

3 DECADES OF IMPACTS



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MESSAGE FROM NSTDA PRESIDENT

I am pleased to present to you “3 DECADES OF IMPACTS”, a publication commemorating the 30th anniversary of NSTDA.

NSTDA was established by the Science and Technology Development Act B.E. 2534 in 1991 to administer the Science and Technology Development Fund under the governance of the National Science and Technology Development Executive Board. Affiliated to the Ministry of Higher Education, Science, Research and Innovation (MHESI), NSTDA is a leading S&T agency with a commitment to advance the country to a knowledge-based economy. Its mission is to support research and development, as well as promote the use of science and technology in all sectors.

Presently, there are five research centers operating under NSTDA auspices. These 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), the National Nanotechnology Center (NANOTEC) and the National Energy Technology Center (ENTEC). These research centers are essential as they provide S&T support that enables businesses and industry to achieve sustainable growth and become the main force to strengthen the nation's economy.

NSTDA operational strategy embraces the concept of new economy aiming to build capacity and expertise in advanced science, technology and innovation for the country, to offer solutions to meet economic, environmental and social goals and to create a positive impact to the nation. Bioeconomy focuses on utilizing biotechnology and an advantage in biodiversity to drive the economy. Circular economy aims at utilizing waste as a raw material for high value product. Intelligent economy employs digital technology to improve productivity and efficiency and create additional value to goods and services. For silver economy, knowledge, technology and innovation are employed to create products and services supporting the aging population. Sharing economy is an economic model that focuses on sharing and collaboration, resulting in new products and services, whereas green economy places emphasis on saving energy, minimizing environmental impact and responding to the Sustainable Development Goals (SDGs).

Over the past 30 years, NSTDA has always strived to evolve and grow. Our strength lies in human capital with exceptional expertise and potential that drives NSTDA to stand at the forefront of Thailand's STI landscape. More importantly, we always have strong partners to collaborate with and through these collaborations, we are able to create innovations, strengthen local businesses and enhance human capability in STI. Some of the achievements are featured in this publication.

I wish to express my appreciation to all former and current NSTDA staff members, advisors, executives and each and every partner for contributing to the success of NSTDA today.



Dr. Narong Sirilertworakul
President
National Science and Technology Development Agency
(NSTDA)



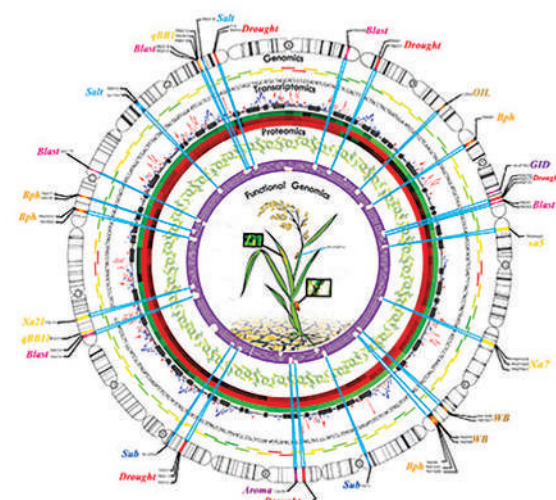
AGRICULTURE AND FOOD

NSTDA R&D in agriculture aims at making improvement on productivity and quality of farm commodities and products, reducing production costs for farmers and manufacturers, enhancing competitiveness and minimizing environmental impact with advanced technologies such as precision breeding and smart farming. Priorities are given to economic crops and livestock such as rice, cassava, sugarcane, poultry and aquaculture. The scope also extends to applying research and innovation to create value to farm products such as natural rubber and cassava, as well as to develop smart solutions for agro- and food industries.

Accelerating Rice Breeding with Genomic Technology

Rice biotechnology research at BIOTEC-NSTDA can be traced as far back as 1989 when the center started to employ marker-assisted selection technology to rice breeding under the collaborative program with the Rockefeller Foundation. In 1999, BIOTEC, representing Thailand, participated in the **International Rice Genome Sequencing Project (IRGSP)** that brought together multiple countries to perform the genome sequence of Nipponbare rice. Thai research team was responsible for chromosome 9 containing submergence tolerance gene. While working on IRGSP, Thai researchers were also conducting the genome sequence of Thai rice in parallel. Recognizing the impact this project would have on Thai rice development, HRH Princess Maha Chakri Sirindhorn bestowed a 2-million-THB seed fund to the project and NSTDA subsequently provided a grant to a magnitude of 50 million THB.

BIOTEC and Kasetsart University co-founded Rice Gene Discovery Laboratory aiming to develop and utilize molecular markers for rice breeding program. Both IRGSP and Thai rice genome sequencing project have strengthened capacity of Thai researchers in genomic technology, leading to the implementation of marker-assisted selection for desired traits – rice quality and resistance to biotic and abiotic stresses - in rice breeding program. Important biotic and abiotic stresses include flood, drought, salinity, blight disease, blast disease, brown planthopper and whitebacked planthopper, for instance. The collaboration extended to the Rice Department and Rajamangala University of Technology Lanna in multi-location field trials.



Significant achievement was made on the rice genomic technology when the research team discovered that the inhibition of Os2AP gene could result in the production of aromatic compound, 2-acetyl-1-pyrroline (2AP), the major potent flavor component of aromatic rice. The **US patent for the method to increase aromatic fragrance in a rice plant** was granted in 2008.

Marker-assisted selection is a powerful technology, enabling breeders to speed up the breeding

process and make it more efficient to achieve rice cultivars with desired characteristics, suitable to environmental conditions of cultivated areas and minimize losses due to disease and pest outbreaks. Several new and improved rice varieties have been developed. Examples include flash-flooding tolerant **Homcholasit**, blast-resistant jasmine glutinous rice **Thanyasirin**, broad-spectrum-disease-resistant fragrant glutinous rice **Nan59** and climate-resilient aromatic glutinous rice **Hom Naga**.

Strengthening Rubber Industry



Thailand has long been the world's leading producer of natural rubber. Recognizing the importance of rubber industry to the Thai economy and the wellbeing of a large number of rubber farmers, MTEC-NSTDA has developed innovative solutions to increase the competitiveness of the Thai rubber industry – ranging from novel technologies to process natural rubber to innovative rubber products and green manufacturing process.

Normally, latex collected from rubber trees has a very short life before spontaneous coagulation and spoilage taking place. Ammonia and sodium sulfite are widely used as preservatives to prevent such reactions. However, ammonia creates toxic fume, endangering workers' health and causing environmental pollution, whereas sodium sulfite leaves air pockets in dry rubber, lowering the rubber's quality. MTEC research team successfully developed latex preservative **BeThEPS** to replace ammonia and sodium sulfite. BeThEPS can extend the shelf life of fresh latex up to 1-3 days, resulting in the elimination of latex loss and the

improvement of dry rubber's quality. The extended period also means less transport frequency from the plantation to the processing factory, saving time and fuel for farmers. All these positive effects add 900 THB value to a ton of rubber production. BeThEPS has been licensed to companies for commercial production.

Industrial production of concentrated latex contributes to several environmental problems from the use of toxic chemicals such as sulfuric acid in the coagulation process of skim latex and latex residue, as well as inorganic substances present in waste and wastewater. These problems can be overcome with MTEC's **GRASS technology**, a highly efficient solution to waste management in concentrated latex manufacturing process. GRASS technology offers high efficiency in removing latex and inorganic substances using sulfuric-free coagulants with different formulations designed for different types of waste, i.e., skim latex, washed water of centrifuging machine and latex sludge. With GRASS technology, wastewater quality is improved and can be used for biogas production. Latex recovered by GRASS technology is of good quality and can be recycled, whereas the separated inorganic substances can be used as fertilizers.

Value-added products from natural rubber are identified as solutions to unstable latex price faced by rubber farmers. A number of innovations have been developed to expand the range of value-added products utilizing natural rubber. Concentrated latex **ParaFIT** for latex foam production contains 30-75% less amount of ammonia and 30% less amount of zinc oxide (ZnO)

and tetramethylthiuram disulphide (TMTD) than commercial concentrated latex. Ammonia, ZnO and TMTD are toxic chemicals causing adverse effects on human health and the environment. While commercial concentrated latex normally requires a 21-day incubation, ParaFIT can be used 3 days after the production date, enabling business operators to reduce their cash flow for purchasing fresh latex and save investment capital in constructing latex storage facilities. ParaFIT technology has been transferred to Banprakha Agricultural Cooperative for the commercial production of latex foam pillows and mattresses. **LOMAR** is a concentrated latex designed for mixing with asphalt cement for road construction. LOMAR has a very low ammonia content of 0.15% by weight and high thermal stability, allowing it to be

processed at 140-160 °C. It can be used immediately within 1-2 days after the production date and has a shelf life of over 6 months. LOMAR is now commercially manufactured by Thai Eastern Rubber Company Limited and supplied to Tipco Asphalt Public Company Limited for the production of para-asphalt cement (PARA AC) for road construction. MTEC, in collaboration with Mahidol University and King Mongkut's University of Technology North Bangkok, developed **eco-friendly and energy-saving solid tires for forklifts**. The performance test has demonstrated that the newly developed tire is twice more durable and provides greater fuel consumption efficiency than the commercial solid tire. The saving was estimated to be 60,000 THB/forklift/year.



