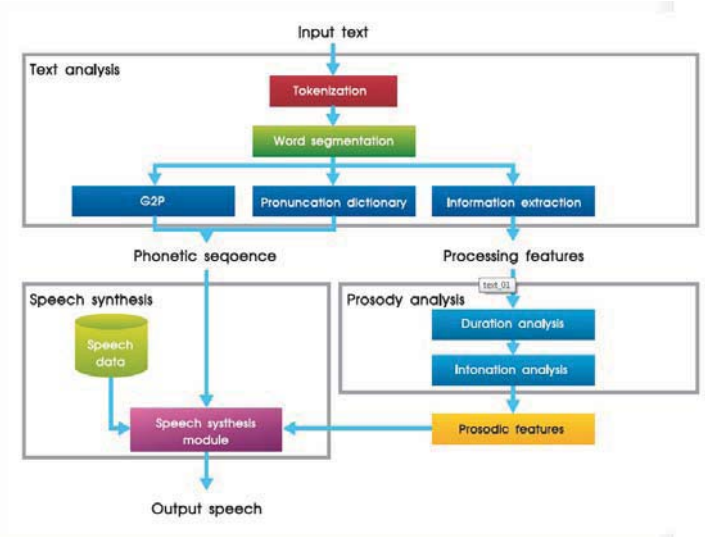

## Overcoming traffic jams using advanced warnings

The automatic rain warning system via mobile phone processes photos from the C-Band radar at the Phasi Charoen Radar Station, Department of Drainage and Sewerage, Bangkok Metropolitan Administration. The system scans and detects rain clouds in Bangkok and the surrounding areas, then combines three to six images to automatically generate a model picture by eliminating unnecessary backgrounds. The colors in the pictures are interpreted into numbers representing the amount and spread of the rain. The method is called translation. It analyzes both current and prior movements and directions of rain clouds to forecast their position in the next hour. The pilot system was tested in 2010 and is now reporting the extent of rainfall through SMS to registered members.
The messages simply informs clients of the amount of rain in their area at three different levels: heavy, medium or light. The rain cloud photos are also available via MMS. This warning system has been helping users prepare and plan their trips to avoid heavy traffic.

NECTEC has combined this scheme with an online traffic information system, Traffy, to develop a rain forecast design for traffic prediction in Bangkok and Chiang Mai, which can effectively help users avoid traffic jams and flooding. The beta system is available at http://info.traffy.in.th.

# High Quality Text to Speech

Automatic spoken text is revolutionizing the online world.
It provides an alternative way to access the internet.
Articles on websites, emails and even news summaries
can be read to you while you attend to another task.
Not only will using the internet become a lot more convenient,
automatically spoken text also helps physically impaired
people access news and information from all over the globe.




## VAJA: high quality Thai speech synthesis software

High quality Thai speech synthesis software, named VAJA, can convert Thai text into speech. VAJA is developed by the Human Language Technology Laboratory (HLT) of NECTEC. The research and development of VAJA began in 1997. The current version, VAJA 6.0, can synthesize more natural sounding Thai speech. In this version, VAJA can also read Thai words not included in the Thai dictionary (its database) using its advanced analysis function.

## VAJA: personal secretary

Associated mainly with language processing technology, VAJA can produce any desired spoken Thai words. The Text-to-Speech Synthesis (TTS) technology can be applied to Thai script for text-to-speech conversion. VAJA can be used in the conversion of a large amount of constantly changing electronic news. Clients can be kept current with stock updates via voice massages and can be alerted to the latest information. News can also be sent via phone and internet. Users can carry on with their tasks while listening to voice messages. The technology can be applied to work with other communication devices including fax machines. Any printed matter that can be faxed can be received in the form of voice. The speaking device will greatly support the speaking-impaired users, while the text reader will tremendously help those visually-impaired people.

This high quality VAJA 6.0 software has now been licensed for commercial distribution. One prototyped application is an e-mail reader. E-mails are converted into speech and sent by phone. Another application is in web browsing where it reads content on websites. One impactful application of VAJA 6.0, however, is in short news report. The News Voice Information Service (NVIS) automatically converts highlighted daily news from RSS feeds from leading sources into spoken messages. At present the Internet Thailand Public Company Limited or INET is the first to hold the rights to use VAJA 6.0 to provide voice services website commercially.

In the future, one can expect to see VAJA being used in an automatic answering machine, in a remote school system, in traffic reports by phone, in a healthcare system for diabetic patients, in facilities for physically-challenged people, in foreign language translation, where one written language is translated into a different spoken language, and more.

# Traffy

Bangkok is notorious for its traffic jam, a problem common to many of big cities with has direct and indirect socio-economic impact. Traffic jams are a major contributor to stress for commuters and a source of air pollution for city dwellers. The solution to this problem is complex. Many parties involved have put in their efforts to solve this problem. One contributing solution is an Intelligent Transport System (ITS) for real time traffic reports.

