

BIOTECHNOLOGY

The Kingdom's position as a global leader in agriculture, one of the top food exporters in the world, and a medical hub of Asia has encouraged the emergence of biotechnology in Thailand. For the past two decades, Thailand has been developing a cutting edge biotechnology industry. This knowledge-based industry has diverse applications across the medical, agricultural, aquatic, and industrial fields. With a greater focus on science and technology, the biotechnology sector has evolutionary implications where industry will move into more value-added activities to support the industry's growth and competitiveness in years ahead.

The foundation of Thailand's biotechnology industry was laid in 1983 with the creation of the National Center for Genetic Engineering and Biotechnology (BIOTEC). Since then, numerous public and private institutions have started conducting biotechnology research. To help facilitate the industry, the National Science and Technology Development Agency (NSTDA) provides resources to develop the critical mass of researchers necessary to achieve Thailand's national research and development (R&D) goals for biotechnology. As the center of biotechnology development in Thailand, BIOTEC established multiple laboratories for conducting research and providing technical services in agricultural, biomedical, and environmental sciences. Additionally, the Thailand Center of Excellence for Life Sciences (TCELS) and the Board of Investment (BOI) have supported the industry, facilitating its progressive growth.

Under the Biotechnology Development Policy Framework 2012-2021, the Thai government is the driving force in stimulating developments in R&D and applications of biotechnology. This initiative aims to transform Thailand into the center of biotechnology in Asia while strengthening the country's competitiveness. Thailand currently chairs the ASEAN sub-committee on biotechnology and is a regional and global contributor to the industry.

Currently, there are approximately 200 biotechnology firms in Thailand with a total market value over US\$2 billion. Through strong and supportive governmental policy and the establishment of alliances between universities and industry these biotechnology companies have flourished. By bringing the appropriate stakeholders together, Thailand has linked

science to business and is able to deliver biotechnological research and innovation that is applied in the industrial sector.

THAILAND BIOTECHNOLOGY DEVELOPMENT POLICY

The National Science Technology and Innovation Policy Office (STI) cooperated with the National Center for Genetic Engineering and Biotechnology (BIOTEC) in formulating the National Biotechnology Policy Framework 2012-2021. The policy framework is directed towards strategic planning, establishing future R&D, and enhancing the country's ability to access new technologies and applications of biotechnology, as well as development of the intellectual capital to strengthen the country's competitiveness. The National Biotechnology Policy Framework 2012-2021 emphasizes the development of four sectors including:

1. Agriculture and food
2. Medicine and public health
3. Bio energy
4. Bio industries

AGRICULTURE AND FOOD

Thailand's abundant natural resources provide the Kingdom with a key competitive advantage over its regional and global competitors in the food processing industry. The country's rich agriculture and the high technology combined with governmental support in food R&D have developed Thailand's reputation as the "Kitchen of the World." Thailand is among the world's leading suppliers of commodities such as rice, sugar and cassava, as well as a leading provider of fresh and canned fish, shrimp, pineapple, and a variety of fruits and vegetables. Moreover, the Thai food processing industry comprises more than 10,000 food-processing companies. In 2013, Thailand's food exports were expected to exceed US\$31 billion, an increase of 5% from 2012. As such a significant player in the global food market, the Thai government, together with the private sector, attempts to promote the implementation of international standards of food safety and hygiene, as well as increasing advanced technology investment to maintain Thailand as a world leader in the food processing industry.

The use of biotechnology will improve food and agriculture product yields and quality, reduce costs and also increase product value to support the country's competitiveness in the food industry. Investments in biotechnology R&D facilities enable product development and improvements in product quality to strengthen the industry. The Food Biotechnology Laboratory, a part of BIOTEC's research units, was established to improve and upgrade the processing and quality of traditional Thai fermented foods and transfer technologies to the private sector. Additionally, the Agricultural Biotechnology Research Unit plays a key role to support the development and implementation of new biotechnologies to drive the country's agriculture sector.