Enhancing Productivity and Sustainability of Cassava Industry

Cassava is one of the most important crops to the Thai economy. The country was the world's largest cassava products exporter in 2019, supplying 68% of the global market. Cassava industry involves players from growers to processing factories. BIOTEC-NSTDA has developed technologies to support this industry, ranging from cassava cultivation and breeding, efficient cassava starch production processes, waste management and utilization and biogas production.

ELISA assay for the detection of cassava mosaic virus was developed to curb the spread of cassava mosaic disease, a severe and widespread disease that damages the production of cassava crop. The test is highly accurate and much cheaper than imported ones. **An anaerobic fixed-film reactor wastewater treatment system** has been implemented in a number of cassava starch



factories. The closed system not only eliminates odor problem associated with the open pond method, but also produces biogas used as energy.

BIOTEC and Kasetsart University have developed **the cassava flour manufacturing technology from bitter cassava**. It is a mechanized process to convert bitter cassava containing high level of toxic cyanide



to high quality cassava flour with less than 10 ppm cyanide content. Since cassava contains no gluten, cassava flour is therefore an ideal substitute for wheat flour in gluten-free baked products. The technology has been licensed to Chorchaiwat Industry, and the company became the first company in Thailand to manufacture gluten-free all-purpose flour SAVA.

Innovations for Sugarcane Production and Sugar Industry



Sugarcane is an important tropical crop and has served as a primary source of sugar. Its importance has been reinforced in recent years for its bioenergy production potential. With limited cultivation land, crop improvement to develop high productivity and sugar content cultivars is the solution to increase sugarcane and sugar production. The National Omics Center of NSTDA and Mitr Phol Sugarcane Research Center launched a joint project on **Integrated Breeding for Sugarcane to Improve Sugar Production**. The project employed omics technologies - genomics, transcriptomics, proteomics and bioinformatics - in a sugarcane breeding program to increase yield and sugar level by identifying genes responsible for

sugar content and yield and developing molecular markers associated with sugar content. Primers specific for DNA markers in sugar metabolism genes have been developed and their application in selecting sugarcane variety with high sugar content has been patented. Based on the technology, nine high potential varieties have been created, two of which - **Phu Khiao 2** and **Phu Khiao 3** - have been certified as new sugarcane varieties. The new varieties were planted in an 88-ha land in 2020. The planting area will be increased to 880 ha in 2021.

In sugar processing, the presence of dextran in cane juice is undesirable as it reduces product yield. It is estimated that the presence of 1,000 ppm of dextran in cane juice can cause a 1.123-kg sugar loss per ton sugarcane. NANOTEC-NSTDA has developed a **dextran test kit** based on a competitive immunoassay technique. The test kit has a cutoff level of 1,000 ppm/brix and over 90% sensitivity, specificity and accuracy. Dextran test kits have been manufactured and supplied to sugar mills for the management of the sugar production process since 2012, resulting in an estimated 100 million THB economic impact/year.



Purity Test for Seed Industry

Thailand's export value of seeds is around 5 billion THB. The favorable factors making Thailand an attractive hub for seed production are suitable geography and weather, skilled farmers and

infrastructure. Seed purity is one of the quality standards in the trading and provides a basis for price determination. Conventionally, a grow out test is used to determine the purity of given seed



lots. In the grow out test, seed samples are grown up to maturity to assess their characteristics. This method is laborious, time-consuming and may not give accurate results.

Developed by the National Omics Center of NSTDA, **HybridSure** is a quick and accurate

DNA-based purity test for a variety of F1 hybrid seeds. It offers a more accurate alternative, as high as 99% accuracy, than the grow out test because customized single nucleotide polymorphism (SNP) markers are used which can differentiate closely related cultivars. The test takes less than 1 day from DNA extraction to the analysis, as opposed to the grow out test which requires 3-6 months. In addition, the National Omics Center holds the largest DNA marker database in Southeast Asia, thus ensuring that this test has a vast varietal coverage of vegetables, fruits and flowers in this region.

HybridSure won the Best Pitch Award of the 2019 Leaders in Innovation Fellowships 2019 Programme organized by the Royal Academy of Engineering of United Kingdom through the Newton Fund and the Most Fundable Innovation Award at the Asia Innovates Summit 2019.

Sustainable Aquaculture System



A closed aquaculture system used in aquaria and for fish production is normally equipped with nitrification biofilter, which serves the purpose of converting highly toxic ammonia to nitrate. However, high concentration of nitrate causes stresses and affects reproduction of aquaculture, and thus the system still requires water exchange from time to time. BIOTEC research team has developed a **Tubular Denitrification Reactor (TDNR)** for nitrate removal. With TDNR, the system can completely remove nitrogen compounds – in the forms of ammonia, nitrite and nitrate, enabling a biosecurity condition for broodstock culture and production of specific-pathogen-free aquaculture and saving on operating cost and labor through prolonging water exchange. TDNR has been licensed to multiple companies for various applications, ranging from aquaria to intensive fish breeding tanks and feed-trial tanks.

The research team also developed a **recirculating aquaculture system (RAS)** prototype. The 10,000L-tank prototype can accommodate 35-40 kg/cu.m. fish density and requires no water exchange throughout the growing period of tilapia and sea bass, thus minimizing the infection risk and the change in water quality conditions. The survival rate was found to be in the range of 90-100%. The team further collaborated with Premier Products Public Company Limited and Farm Story Company Limited in creating **RAS for high-density tilapia farming**. The system is designed to save energy by using gravity flow, reduces water consumption by 95% and requires 20-30 times less space than an earthen pond system. Solid waste, dead fish and sick fish are automatically removed from the tank, allowing owners to monitor mortality rate and quarantine sick fish for diagnosis and disease management and planning.

RAS is a sustainable aquaculture system as it is eco-friendly and water efficient and does not cause adverse environmental impacts.

Innovative Technology for Thai Shrimp Industry



In 2003, a project to produce specific-pathogen-free (SPF) shrimp broodstock was initiated at BIOTEC-NSTDA when the center, in collaboration with Mahidol University, Prince of Songkla University and the Royal Thai Navy, established **Shrimp Genetic Improvement Center** serving as a production facility for the selective breeding of the black tiger shrimp *Penaeus monodon*. The facility supports research in shrimp genetic improvement and multiplication of SPF shrimp broodstock for shrimp hatcheries and subsequently for distribution to shrimp farmers. In 2005, **Aquaculture Service Development Research Team** was founded at BIOTEC to provide research, technical and consultancy services to support the farming of shrimp and other aquatic species.

The challenges in developing aquaculture feed include bioavailability, nutrient absorbability, stability of enzymes and hormones in feed as well as the EU policy to reduce the use of fishmeal as an ingredient in animal feed. NANOTEC-NSTDA has developed **fishmeal-free shrimp feed hydrogel**. The

innovative shrimp feed utilizes hydrogel technology as a delivery system for protein and active ingredients, thus improving their bioavailability and absorbability. Soybean meal is used as a protein source, instead of fishmeal. This product exhibits similar level of survival and growth rates to commercial feeds, while requires 20% less amount. The technology has been transferred to a company for commercial production.



On the disease control and management front, BIOTEC-NSTDA has developed an **EMS detection kit Amp-Gold**. Amp-Gold employs loop-mediated isothermal amplification (LAMP) technique in combination with a DNA-labelled gold nanoparticle probe for visual detection of *Vibrio parahaemolyticus*, a causative agent of acute hepatopancreatic necrosis disease (AHPND) which is a component cause of early mortality syndrome (EMS) in shrimp. This device is 100 times more sensitive than the PCR technique and takes less than one hour to give results. Amp-Gold was honored with the 2017 Invention Award in Agricultural Science and Biology presented by the National Research Council of Thailand.



Smart Farming Technology



One of Thailand 4.0 objectives is to modernize Thai agricultural sector by embracing smart farming. ICT is a powerful technology that enables efficient, rapid and convenient farm management, overcoming limitations in labor, land and market access. NECTEC-NSTDA has developed a range of smart farming technologies under the banner “NECTEC FAARM series: Technology for Agricultural Industry”.

HandySense is a tool for precision farming. The system employs sensor technology and internet of things (IoT) to measure and control the environmental conditions – temperature, moisture, and light intensity, for instance - and inputs – such as water, fertilizer and pest control - to promote plant growth. Users can monitor and control growing parameters from a computer and a mobile device for actions and planning of agricultural activities. Historical data is retrievable for

monitoring and forecasting purposes. HandySense can improve quality and quantity of farm products by 20% and reduce labor requirement by 52%. The system has been used in a vegetable garden and a melon orchard in Chachoengsao province and will be promoted among farmers and growers in the Eastern Economic Corridor.

Aqua Grow is a smart water quality control and monitoring system for aquaculture. The system consists of three main technologies: a water management system, a chemical reader and a bacteria growth monitoring system. Aqua Grow can also perform data analysis on water conditions, and then notify users with suggestions if water quality is at risk. Users can monitor data via a smartphone.

Aqua-IoT is a project launched by NECTEC to promote IoT-based aquaculture monitoring, control and warning system among shrimp and fish farmers. This project has been implemented in eastern Thailand.