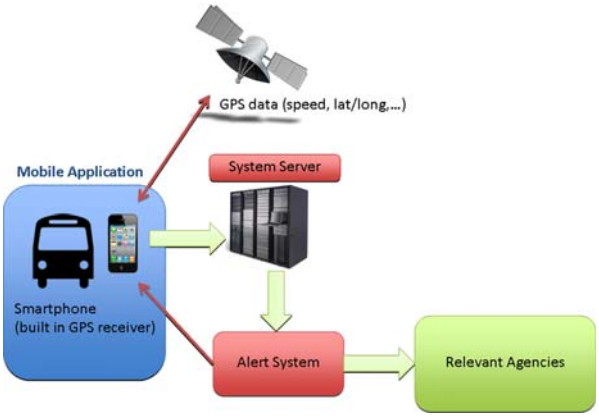


### Intelligent Transport Systems

Traffy, one example of ITS, is a traffic information platform that collects, estimates and provides real time traffic reports for Bangkok and its perimeters. The platform includes application programs that show current traffic conditions at the www.traffy.in.th website. Traffy can also be accessed via mobile applications and a smart TV. It supports Java, Symbian, Windows Mobile, iOS (iPhone), Android and Blackberry. Traffy provides both inbound and outbound traffic information, in the form of maps using colored lines, images from CCTV, and incidents alert messages. It can also be used in a route planning before and during the travel to find the most expedient route. Traffy has the ability to predict traffic conditions up to 10-30 minutes ahead of time, thereby giving drivers sufficient time to plan an alternative route which would get them to the destination more quickly.

Traffy works in three stages: (1) traffic data collection, (2) processing, and (3) dissemination of information to the public. The data obtained is from several sources including the Bangkok Metropolitan Administration, the Thai Traffic Police Administration, and the Expressway Authority of Thailand. Traffy also uses information from the GPS coordinates of fleet vehicles, traffic congestion and incidents tweets submitted via Twitter, and shared photos from the community-based CCTV project called **Traffy Social Eyes** provided by public and private CCTV and IP cameras. These traffic photos help road travelers have access to information from locations across the country allowing them to plan their trip accordingly to avoid routes with heavy traffic before making their trips.

Traffy comes in different forms that fit different needs. The service can be accessed through a website or through mobile phones that support Platform J2ME, Symbian, Windows Mobiles, iPhone and WAP. Through Traffy, one can also obtain traffic reports or submit queries via Twitter.




## More advanced applications

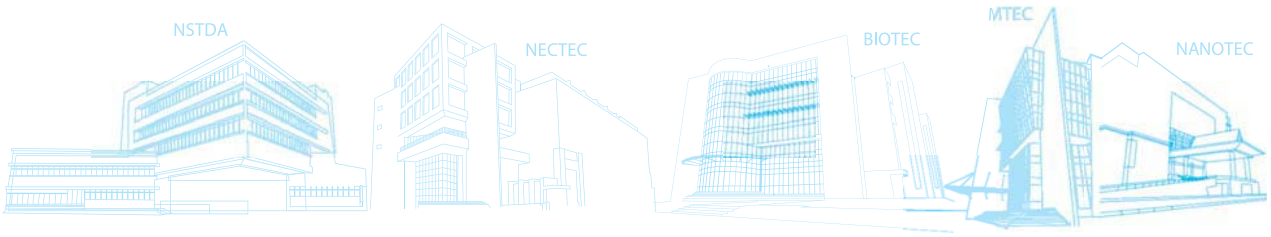
The Traffy Application Programming Interface (Traffy API) has been implemented for public use. It also serves as a platform for further development. Information obtained includes:

- Traffic photographs - from surveillance cameras of the Traffy Social Eyes project
- Traffic condition reports - traffic news, traffic sign pictures and information, traffic reports, and rain forecasts
- Road information - road names in Bangkok and perimeters
- Shared traffic information - news and GPS information
- Speed and time to destination estimation

Several applications based on Traffy API have been developed by independent developers and available to the public in various platforms including Android, Blackberry, and iPhone. Examples of these applications are iTraffic, Traffik, Traffoid and Highway Police. New applications have continued to emerge.

Traffy's contribution to the society and industry is by way of the Traffy API web service and the community-based CCTV (Traffy Social Eyes) system. On-going research extending theTraffy platform includes travel time prediction, safe driving behavior, and automatic incident detection.

| | |
|---|---|
| Established: | December 1991, Member of Ministry of Science and Technology |
| Location: | In Thailand Science Park, 30 kilometers north of Bangkok |
| Vision: | Key S&T partner towards knowledge based society/economy |
| Missions: | Research & Development, Technology Transfer, S&T Human Resources Development and S&T Infrastructure |
| Employees: | >2,600 (approx. 1,700 fulltime researchers and 400 Ph. D.s)<br>67% Research, 25% Operation, 7% Management and 1% Executive |
| Budget: | Approx. 100 million USD allocated from government |
| 4 National R&D Centers & 1 Technology Management Center: | BIOTEC: National Center for Genetic Engineering and Biotechnology<br>MTEC: National Metal and Materials Technology Center<br>NECTEC: National Electronics and Computer Technology Center<br>NANOTEC: National Nanotechnology Center<br>TMC: Technology Management Center |
| 1 Focus Center: | Advanced Dental Technology Center (ADTEC) |




# NSTDA IN BRIEF

Published January 2012

A Driving Force for National Science and Technology Capability

111 Thailand Science Park,
Phahonyothin Road,
Klong 1, Klong Luang,
Pathumthani 12120, Thailand.
Tel. +66 2564 7000
Fax. +66 2564 7002-5
www.nstda.or.th