Current Agricultural Biotechnology projects in Thailand focus on plant and animal biotechnology, including field testing recombinant DNA techniques in transgenic plants to yield resistance to diseases, pests and abiotic stress; enhancements in the nutritional value of rice and its tolerance to flooding, drought and disease; germplasm collection in plants; trait selection such as an aroma marker and a submergence tolerance marker; small particle cassava starch development for use in the pharmaceutical and food industries; and, development of methods to diagnose viruses in shrimp.

Plant Breeding Development

In Thailand, technologies, such as Marker Assisted Selection (MAS), gene discovery and transformation systems are adopted for plant breeding with desired traits, including markers for fragrance, cooking quality, disease resistance in rice, and sweetness in sugarcane. BIOTEC and the Rice Department of Ministry of Agriculture and Cooperatives have conducted collaborative research using MAS technology to develop new rice varieties that are resistant to diseases and insects as well as tolerant to environmental stresses including submergence-tolerant Khao Dawk Mali (KDML) 105 jasmine rice variety, salt-tolerant KDML 105 and blast-resistant RD6. Moreover, BIOTEC and the Rice Department will develop additional varieties with desirable traits such as tolerance to drought and resistance to brown-plant hopper.

“The Thai seed industry is a good example of a stakeholder who invests in new technology to improve their competitive edge. The market value of the seed industry is close to US\$0.27 billion. Sizeable companies such as Chia Tai, East-West Seed Thailand, and Pacific Seeds have their own R&D facilities with the state of the art technology in screening and improving the quality of their products. Recently, several seed companies and related government organizations have come together to start a “seed cluster” in order to develop Thailand as the “Seed Hub of Asia.”

- Dr. Kanyawim Kirtikara,
Executive Director of National Center for
Genetic Engineering and Biotechnology (BIOTEC)-

Genetic Engineering Policy: Transgenic plants

The National Biotechnology and Biosafety Policy framework is focused on utilizing biotechnology for the prosperity of businesses, economic self-sufficiency, and the wellness of society. The National Biotechnology Policy Committee issued a genetically modified organisms (GMO) roadmap for building R&D capabilities from research and development to commercialization. Thailand has adopted the Biosafety guidelines in 1992 for laboratory and field work and is now preparing the development of a Biosafety law.

Diseases Diagnosis and Services

Bioactive ingredients, such as the monoclonal antibodies, are developed to detect diseases and select tolerant traits. Monoclonal antibodies have become increasingly important diagnostic tools in agriculture. BIOTEC’s research focuses on monoclonal antibody production and immunoassay development for efficient detection of plant pathogens to be used in agriculture and seed inspection business. For example, white leaf disease test kits are developed and used in the sugarcane industry. The seed industry is also working on generating solutions to detect crop diseases.

MEDICINE AND PUBLIC HEALTH

Thailand, as the world's largest medical tourism market, is well positioned to be the medical hub of Asia. The country offers state-of-the-art technological infrastructure, premium medical services, excellent medical expertise and a wide range of world-class hospitals at affordable costs. The price of medical services in Thailand is far below the USA or Europe. Thailand attracts more than 2.5 million international patients from all over the world for a variety of treatments ranging from advanced procedures, such as stem cell treatment, to general treatments like dental care and basic health check-ups. As a result of the robustness of the medical sector, Thailand's 2012 revenue from medical tourism surpassed US\$4 billion.

Moreover, Thailand has developed several biotechnology programs to support the medical sector especially in alternative disease solutions for emerging diseases, re-emerging diseases, and tropical diseases. Many research programs were created by BIOTEC to provide the resources and facilities for biotechnology development including the facilitation of advanced technology transfer from overseas, human resource development, and specialized laboratories.