Precision Agriculture with Plant Factory

NSTDA initiated a project to establish **Plant Factory with Artificial Light** (PFAL) at Thailand Science Park to support research on the production of high-value crops such as herbal plants. Plant Factory is a closed facility utilizing artificial control of light, temperature, moisture, and carbon dioxide concentration to achieve constant production and uniformity of crops without the use of pesticide. Plant productivity and content of active ingredients can be enhanced by providing optimal conditions for plant growth.

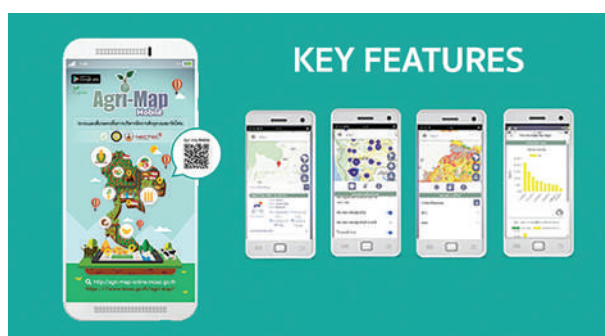




Open in 2019, NSTDA PFAL was built with the most advanced technologies and Prof. Toyoki Kozai, a

plant factory pioneer, serving a project advisor. With 1,200 sq.m. space, the facility has an R&D zone and a production-scale zone. R&D focuses on finding the optimal conditions for growing herbal plants, whereas the production zone is designed for plant production trial based on optimal conditions derived from R&D work. In addition, BIOTEC-NSTDA also built a plant factory system in Nakhon Phanom province with an aim to improve the quality and productivity of herbal plants supplied to Renunakhon Hospital, a major hospital in Nakhon Phanom that manufactures traditional medicines for the hospital and health centers in the province.

Digital Platform for Efficient Agricultural Management



Developed by NECTEC-NSTDA, **What2Grow** employs big data analytics to enhance agricultural land use efficiency. The system integrates information on geographical map, crop production, crop productivity, soil condition, irrigation system, economic data on prices, buyers, supplies and demands and creates mathematical models for efficient management of agricultural land, resource and production. What2Grow can provide suggestions to individual farmers on alternative crops and activity planning based on information on agricultural land of individual farmer as well as price and weather forecast. Such feature can help farmers make more profits and reduce government spending on farm subsidy.

In 2015, What2Grow was integrated to Agri-Map, the Thai government's initiative to integrate agricultural data for agricultural zoning and management. Under the collaboration with the Ministry of Agriculture and Cooperatives, a web-



based tool called **Agri-Map Online** and a mobile application were launched, providing an easy access to information for agricultural management.

FAARMis is an application designed to support farmer and field registration. The system allows officers of the Agriculture and Cooperatives Ministry to use tablet devices to collect and record data about farmers, their fields, and plants or crops grown. The data is then transferred from the tablet to the server. By linking to databases of other government agencies and satellite data, inspectors can conveniently verify farmers' personal information, field location, land ownership to expedite the farmer registration process.

Biocontrol Products for Sustainable Agriculture



Biocontrol is a pest management strategy by introducing natural enemies of target pests. It is an environmentally friendly alternative to pesticides, and a healthy choice for farmers and consumers. BIOTEC-NSTDA has engaged in biocontrol research and developed a range of products.

Three **nuclear polyhedrosis virus (NPV)** products have been developed and are commercially

available for controlling each of these pests: beet armyworm (*Spodoptera exigua*), cotton bollworm (*Helicoverpa armigera*) and tobacco cutworm (*Spodoptera litura*). ***Beauveria bassiana*** is a fungus that infects a wide variety of insects in all stages, thus making an excellent biocontrol agent. BIOTEC research team has developed a low-cost technique to maximize spore production of *B. bassiana*. The technology has been transferred to government agencies, farmers and industry.

VipPro is a recent biocontrol product developed by BIOTEC. The product contains Vip3A, a group of vegetative insecticidal proteins produced during vegetative growth phase and secreted into the culture media by some strains of *Bacillus thuringiensis* (Bt). VipPro is derived from an extensive study of Vip3A exhibiting toxicity against *S. exigua* and *S. litura* from over 500 Thai Bt isolates. The product is fast-acting and works well against insects resistant to pesticides and insecticidal crystal proteins. VipPro has a synergistic effect when used in combination with NPV, *B. bassiana* and Cry toxins.

Feed Solution to Enhance Egg Quality



Quality of eggs depends on the poultry rearing system, including feed. NANOTEC-NSTDA, in collaboration with Grenades Biotech Company Limited (previously known as KLEAN Greentech

Company Limited), has developed a poultry feed supplement for enhancing egg quality called **Designer-8**. The supplement contains oregano and basil oils. Oregano oil is an effective natural antimicrobial and antioxidant agent, whereas basil oil can effectively prevent poultry coccidiosis. As avian digestive system is comparatively short, nutrients are not efficiently absorbed. Self-emulsifying drug delivery system (SEDDS) is employed to improve solubility and bioavailability of oregano and basil oils. Designer-8 offers better egg quality and reduces the use of antibiotics.

Designer-8 was named the winner of 2016 National Innovation Awards presented by the National Innovation Agency.

Breathable Packaging Film



Quality and freshness of fruits and vegetables deteriorate over time after they are harvested. Retailers and consumers are looking for ways to prolong their quality and freshness for as long as possible. In 2001, MTEC-NSTDA embarked on a collaboration with Kasetsart University to develop packaging film for preserving the quality of fresh fruits and vegetables. The team successfully created **ActivePAK™** film based on Equilibrium Modified Atmosphere (EMA) technology. It can keep fruits and vegetables fresh for 2-5 times longer, while maintaining the quality and taste of the produce. In addition, the film is clear and



anti-fog, and therefore enhances the appearance of the products. ActivePAK™ film has been used in multiple modern trade outlets in Thailand, including Tops Supermarket and Tesco Lotus. In collaboration with the Royal Project Foundation, the research team further developed **ActivePAK™ Ultra** designed for produce with a high respiration rate such as asparagus and mushroom that spoil rather quickly after harvesting. ActivePAK™ Ultra can maintain the freshness of mushroom for 9 days at 4-8 °C, as opposed to 3 days.

Starter Culture Technology for Traditional Fermented Pork Sausage

The production of Thai fermented sausage, or Nham, traditionally involves different microorganisms naturally present in the ingredients and the environment. This process poses difficulty in quality and flavor control, as well as runs the risk of food-borne pathogens. BIOTEC-NSTDA isolated microbes associated with Thai fermented sausage. Studies were performed on each microbe to understand their contribution to flavor profile and texture. From the extensive studies, the research team designed three formulas of **starter culture for Nham production**, each containing different mix of microbial species for different fermentation conditions. The technology of Nham starter culture has been licensed to Talent Company Limited for manufacturing and supplying starter culture to Nham manufacturers. Six petty patents have been applied.



Starter culture technology was among the first topics of food biotechnology research at BIOTEC-NSTDA. The study has paved the way for other applications of biotechnology to enhance the competitiveness of Thai food industry.

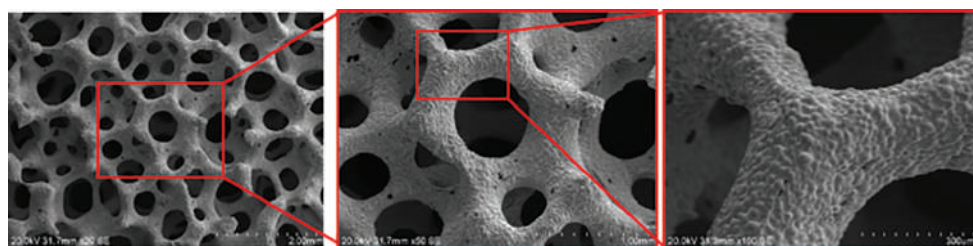
MATERIALS, ENERGY AND ENVIRONMENT

R&D in materials, energy and environment at NSTDA covers a vast scope. Materials research involves the creation of new materials – from both natural resources and synthesis - and materials with novel functionalities or performance improvements, as well as material fabrication. Energy and environment research aim to address sustainable energy from renewable sources and conventional energy with topics include energy storage, diesel hydrotreating process to improve diesel quality for higher blending ratio, solar energy and biogas.

Fabricating Metal Foams for Industry

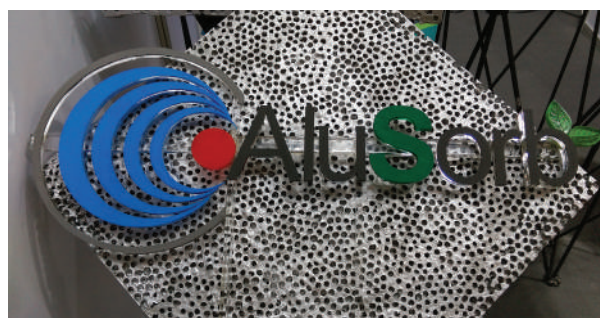
A metal foam is a cellular structure made up of a solid metal with 75-95% of gas-filled pores by weight. Due to its properties which include lightweight, high strength, good thermal conductivity and good sound absorption, metal foams are used in various applications. MTEC-NSTDA, in collaboration with Taisei Kogyo (Thailand) Company Limited, has developed **the fabrication of open-cell titanium foam using slurry impregnated polymeric foam**. With high

surface area, high compressibility and corrosion resistance, this titanium foam has numerous applications such as high temperature filter materials, electrochemical electrode materials and biocompatible implant materials. The invention received the 2016 NRCT Research Award and was applied for a patent. Titanium foam based on this invention is commercially manufactured by Taisei Kogyo (Thailand).



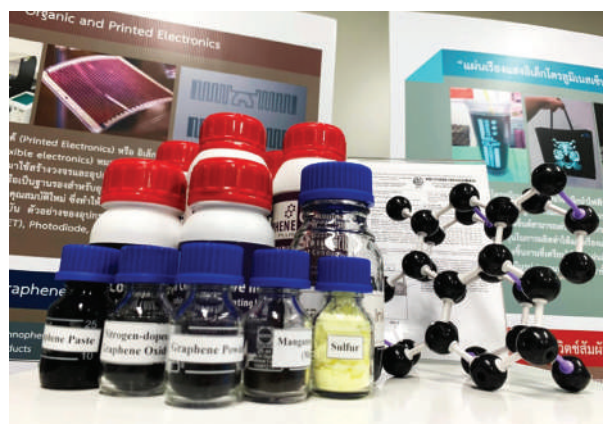
In addition, MTEC research team has developed a **new low-cost process for producing an aluminium foam with required structures**. In this process, template balls are used to create cavities in aluminium foam during the production. Also developed by the research team, the template balls are made with low-cost materials, have high temperature resistance and good water solubility and can be shaped into various spherical sizes using available pellet machines. Arrangement of template balls with desirable sizes also allows structure of aluminium foam to be tailor-made, which is impossible by other production processes. As a sound-absorbing, fire resistant, eco-friendly

material, aluminium foam is an excellent soundproof material for construction industry. This technology has been licensed to a company for commercial production.



Graphene: Material of the Future

Graphene is a single layer of carbon atoms arranged in a two-dimensional hexagonal lattice. It is stronger than steel and the best conductor of heat and electricity. With remarkable properties, graphene holds great promise for various applications. In 2010, NECTEC research team was the first in the world to **synthesize graphene polymer conductive ink by using the electrolytic exfoliation method**. The technology was licensed to a company for commercial production of conductive inks which are used for printed electronics and as a component in RFID, OLED, intelligent packaging, battery cells and sensors. Following this success, NSTDA founded **Thailand Organic & Printed Electronics Innovation Center (TOPIC)** to facilitate a network of public and private sectors in the area of research and application of graphene. Subsequently, **Haydale Graphene Industries**, a UK-based company specializing in graphene technology, established Haydale Technologies (Thailand), its first graphene



research center in the Asian region, at Thailand Science Park.

TOPIC is now part of the National Security and Dual-Use Technology Center (NSD), one of NSTDA focus centers. The research team continues to find innovative applications of graphene in sensors and supercapacitors.

Improving Material Functionalities with Nanocoating

Research team at NANOTEC-NSTDA has developed **nanocoating technology for parabolic troughs**. A parabolic trough is a type of solar thermal collector used in the concentrated solar power (CPS) plant. Graphene-silica heat absorber was developed for parabolic trough solar concentrator. This graphene-silica coating adheres well to steel surface and costs 70% less than the traditional physical vapor deposition coating. This technology has been transferred to ATE Company Limited, a solar thermal energy solution provider in Thailand.



Another notable application of nanocoating is in the construction industry. A silica-based nanocoating with waterproof, dustproof, anti-fungal and anti-algal properties was created for **preserving cultural heritage buildings**. The coating was developed based on extensive study of chemical and physical properties of surfaces of Buddhist religious structures. The coating was tested with several religious buildings and demonstrated an ability to protect the building surface against fungal and algal growth due to humidity and prevent cracks. In addition to preserving national treasures, this technology also saves maintenance cost.



The Future of Mobility

Mobility and logistics are among ten technology development groups (TDGs) on which NSTDA concentrates its R&D effort, embracing the trend towards clean, safe and sustainable transport systems. The agency has been collaborating with industrial partners to strengthen the transport industry. A prime example is NSTDA-Choknamchai Group partnership focusing on joint research and development of next generation vehicles, including parts, frames and components, as well as innovative technology for die making, designing and manufacturing of lightweight frame. Choknamchai Group or CNC Group is the largest automotive dies and parts maker in Thailand.

By combining the expertise of each side – CNC Group specializing in die making and high-strength aluminum forming, and MTEC-NSTDA and the Design and Engineering Consulting Service Center of NSTDA in computer-aided design and strength analysis with the finite element method, the collaboration has enabled Sakun C Innovation



Company Limited, a member of CNC Group, to become the first Thai manufacturer of aluminum-body vehicles - bus and boat. The vehicles resulted from the research collaboration include an **aluminum bus “C Bus by Sakun.C”** and a **20-meter electric aluminum boat** built with seamless boat assembly technology and powered by a 500-kW motor. In addition, a **prototype electric aluminum bus** has been developed for Bangkok Mass Transit Authority (BMTA). The prototype bus was made with high-strength aluminum alloy which is four times stronger than steel but two times lighter.



Enabling B10 Biodiesel Commercialization

An innovative **H-FAME technology** has been developed by the Thailand-Japan research consortium of which MTEC-NSTDA is a member. H-Fame is a process of partial hydrogenation, feeding hydrogen to react with conventional biodiesel at low pressure, resulting in significantly upgraded biodiesel quality and enabling a higher blending ratio of biodiesel.

In 2018, MTEC-NSTDA and the Department of Alternative Energy Development and Efficiency (DEDE) launched a collaborative project aiming to



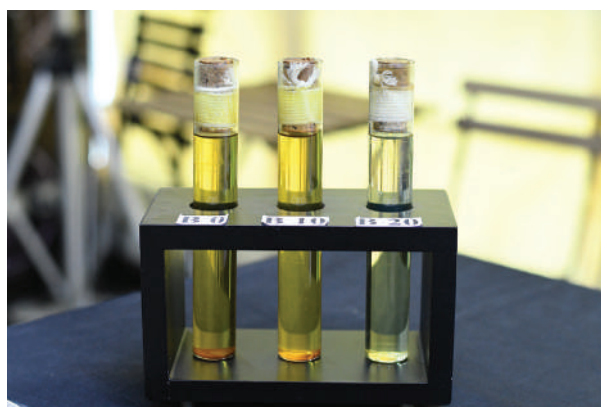
increase the consumption of biodiesel in Thailand by enabling the commercial production of B10 biodiesel with H-FAME technology and testing its performance to build consumer confidence. Under this project, H-FAME technology has been transferred to Bangchak Biofuel Company Limited (BBF) and Global Green Chemicals PCL (GGC) and more than 10,000 L of high-quality biodiesel were produced for testing. The quality of biodiesel was tested and met the standard of Thailand's Department of Energy Business and Japan Automobile Manufacturers Association (JAMA). B10 biodiesel produced from this high-quality biodiesel was used in the on-road test of 8 pickup trucks at 100,000 km each and 150 government vehicles under the collaboration with the Royal Thai Naval Dockyard, Kasetsart University,



Rajamangala University of Technology Thanyaburi and NSTDA.

The project was a success, demonstrating the high quality of biodiesel produced from H-FAME technology by local commercial producers and the safe B10 usage. In 2020, the Notification of the Department of Energy Business was released on the Specification for Appearance and Quality Biodiesel Oil, making B10 the standard biodiesel blend available at gas stations across the country and providing the list of compatible car models.

NSTDA research team is currently working on high blend biodiesel, B10 and B20, with high-quality diesel and cleaner vehicle emission to comply with the Euro 5 standard.



Turning Wastewater into Biogas

For decades, BIOTEC-NSTDA and King Mongkut's University of Technology Thonburi have been engaging in research and development of biogas production technology. In 2004, the research team started to implement an **anaerobic fixed-film reactor wastewater treatment system** in the agro-food industry, including manufacturers of cassava starch, palm oil and canned fruit.

The cassava starch processing industry generates a large volume of wastewater and consumes considerable amount of energy. A cassava starch factory with a 200-ton daily production capacity typically produces around 4,000 cu.m./day of wastewater that is normally treated through a series of open ponds causing odor problem to the surrounding area. The energy cost usually runs

around 1,000 THB/ton starch. In this anaerobic fixed-film reactor wastewater treatment system, microbes are immobilized on the medium surface so that they can be retained within the reactor to provide process stability. This system has demonstrated high efficiency in wastewater treatment, up to 80-90% organic removal, and requires much less space than a conventional open pond wastewater treatment system. More importantly, it produces biogas - an energy source - for the factory.

The anaerobic fixed-film reactor wastewater treatment system has already been installed in a number of factories including starch factories (Cholcharoen, Chaiphaphum Plant Products, Northeastern Starch (1987) and Sima Inter

Product), Thachana Palm Oil factory and dry fruit / canned fruit factories (See Ong Hong Enterprise and Ruam Arharn).



This technology was transferred to Nigeria to convert abattoir waste to energy under the “Cows to Kilowatts” project. Cows to Kilowatts project was one of five SEED Award winners in 2005.