Diagnostic Kits

Thailand has invented and developed numerous medical diagnostic kits that can be used in actual diagnosis efficiently and accurately. The medical diagnostic kits developed in Thailand include test kits for the Alpha Thalassemia carrier, the Alpha Thalassemia immunochromatographic strip test, white blood cell count solution, red blood cell test, conjugate solution for Rabies diagnosis, biosensors for Avian Influenza H5, biosensors for Bird Flu, and simple CD4+ lymphocyte test for counting CD4 lymphocytes or T-cells in HIV patients.

Pharmaceutical products

Many diseases can be treated with protein-based drugs; however, drug manufacturers face many problems producing large quantities of protein. In order to solve these issues, Thailand NSTDA has successfully characterized the protein-production performance of a methylotrophic strain, *Pichia thermomethanolica* in order to use it as the active ingredient in innovative protein-based medicine.

Stem Cell Technology

Thailand is one of the leaders in stem cell research in Southeast Asia. Thailand adopted a free enterprise model funded by both public and private institutions. In 2013, Chulalongkorn University successfully produced human embryonic stem cells, Police General Hospital developed adult stem cells to treat arthritis sufferers while Siriraj Hospital discovered a method to extract stem cells from human amniotic fluid. Thailand is also one of the leaders in stem-cell banking. Chulalongkorn University set up Thailand's first embryonic stem-cell bank while THAI StemLife cooperates with Cryoviva Thailand, CordLife and others to store stem cells from the roughly 800,000 babies born each year in Thailand.

Vaccine

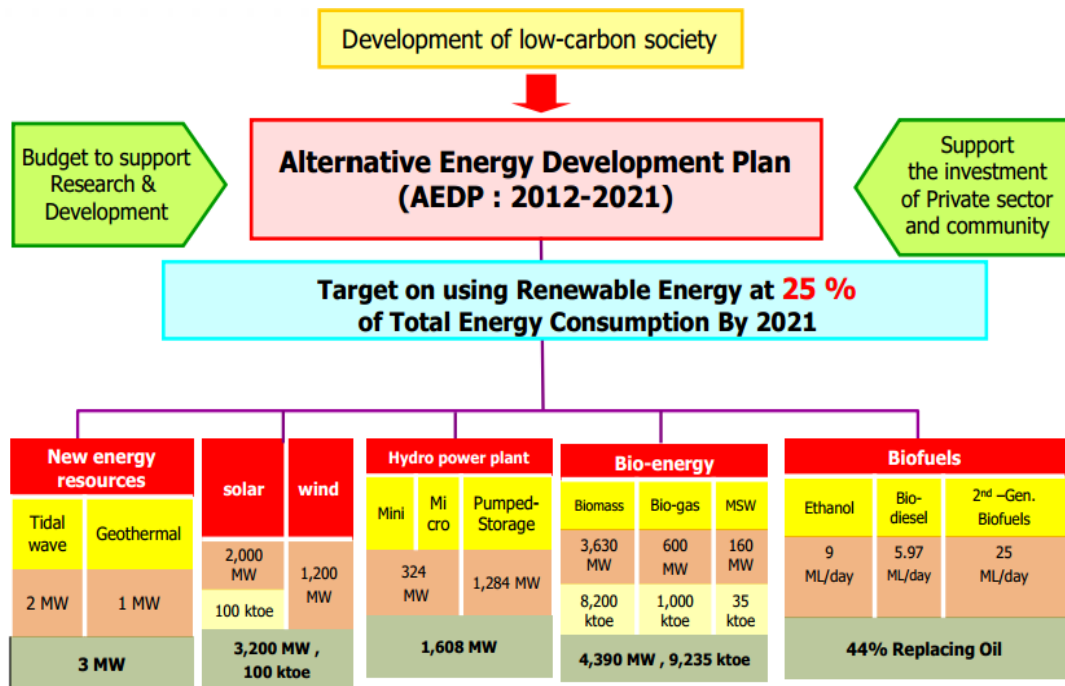
Thailand NSTDA collaborates with BIONET Asia to develop vaccines. They have successfully developed a 5-in-1 or 'cocktail' vaccine that covers diphtheria, tetanus, pertussis, hepatitis B, and meningitis. This vaccine is expected to be released in 2017. Moreover, NSTDA developed a dengue vaccine to prevent dengue fever along Thailand's borders.