Smart Enzyme for Textile Industry

Textile is considered one of the industries with large chemical inputs. Chemicals are used in virtually every process in textile production, in particular the desizing and scouring processes that use very acidic or alkaline chemicals such as hydrogen peroxide and caustic soda. Moreover, desizing and scouring require different operating conditions and therefore are performed in two separate steps.

Researchers from BIOTEC and MTEC, in collaboration with Thanapaissai textile factory, have developed **ENZease**, a duo-activity enzyme for one-step biodesizing and bioscouring process. Produced by fermentation of agricultural wastes using selected microorganisms from Thailand Bioresource Research Center (TBRC), ENZease is a “smart enzyme”, consisting of amylase and pectinase activities which are capable of working in the same pH and temperature ranges, thus enabling a one-step biodesizing and bioscouring process. ENZease is able to lower chemical consumption, minimize step in the process, shorten treatment



time, and thus reduces operating cost and space, making the large-scale operation simpler and more cost effective.

The technology has been licensed to Asia Star Trade Company Limited, a company specializing in industrial-scale enzyme production, for the production and commercialization. The technology has also been transferred to community enterprises and SMEs engaging in the traditional textile production.

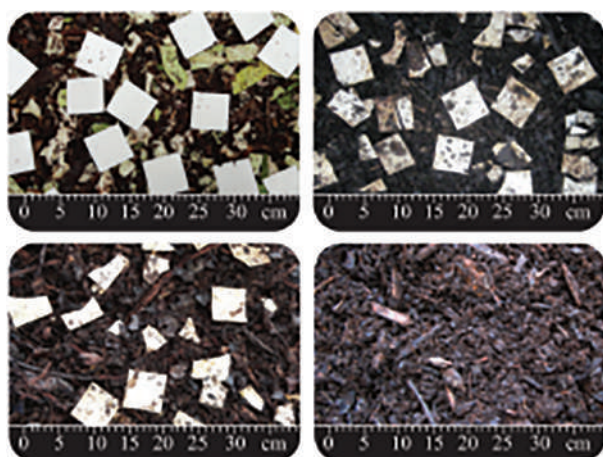
Biodegradation Testing Laboratory

Due to growing demand for eco-friendly products, MTEC-NSTDA established **Biodegradation Testing Laboratory** to offer comprehensive testing services, including biodegradability, compostability and ecotoxicity testing, enabling Thai bioplastics

industry to deliver products that meet the quality requirements. Reports provided by the laboratory can be used to apply for certifications and internationally recognized certification marks.

Biodegradability tests can be performed under various conditions, including actual settings, aerobic (compost, soil, marine) or anaerobic (landfill) conditions. Material shelf-life and service life testing is offered to a wide range of materials including plastic, rubber and paper. Material degradation is evaluated by accelerated weathering methods including UV Exposure and Xenon Arc. Ecotoxicity testing assesses the impacts of test samples on the environment and their effects on plants and animals.

Biodegradation Testing Laboratory obtained an ISO 17025 certification from DIN CERTCO to perform compostable materials testing.



RakNam: A Prediction and Scenario-based System for Saltwater Intrusion

Developed by NECTEC-NSTDA, **RakNam** is a system for saltwater intrusion forecasting and scenario-based planning. It is a decision-support system, enabling the Metropolitan Waterworks Authority (MWA) to make critical decisions on the timing of the availability of freshwater in the Chao Phraya River.

RakNam consists of three components:

- *Monitoring.* Providing a single window for saltwater intrusion related data including water quality parameters, rainfalls, discharges and tides.
- *Forecast.* Giving high-fidelity seven-day salinity and tides forecasts with daily update.
- *Scenario.* Supporting an evaluation of alternative strategies for effectiveness in saltwater intrusion management.



RakNam has been applied for a patent and licensed to MWA for 7 years from 18 June 2019 to 29 September 2026. NECTEC research team is currently working on adding an *Optimize* component to identify the best practices for tackling saltwater intrusion issue with all concerns taken into account.

HEALTH AND MEDICINE

NSTDA R&D in health and medicine covers the areas of disease diagnostics and treatment encompassing vaccines, medicines and biopharmaceuticals, medical devices and cosmeceuticals. The work in the area of medical devices involves biomedical signal processing devices, rehabilitation technology, accessible and assistive technology in order to improve the quality of life, particularly of the elderly, people with disabilities, the disadvantaged and vulnerable group, whereas cosmeceutical research aims to enhance the capacity of cosmeceutical industry throughout the value chain.

P218: New Antimalarial Drug Candidate

Malaria is one of the most important infectious diseases with over 200 million cases worldwide, resulting in an estimated 600,000 deaths annually. An important problem of malaria treatment is the rise of parasites' resistance to currently available antimalarial drugs. There is an urgent need to develop new drugs that effectively kill drug resistant parasites.

For over two decades, a research team at BIOTEC-NSTDA led by Prof. Dr. Yongyuth Yuthavong has been conducting research on novel antimalarial drugs. A breakthrough was made in 2003 when the team obtained the crystal structure of a primary malarial drug target dihydrofolate reductase-thymidylate synthase (DHFR-TS), providing a new approach for the antimalarial drug design. The discovery led to the development of new antimalarial drug candidate "**P218**" that effectively kills both sensitive and resistant parasites. P218 is the first antimalarial drug candidate designed and synthesized by Thai research team. In 2014, a partnership between NSTDA and the Medicines for Malaria Venture (MMV), a non-profit organization promoting public-private collaborations in malaria drug R&D, was formed to engage in P218 preclinical evaluation. Preclinical assessment results showed satisfactory safety profiles across a panel of required toxicology package in both in vitro and animal models (rodent and dog models) to demonstrate feasibility for first-in-human (FIH) study.



The research team further characterized serine hydroxymethyltransferase (SHMT) and identified it as another target for antimalarial drug development. Under collaboration with local and international partners, SHMT inhibitory effect of pyrazolopyran compounds was discovered. BIOTEC research team continues to exploit this knowledge to develop new antimalarial drug candidates.

Accomplishments in drug development research at BIOTEC can be attributed to collaboration with local and international partners, including Mahidol University, Burapha University, Chulalongkorn University, the University of Michigan-Ann Arbor (USA), California Institute for Biomedical Research (USA), BASF (Germany), Swiss Tropical and Public Health Institute (Switzerland), ETH Zurich (Switzerland), GlaxoSmithKline (Spain), Monash Institute of Pharmaceutical Sciences (Australia) and the National Synchrotron Radiation Research Center (Taiwan).

DentiiScan: Thai-made Dental Scanner



DentiiScan is the first cone-beam computed tomography (CBCT) scanner for dental and maxillofacial imaging developed and manufactured in Thailand. It provides 3D internal anatomy images of dental and maxillofacial structures, without distortion and superposition of anatomic structures. The machine supports medical procedures such as dental implant, wisdom tooth extraction, oral and maxillofacial surgery as well as sinus abnormality assessment.



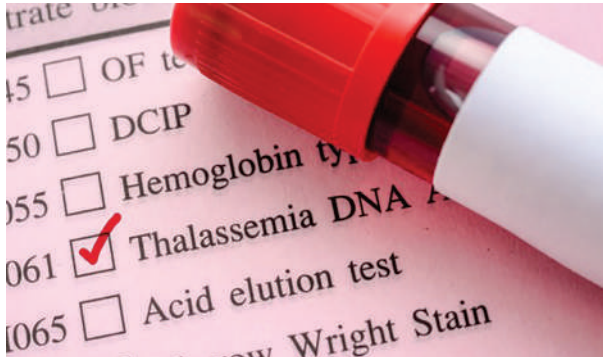
The development of DentiiScan was initiated by Prof. Dr. Pairash Thajchayapong. He assembled researchers from NECTEC and MTEC. NECTEC team, under the leadership of Dr. Saowapak Thongvigitmanee, is in charge of software development, whereas MTEC team, led by Dr. Kritkrai Sitthisereepratheeep, is responsible for hardware development.

The first version DentiiScan 1.0 was successfully created in the laboratory on 8 August 2008. With continuous development, new versions - DentiiScan 1.1 and DentiiScan 2.0 - were successively introduced.

The latest version DentiiScan 2.0 - developed under the Assistive Technology and Medical Devices Center, a new focus center of NSTDA - takes 18 seconds to complete a 360-degree rotation to provide a high-quality 3D image that enables accurate diagnosis and safe treatment planning. It has been tested for the radiation safety and the electrical and electronic product safety according to international standards. Funding was obtained from the National Research Council of Thailand (NRCT) and Thailand Center of Excellence for Life Sciences (TCELS), enabling the manufacturing of DentiiScan 2.0 machines for distribution to six hospitals. Ministry of Higher Education, Science, Research and Innovation (MHESI) granted funding from the Big Rock Project to NSTDA to support the production of DentiiScan 2.0 for 50 hospitals across the country, along with the training of dentists and technicians on how to use the machine.



Alpha Thalassemia Detection Test



Thalassemia is an inherited blood disorder that causes anemia and other health problems. The disease is caused by mutations in genes that regulate the production of hemoglobin. Though only one per cent of the Thai population are affected with thalassemic diseases, about 40% of the population are carriers of the abnormal gene.

PCR technique is commonly used to detect thalassemia carrier, but the technique has some limitations for the need of expensive equipment and well-trained technicians. A research team at Biomedical Technology Research Center, a joint

lab between BIOTEC-NSTDA and Chiang Mai University, developed an **immunochromatographic strip test to detect hemoglobin Bart's in red blood cell hemolysates**, which is usually present in a small amount in red blood cells of the carriers of alpha thalassemia 1. The technique is easy to perform, inexpensive, quick and requires no equipment.

This technology has been licensed to i+MED Laboratories Company Limited and the product is available under the trade name "i+LAB α THAL".



μ Therm FaceSense: Multi-people Temperature Screening System

μ Therm FaceSense is an intelligent thermal scanning system utilizing IoT computing and data storage. It is equipped with an automatic face detection and can process multiple people at the same time. The system takes the temperature through a facial scan from a maximum distance of 1.5 meters in 0.1 seconds. The temperature reading is displayed on the screen and if it exceeds the pre-specified threshold, the display will change color and an alarm will be triggered.

μ Therm FaceSense complies with IEC60950-1 requirement (safety standard for information technology equipment) and CISPR 22 requirement (electromagnetic compatibility standard) as tested by the Electrical and Electronic Products Testing Center (PTEC) and has a calibration certificate for temperature issued by the National Institute of Metrology.

As body temperature is one of the key signs of COVID-19 infection, this system is an effective tool to screen people before being allowed to enter an establishment. Forty units of μ Therm FaceSense have been manufactured and distributed to multiple organizations to provide safeguard against COVID-19.



Assistive Technologies for the Elderly and Disabled

Aging population is one of the global megatrends as every country is experiencing growth in the number of older people in their populations. As a response to this megatrend, NSTDA has been engaging in the development of innovative solutions for the elderly, patients as well as the disabled. A number of solutions have been created. **MONICA** is a brain training mobile application designed to enhance the memory and concentration among seniors. The app is available for free download. **BEN** is a bedside step stool for seniors. **3D Sole** is a personalized insole made with 3D printing technology for flat feet.

Joey-Active Bed is a mechanical bed that supports bodily movement for the elderly and patients. Developed by MTEC-NSTDA using human-centric approach, Joey-Active Bed addresses basic needs - such as bodily movement, safety and ergonomics -

of the elderly, bedridden patients, and convalescent patients. The bed has an adjustable backrest, and the mattress can be rotated up to 90 degrees which is a proper position for standing and sitting beside the bed. The technology has been licensed to SB Design Square Company Limited that introduces the bed to market as “Power Lift Bed”.

M-Wheel is an electronic device that turns a normal wheelchair into a motorized wheelchair at an affordable cost. The device consists of three parts: a power unit, a control unit and a power source unit. Fully charged battery lasts for 4 hours and can achieve a range of 20 km. M-Wheel is easy to install and control even on slopes. It supports up to 80-kg weight. The device complies with the standard for electromagnetic compatibility of medical devices and passes the risk assessment of medical devices.



Nanoscale Delivery Systems: Key to Nutraceuticals and Cosmeceuticals

Thailand is blessed with diverse biological resources, including medicinal plants, agricultural products and by-products from agro industry. The value of these biological resources can be multiplied by turning their bioactive ingredients into nutraceutical and cosmeceutical products. At NANOTEC-NSTDA, researchers design and synthesize nanoscale delivery platforms with improved multi-performance characteristics and pharmaceutical actions using a combination of various strategies. The expertise expands to green extraction and purification techniques to acquire new substances from natural products, as well as systemic biological activity screening to identify their potential applications. The technology has been employed to develop a



range of products from medicinal plants, agricultural products and by-products from agro industry.

Perilla is a native plant in northern Thailand. Its seed oil is rich in polyunsaturated fatty acids that can lower cholesterol and sesamol exhibiting anti-cancer and anti-aging properties. To improve solubility and absorptivity of perilla seed oil, NANOTEC research team developed a self-emulsifying drug delivery system. The oil is then encased in soft capsules as a finished product – **perilla seed oil capsule**.



Policosanol - an extract derived from sugarcane wax- has been reported to have an ability to lower cholesterol. NANOTEC research team developed an extraction and purification of policosanol from sugar mill waste and employed nanostructured lipid carriers (NLC) as an effective delivery system for policosanol ready for applications in functional food and nutraceutical industry.



Research on an encapsulation of *Centella asiatica* and mangosteen pericarp extracts, and clove oil has led to the development of an **acne treatment gel**. Extracts of *Centella asiatica* and mangosteen pericarp and clove oil are known to have an

anti-inflammatory property, including inhibitory effects against *Staphylococcus aureus* causing skin infection and *Propionibacterium acnes* responsible for acne. The encapsulation technique has been applied for a petty patent and ready for technology transfer.



Sericin- a protein derived from silkworm - is widely used in cosmeceuticals due to its antioxidant, antityrosinase and antielastase properties, as well as moisturizing ability. NANOTEC research team fabricated sericin-loaded liposomes to enable effective controlled release and improve sericin stability and activity. The technique was applied to formulate a **sericin face serum**. Available for licensing, this technology is beneficial not only to cosmetic industry, but also to sericulture community enterprises.

Another invention is a **herbal haircare product containing *Litsea glutinosa* and *Centella asiatica* extracts**. Extract of *Litsea glutinosa* leaves has an ability to promote hair growth, whereas extract of *Centella asiatica* leaves has an anti-inflammatory property. Liponiosome was developed as an effective delivery system for these extracts.



Food Structure Design for Creation of Alternative Food Products

The market for healthy and nutritious food products has been steadily growing, as more and more consumers look for food products that are nutritious, non-allergenic, fiber-rich, high-protein, and low-fat, and may contain micronutrients and bioactive compounds. However, healthy food is normally inferior in taste, texture, and stability compared to conventional food.

At MTEC-NSTDA, researchers employ food structure design to create and control food texture, shape, aroma, and taste, thus making healthy food palatable and comparable to those of the conventional food, resulting in the development of healthy food and food products for special groups such as the elderly and patients.

A **thickening agent for people with dysphagia** was developed by MTEC under a commissioned research project for a company. People suffering from dysphagia have difficulty in swallowing and end up aspirating. Thickening agent is added to water and beverage so that people with dysphagia can drink them safely without aspiration.



Seniors as well as people wearing braces or with orthodontic problems usually avoid eating meat due to its toughness. With food structure design and texturing agent, MTEC created an **easy-to-chew meat**. The meat is more tender while maintaining the meaty texture.

A **low-fat sausage** is another creation of MTEC gearing towards health-conscious consumers. This product contains less than 4% fat, whereas conventional sausages usually contain 20-25% fat. This is achieved through the replacement of animal



fat with a mixture of fat replacer, plant fiber and rheology modifier. Despite containing low calories, this sausage is full of flavor and has great texture, comparable to the full-fat version. The technology has been transferred to Betagro Group and the product is already available in the market.

The gluten-free diet has gained popularity in recent years. This trend prompts companies to introduce gluten-free products to the market and KCG Corporation is one of those companies. The company worked with MTEC to develop **gluten-free sandwich bread and croissants** by using rice flour as the main ingredient, instead of wheat flour that contains gluten. The baked goods also contain natural starch, modified starch, and food hydrocolloid which makes bread and croissant rise, resulting in good texture in finished products.

A **plant-based chicken meat** has been developed as alternative protein for people living healthy and eco-friendly lifestyle. The soy-based chicken meat has a similar texture to chicken. It contains 10-16% protein, 6-10% dietary fiber and 6-9% plant fat by weight. Unlike chicken, plant-based chicken is completely free from cholesterol and growth hormone residue.



DIGITAL TECHNOLOGY

NSTDA's contribution to digital technology in Thailand can be traced back to the early day of NSTDA when NECTEC, one of NSTDA research center, initiated SchoolNet Thailand project aiming to provide internet access to schools throughout Thailand, and later expanded to other groups such as the disabled and inmates under the initiative of HRH Princess Maha Chakri Sirindhorn. Over the past three decades, the capabilities have been built in the areas of natural language processing, microelectronics, sensors and internet of things (IoT), enabling the development of various digital platforms serving a vast array of industries.

Princess's IT Project: Expanding IT Access and Impacts



HRH Princess Maha Chakri Sirindhorn always shows great interest in the information technology and its benefit to the national development. In 1996, NECTEC -NSTDA in collaboration with the Thai Federation of ICT Technology Association and a group of experts founded the **Information Technology Project under the Initiative of Her Royal Highness Princess Maha Chakri Sirindhorn**. In its capacity as the project's secretariat, NECTEC has implemented activities in six areas:

- **IT for Education.** To improve access to quality education among students in rural areas, the project procures computers and provides IT training to rural schools. Computer training centers were established in Nakhon Nayok province to offer IT and computer-assisted instruction (CAI) courses, and computer service centers were set up in Chiang Rai, Nakhon Sawan, Pathum Thani and Ubon Ratchathani.
- **IT for the Disabled.** Recognizing the potential of IT in improving the quality of life and promoting independence of people with disabilities, the project promotes the design of devices and software for disabled people such as communication aids and software, as well as supports IT education and the implementation of assistive technology in schools for children with special needs and disabled homes. Beneficiaries include Sri Sangwan School for children with disabilities and Siri Wattana Cheshire Foundation Under the Royal Patronage of Her Majesty the Queen.
- **IT for Sick Children in Hospitals.** The project aims to enhance access to education among children with chronic illnesses in hospitals through the application of IT. A computer center for sick children was first set up at King Chulalongkorn Memorial Hospital and

later at Lerdsin Hospital, Queen Sirikit National Institute of Child Health (Children's Hospital) and Maharaj Nakorn Chiang Mai Hospital. The initiative was subsequently taken up by the Ministry of Public Health, enabling the expansion to other hospitals throughout Thailand.