To ensure Thai vaccines meet international standards and gain a competitive advantage, the National Biopharmaceutical Facility (NBF) was established as the center of technology transfer for vaccine production in Thailand. The NBF is co-invested by BIOTEC, NSTDA and King Mongkut's University Technology Thonburi (KMUTT).

BIO ENERGY

Thailand's annual energy consumption has risen sharply during the past decade and will continue its upward trend. With limited domestic energy sources, Thailand needs to produce more energy from its own renewable resources including solar, wind, hydro power, bio-energy and bio-fuel. In an effort to maintain the sustainability of energy, the Thai Government developed the Alternative Energy and Development Plan (AEDP) 2012-2021, to promote renewable and alternative energy development to 25% of total energy consumption in 10 years.

Alternative Energy Development Plan (AEDP), 2012-2021



Source: Department of Alternative Energy Development and Efficiency, Ministry of Energy

Thailand has an abundance of agriculture products and agriculture waste to be utilized as bio energy. The bio energy in Thailand includes biomass, biogas, ethanol and biodiesel.

Biomass

Biomass is an organic and renewable material made from agricultural waste or byproducts of rice husks, sugarcane, palm oil waste, cassava waste, rubber and wood waste. Biomass is one of the highest potential sources of an alternative energy in Thailand. With its strong agricultural base, Thailand is well positioned to utilize biomass as an alternative energy source. Biomass currently accounts for approximately 80% of Thailand’s renewable energy, representing over 10% of the country’s total energy consumption. According to the AEDP 2012-2021, Thailand aims to produce 3,630 megawatts annually from biomass by 2021.

Biogas

Biogas is composed of methane and inert carbonic gas generated through the process of anaerobic digestion or the fermentation of biodegradable materials such as industrial waste, farm waste, waste water, sewage, and Municipal Solid Waste (MSW). Due to the abundant availability of industrial waste and livestock manure in Thailand, biogas has high potential to

generate power. According to the AEDP 2012-2021, Thailand is targeting to generate 600 megawatts annually from biogas by 2021.

Ethanol

Ethanol is an alcohol-based fuel made by fermenting and distilling plant materials such as starch crops, sugar cane or molasses, tapioca, paddy straw, cassava, and corn. Most of the ethanol produced in Thailand is made from cassava and molasses. As the world's largest exporter of cassava and the second largest exporter of sugar in 2013, Thailand has high potential to increase the production of ethanol. The use of ethanol can reduce Thailand's dependence on foreign oil and reduce greenhouse gas emissions.

In 2013, there were 21 factories producing ethanol in Thailand with a total capacity of 3.89 million liters per day. Another 1 ethanol plant will open in 2014, adding to overall production. Thailand's AEDP aims to produce 9 million liters of ethanol per day by 2021.

Biodiesel

Biodiesel is a form of diesel fuel manufactured from plant oils. Biodiesel is safe and produces less air pollutants than petroleum-based diesel. Biodiesel can be used in pure form (B100) or blended with petroleum diesel. There are several types of blends depending on the percentage of biodiesel such as B2 (2% biodiesel), B5 (5% biodiesel) and B20 (20% biodiesel).

The Government of Thailand has undertaken serious efforts to boost the production of biodiesel in the country. With more than 600,000 hectares of palm oil plantations, Thailand has abundant resources to produce biodiesel. Thailand currently has a B5 biodiesel mandate in place. The government aims to roll out a B7 mandate in 2014 and also plans to roll out B10 in 2019.

Currently, Thailand has 15 biodiesel plants with a total production capacity of 5.3 million liters per day. Thailand's AEDP targets to increase the consumption of biodiesel to 5.97 million liters per day by 2021.

BIO INDUSTRY

Thailand's agricultural base and the well-developed biotechnology sector provide a competitive advantage to the bio industry of Thailand over neighboring countries. The Thai Government appointed the National Innovation Agency (NIA) to create a national roadmap for Thailand to develop the bio plastic industry as a new wave industry. Thailand offers huge opportunities for the bio plastic industry due to its abundant supply of biomass, numerous supporting industries, and strong government support.

Bioplastics

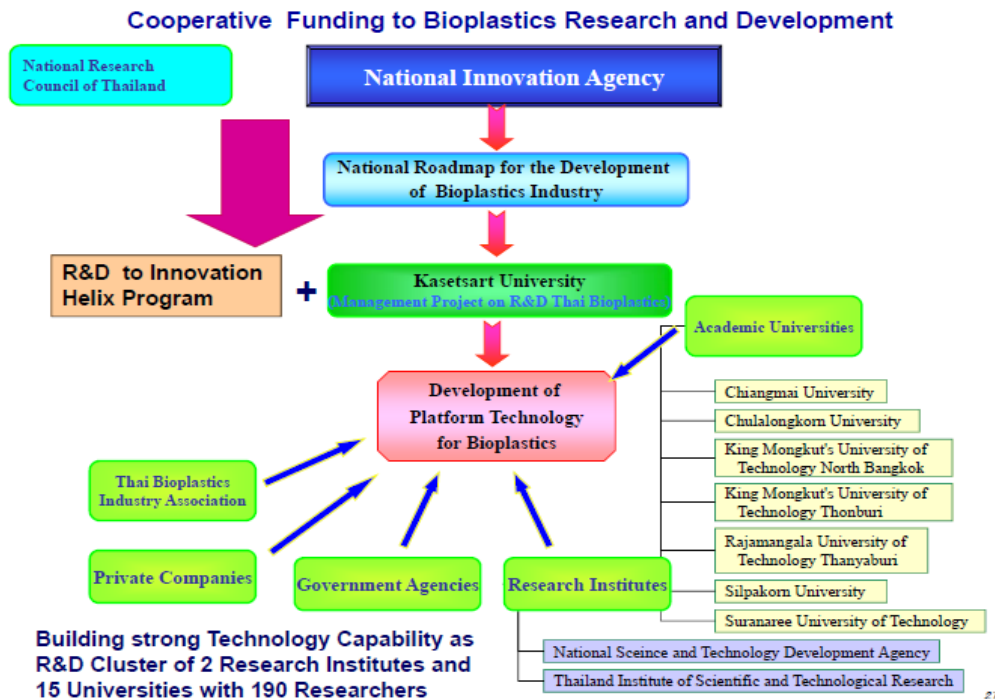
Over the past decade, the Thai Government has taken an active role in developing the bio plastics industry to support Thailand in becoming a regional and worldwide leader in industrial growth and innovation. The Thai government initiated a national roadmap for the development of the bio-plastics industry. Recently, Thailand's National Bio-plastics Roadmap moved on to Phase 2 (2011-2015) which aims to develop improved market promotion and environmental management, R&D, biomass supply chain and business, and investment incentives and privileges.

Thailand has plenty of agricultural products that can be used as biomass feedstock for bio-plastics such as rice, cassava, and sugarcane. In 2013, Thailand produced an estimated 28.28 million tons of cassava, maintaining Thailand as the world's largest cassava exporter.

The country has a comprehensive offering of suppliers across the bio plastics value chain. According to the International Trade Center, Thailand was ranked the second largest exporter of plastic products in ASEAN and was ranked 20th in the world in 2012. Currently, Thailand has more than 3,000 companies in the domestic plastics industry. This ensures that these established plastics industries can be used effectively to manufacture biomass into high-value-added bio-plastics.