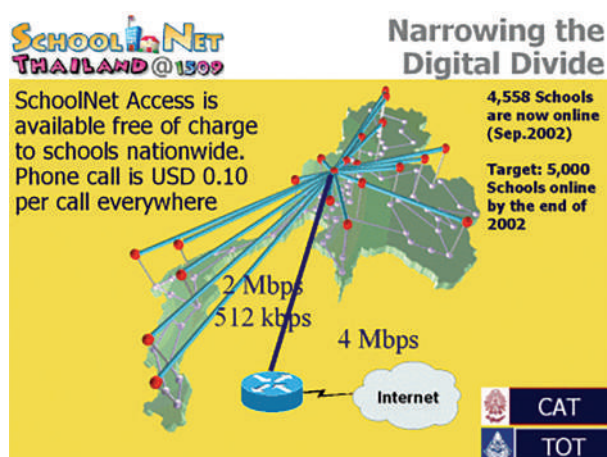
- **IT for Missing People Information Management.** The project in collaboration with the Royal Thai Police, the Department of Public Welfare, NGOs and Computer Associates Company Limited employs information management system to establish a database and website of missing persons information to assist the investigation.
- **IT for Prison Inmates.** The initiative was implemented as a pilot project from 1999-2002 with a provision of 20 computers and 2

printers to the Central Women Correctional Institution, enabling female prisoners to receive IT training to improve job prospect after release from prison.

- **IT for Cultural Dissemination.** The project aims to digitalize information about Thai culture for dissemination and support education purposes. Information compiled by the Office of the National Culture Commission include historical sites, important figures and philosophers, ways of life, local wisdom, local products, manuscripts and natural history.

Through numerous initiatives, the IT Project is able to realize the benefit of IT in improving social disparities and enabling the disadvantaged to gain access to technology.

SchoolNet Thailand



Launched in 1995 as a pilot project by NECTEC-NSTDA in response to the national information technology plan or Thailand IT 2000, **SchoolNet Thailand** aims to provide internet access to schools throughout Thailand as a way to improve the quality of education and reduce the disparities between students in cities and remote areas.

In February 1998, HRH Princess Maha Chakri Sirindhorn extended her support to the project by allowing SchoolNet members to access SchoolNet via the Golden Jubilee Network. Supports were also received from TOT Public Company Limited and CAT Telecom Public Company Limited, enabling members to connect to SchoolNet by simply

dialing 1509 with a charge of 3 THB per connection, thus earning the "SchoolNet@1509" moniker.

On 5 October 1999, SchoolNet Thailand was among projects endorsed by the cabinet to celebrate the His Majesty King Bhumibol Adulyadej's 6th Cycle Birthday. The target was to achieve 5,000 members consisting of primary, secondary and vocational schools.

SchoolNet Thailand was cited as an example of using technology to improve quality of life in Human Development Report 2001: Making New Technologies Work for Human Development published by the United Nations Development Programme (UNDP) and as one of case studies in New Economy and APEC, 2001 published by the Asia-Pacific Economic Cooperation.



SchoolNet Thailand project was handed over to the Ministry of Education on 1 October 2003 to implement the project at the national scale, covering 38,000 schools.

Electronic Distance Learning Television

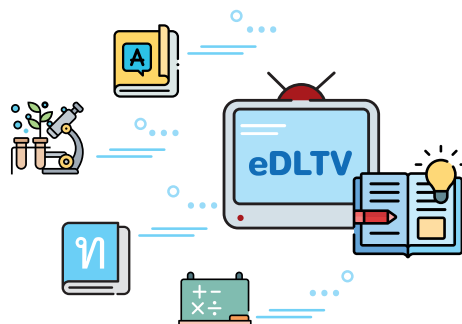


To alleviate educational inequality and teacher shortage faced by rural schools, His Majesty King Bhumibol Adulyadej founded the Distance Learning Foundation under the Royal Patronage to implement a distance learning television (DLTV) project broadcasting classroom session taking place at Wang Klai Kangwon School to schools in remote areas. In 2007, the Information Technology Project under the Initiative of HRH Princess Maha Chakri Sirindhorn and the Distance Learning Foundation co-created **Electronic Distance Learning Television (eDLTV)** to commemorate the Auspicious Occasion of His Majesty King Bhumibol Adulyadej's 80th Birthday Anniversary. eDLTV serves as a platform providing education resources to rural schools under the Information Technology Project.

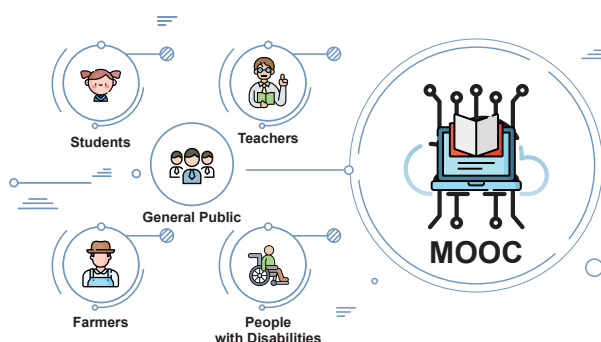


eDLTV contains learning resources produced and owned by DLTV. The contents are available in various forms - including VDOs, powerpoint presentations, worksheets and tests – designed for secondary education (grade 7 to 12) in the following subjects: Thai, English, science, mathematics, social sciences, religion and culture, as well as health and physical education. The e-learning platform is flexible, allowing students to access educational materials of interest anytime and available both online and offline.

By making education resources freely accessible through internet, beneficiaries of eDLTV are no longer confined to students in remote areas, but also encompass people with disabilities, prison inmates and people suffering chronic illnesses unable to attend normal schools.



Thailand Massive Open Online Course Platform



In its capacity as the secretariat of the Information Technology Project under the Initiative of HRH Princess Maha Chakri Sirindhorn, NSTDA and the Office of the Basic Education Commission (OBEC) upgraded the eDLTV platform to **Massive Open Online Course (MOOC)** to celebrate the HRH Princess Maha Chakri Sirindhorn's 5th Cycle Birthday on 2 April 2015. MOOC follows the Open Educational Resources (OER) concept and contains teaching, learning and research materials released

under Creative Commons (CC) licenses that permit no-cost access and use. MOOC can accommodate as many as 200,000 educational materials for primary and secondary education and support concurrent users of up to 10,000 students.

MOOC concept was applied to create **Thailand Massive Open Online Course Platform (Thai MOOC)** under the collaboration between NSTDA,

the Office of the Higher Education Commission (OHEC) and the Ministry of Digital Economy and Society (DES). Thai MOOC serves as a lifelong learning space providing open-access courses to general students and people from any educational and occupational background. Online courses available on Thai MOOC cover a vast range of subjects taught in normal university curriculum as well as vocational trainings.

Mae Hong Son IT Valley



Initiated in 2006, **Mae Hong Son IT Valley** is a collaborative project between NECTEC, BIOTEC and King Mongkut's University of Technology Thonburi (KMUTT). The project evolved from an annual S&T fair organized in Mae Hong Son province since 1997. Mae Hong Son IT Valley aims to apply information technology to develop manpower by providing IT training to students and teachers, to create jobs in IT development and to build networks of public and private enterprises to adopt IT in their organizations.

In 2007, Mae Hong Son IT Valley was among projects selected for the celebration of His Majesty King Bhumibol Adulyadej's 80th Birthday Anniversary. The activities were implemented through five core projects: 1) IT skill development of high school teachers and students, 2) science contest, 3) promotion of open-source software and e-learning, 4) landslide warning system, and 5) promotion of Thailand-Japan relationship through science and cultural exchange between high school students of the two countries via internet and electronic media.

To build IT infrastructure for Mae Hong Son IT Valley, NECTEC research team installed WiMAX technology in the province. The WiMAX technology later supports other activities such as an e-learning project and VDO conferences.

Mae Hong Son IT Valley exemplifies the power of information technology in developing human capital, providing job opportunity, and offering sustainable solutions to social challenges.

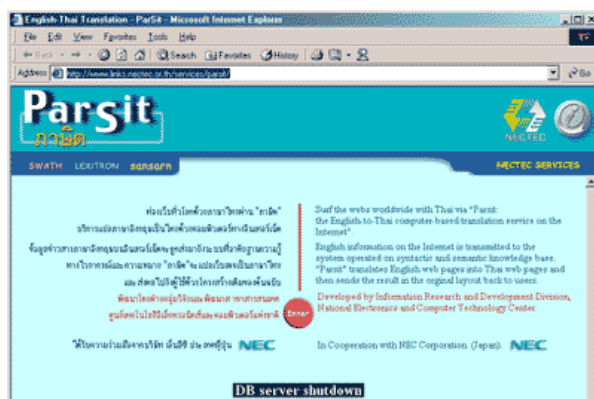


Breaking Communication Barriers with Natural Language Processing

Natural language processing (NLP) refers to the ability of a computer to process and analyze human language. Its vast applications include machine translation to help overcome language barrier and text-to-speech to aid the visually impaired. NECTEC-NSTDA was among the first groups in Thailand to conduct NLP research and development with an establishment of NECTEC Linguistics and Knowledge Science Laboratory (LINKS).