The Thai government has a strong network to support investment in bio-plastics industry. The National Innovation Agency (NIA) is one key agency charged with maintaining a strong network to support the bio-plastics industry.

Strong Networking to Support Bio-plastics Industry



Source: The National Innovation Agency (NIA)

There are a number of bio plastic firms in Thailand including PURAC, PTTGC/Nature Work, and PTTMCC Biochem – a joint venture between PTT and Mitsubishi Chemical.

Thailand's richness of agricultural resources, strong plastics companies and supporting governmental organizations make it an ideal location for bio-plastics investment. Thailand is readying itself to be the regional hub of bio-plastics and continues to develop and implement new innovative technologies.

WHY THAILAND

Thailand offers various outstanding advantages for companies in the biotech industry. These include:

Skilled Labor

Thailand continuously supports work force development to strengthen the biotechnology sector through numerous training programs as well as financial support for students and researchers. Currently, there are 24 universities across the country with biotechnology programs educating approximately 7,000 students in the subject each year. With the National Biotechnology Policy Framework 2012-2021, the government called for the human resource development program to increase the number of bachelor's, master's, and doctoral degrees in the field of modern biological science to at least 10,000 students. These statistics should persuade foreign experts in biotech to conduct research and development in Thailand and create on-the-job training to provide a skilled workforce for the private sector through cooperation among research institutes and universities.

Access to markets

The free trade agreements (FTAs) between Thailand and various countries including India, China, Japan, Australia, New Zealand and Peru, extends international trade opportunities. Moreover, the establishment of the ASEAN Economic Community (AEC) in 2015 will expand the Thai market to more than 600 million consumers across the 10 member states of ASEAN. The AEC will open new doors to manufacturers by transforming ASEAN into a region with the free movement of goods, capital, services, investment, and workforce. With Thailand's strategic location in the center of Southeast Asia, Thailand is a regional transportation hub. Thailand has excellent transportation infrastructure to support product distribution to nearby countries including Laos, Cambodia, Vietnam, Myanmar, Malaysia, Singapore and also southern China.

“This is an unprecedented moment to invest in biotechnology in Thailand. With the approaching of AEC in 2015 as well as the strong capabilities of Thailand, we stand a good chance to become a “hub” of advanced biotechnology whether it is the products of local research or the technology introduced from outside the region. Thailand is attractive as a landing pad for introduced technology due to its central location among AEC countries, its strong background in this field including its skilled workforce, and the readiness of existing large companies to absorb new technology.”

- Dr. Kanyawim Kirtikara,
Executive Director of National Center for Genetic Engineering
and Biotechnology (BIOTEC)-

DEVELOPED NETWORK OF SUPPORTING ORGANIZATIONS

Government and organizations supporting the growth and competitiveness of biotechnology industry in Thailand include:

- **National Science and Technology Development Agency (NSTDA):** NSTDA is home to four national research centers and one technology management center (TMC). The four national research centers are the National Center for Genetic Engineering and Biotechnology (BIOTEC), The National Metal and Materials Technology Center (MTEC), The National Electronics and Computer Technology Center (NECTEC), and The National Nanotechnology Center (NANOTEC).

NSTDA acts as a bridge between academic research and the private sector. During the Strategic Planning Alliance II (SPAII:2011-2016), NSTDA focused on five target sectors including Agriculture & Food, Energy & Environment, Health & Medicine, Bioresources & Community, and Manufacturing & Services Industries. Along with the Thailand Science Park, the TMC provides services including intellectual property management, incubation facilities, industrial consulting and technological upgrading of the private sector.

- **Thailand Science Park (TSP):** TSP is the first technology and innovation hub of Thailand. It is a key area for research and development where specialists and researchers from industry, academia, and NSTDA collaborate to stimulate development in the areas of Biotechnology, Information Technology, Metals and Materials Technology and Nanotechnology. A strong network of 1,600 full-time

researchers and technicians, of whom around 400 hold doctorate degrees, can be found at TSP. TSP serves as a one-stop service center to assist both foreign and local companies engaged in scientific and technological research. TSP provides 5 business services including design and consultation for laboratory construction, legal & registration services, business development & HR services, R&D support & services, and facilities & amenity services.

- **Research and Development Certification Committee Secretariat (RDC):** The RDC, a unit under the supervision of the NSTDA, provides support to the private sector in the areas of technology research and development investment. Working closely with the Revenue Department, the RDC grants tax privileges that serve to promote and attract investment in science and technology within the private sector. These privileges also aim to stimulate innovation in product and production procedures in the private sector, raising the overall competence of the nation in science and technology. Tax amounting to twice the expense of the company's corporate income tax can be deducted for approved projects.
- **Thailand Center of Excellence for Life Sciences (TCELS):** TCELS is positioned as a center for all life science business and research and investment in Thailand. TCELS was established in 2004 by the government with the core intention of providing the central link between innovation and investment as well as facilitating domestic and international partnerships in life science business in Thailand. Its primary functions are to support the establishment of bioscience companies in Thailand; develop basic infrastructure to increase product value; service and investment; set up funding for business; and bridge the public and private sectors in the development of products, business and investment.
- **Thailand Institute of Scientific and Technological Research (TISTR):** TISTR is a non-profit state scientific research institute under the Ministry of Science and Technology (MOST). TISTR's mission is to conduct research and development work focusing on food technology, pharmaceutical and natural products, post-harvest technology, agricultural technology, biotechnology, microbiological resources, environment, ecology and energy, materials technology and engineering.

Additionally, the technology transfer group offers industrial and technical consulting and training to the public, promoting the creation of a learned society. The organization also serves as the incubator for the Thai Science Park in Chiang Mai.

- **The Venture Capital (VC) Industry in Thailand:** There are a number of Thai venture capital firms focused on the biotechnology industry. One such firm is One Asset Management Limited, which has supported several biotech companies through the SME Venture Capital Fund, and VNET Venture Capital.

Stang Holding Co. Ltd., a joint venture between Mahidol University, Small and Medium Enterprise Development Bank of Thailand (SME Bank) and The National Innovation Agency (NIA), is another private organization that provides long-term co-investment and assistance in capital and project value creation for science and technology developments. The Market for Alternative Investment (MAI) matching fund is also available for companies interested in investing in biotechnology businesses.

ATTRACTIVE INVESTMENT INCENTIVES

Recognizing the value of biotechnology, biotechnology is classified as a priority activity that has special importance and benefits to the country. As such, projects in biotechnology shall be granted an eight-year corporate income tax exemption, regardless of location and are not subject to the corporate income tax exemption cap. They also receive an exemption of import duties on machinery, regardless of location; and other rights and benefits shall be granted according to BOI Announcement No.1/2543 dated August 1, 2000.

Projects that are located in science and technology parks shall receive a five-year additional 50 percent corporate income tax reduction for net profits after the end of corporate income tax exemption period.

Projects must use modern biotechnology as approved by the National Science and Technology Development Agency (NSTDA) or the Thailand Centre of Excellence for Life Sciences (TCELS).

FOR FURTHER INFORMATION:

The Thailand Board of Investment (BOI): <http://www.boi.go.th>

The National Science and Technology Development Agency (NSTDA):

<http://www.nstda.or.th>

The National Center for Genetic Engineering and Biotechnology (BIOTEC):

<http://www.biotec.or.th>

The Thailand Science Park (TSP): <http://www.sciencepark.or.th>

The Thailand Center of Excellence for Life Sciences (TCELS): <http://www.tcels.or.th>

The Thailand Institute of Scientific and Technological Research (TISTR):

<http://www.tistr.or.th>

The Venture Capital (VC) Industry in Thailand: <http://www.venturecapital.or.th>