In early 1990s, a number of innovations were created. Examples include translation software, Thai-English electronic dictionary LEXITRON, optical character recognition software and speech recognition software. Some of these innovations have been successfully commercialized by Thai companies including Wanthai Computer Company Limited and Thavorn Computer Company Limited. NLP software developed by NECTEC that widely gain recognition are ParSit, Vaja and Party.

ParSit is the first English-Thai machine translation system through the internet. Derived from a collaboration between NECTEC and Japanese NEC Corporation, ParSit translates any English webpage into Thai by keeping the original layout, providing Thai speakers access to vast pool of information available on the internet by removing language barrier. Currently, the system extends its service to Chinese-Thai translation.

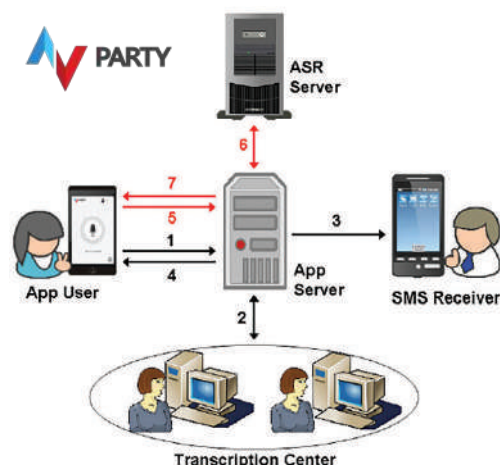


Vaja is a text-to-speech synthesizer. The system can be integrated into a variety of applications and services such as an automatic announcement system, voice navigation system, eBook reader and support for people with visual impairments. An automatic announcement system using a

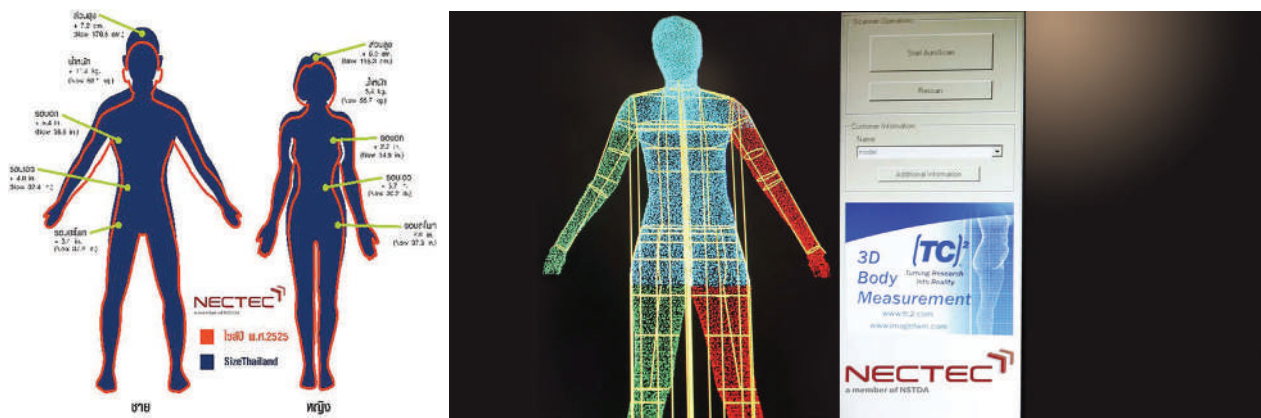
text-to-speech synthesizer is in fact more flexible than a pre-recorded speech. Vaja's key features include customizable pronunciations, adjustable speaking volume, regular update with further improvement on the quality of voice and pronunciation, support to both English and Thai languages in one installation and automatic and simple installation.



Party is a Thai speech-to-text system employing the automatic speech recognition (ASR) technology. The system was completed in 2015 after 15-year development. Party uses a novel algorithm to include only less than 40,000 lexical words combining both words and syllable-like units frequently used in Thai. The syllable-like unit could be used to construct new words. It thus drastically reduces the resource required to operate the engine. Under the data-channel smartphone environment, Party has achieved nearly 80% recognition accuracy. This system is a fundamental component for various services and applications including TV captioning, audio transcription and captioned phone service for people with hearing loss.



SizeThailand: Standard Sizes of Thai People



In 2006, NECTEC-NSTDA launched **SizeThailand** project embarking on a survey of anatomical dimensions of Thai people through the use of advanced 3D body scanning technology and creating a database on the physical measurements of Thai people. The project is a public-private cooperation with participations of Kasetsart University, the Thai Industrial Standards Institute (TISI), the National Statistical Office, Ramathibodi Hospital, the Thai Tailors Association, the Thailand Textile Institute, the Federation of Thai Industries, Pattern For Industrial Training Center, Thai Wacoal, Toyota, Tesco Lotus, and Thanulux, aiming to develop a standardized size chart specific to Thai people.

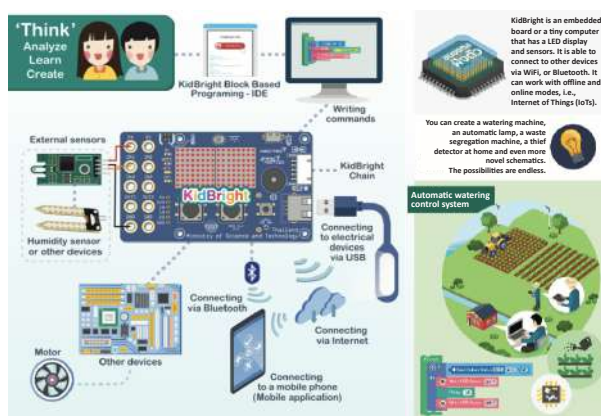
The project has scanned and processed measurements of 13,442 males and females over 16 years old nationwide, and established size charts for Thai male and female. A male size chart

consists of 9 sizes, ranging from 32 to 48, each with measurements of bust and waist. A female size chart has 10 sizes, from 28 to 46, each with measurements of bust, waist and hip. The size charts are available on www.sizethailand.org.

Results from this project serve various purposes. General public can use the information for health assessment, whereas manufacturers can design products - garments, automobiles and furniture - that better suit the typical Thai physique.

As an extension of SizeThailand project, a health monitoring and diagnosis system called **SizeThailand e-Health** was developed. The system allows users to regularly monitor their body shape and health online. The data can be sent to doctors to seek a consultation on the health status for each user. The system is also designed to support data upload from a 3D body scanner.

KidBright: Coding at School



An embedded board **KidBright** was developed by NECTEC-NSTDA as a tool for kids to easily learn about coding through coded sets of command which connect with various types of sensors, enabling Internet of Things (IoT). With KidBright, children can develop logical thinking process and creativity.

KidBright consists of three parts: the embedded board, the firmware and the coding commands in the KidBright Integrated Development Environment program, or KidBright IDE. It is easy to use by

dragging and dropping command blocks. The command is then sent to the embedded board to work as it is programmed such as watering plants according to specified humidity level or switching the light on or off at specified time.

Funding was obtained from the Ministry of Higher Education, Science, Research and Innovation for **KidBright: Coding at School project** designed to support Thai children to learn computer programming. The project manufactured a total of 200,000 KidBright boards for 2,200 schools nationwide. Over 4,000 teachers and educators participated in “train-the-trainer” sessions. Manuals were developed to offer useful information on science project creation and STEM

education. KidBright contests were organized for children to exercise their creativity and coding skill.

To encourage innovation through collaboration, NECTEC initiated the formation of **KidBright Community** – a community of makers from all over the country to participate in further development of KidBright. KidBright hardware and software were released as open source, allowing makers to create commercial products in the forms of KidBright extensions and plugins.

KidBright not only helps children develop coding skill, but also improves STEM education, supports the growth of the maker culture in Thailand and strengthens Thai electronics industry.

Thai School Lunch: AI Platform for School Lunch Menu Planning



NECTEC-NSTDA in collaboration with the Institute of Nutrition, Mahidol University developed an automated system to provide recommended school lunch menus in 2012. Powered by big data analytics and artificial intelligence, the system called **Thai School Lunch** is a useful tool to help schools self-plan nutritious school lunch menus according to the nutrition requirements for each school age group and available budget. Users can

self-create menu or choose from more than 1,000 dishes readily available in the system. For each available dish, the system provides a list of ingredients, quantities of ingredients required to purchase, an estimated cost based on current ingredient prices and total nutritional value.

Thai School Lunch program has been implemented in schools across Thailand through collaboration with partners such as the Office of the Basic Education Commission (OBEC), the Department of Local Administration, the Department of Health, the Bangkok Education Office, the National Health Commission Office and the Thai Health Promotion Foundation. School interested to use the system can register for access at: www.thaischoollunch.in.th.

Thai School Lunch is connected to **KidDiary** – a platform also developed by NECTEC for child growth monitoring. In combination, parents can assess child’s health and nutritional status.

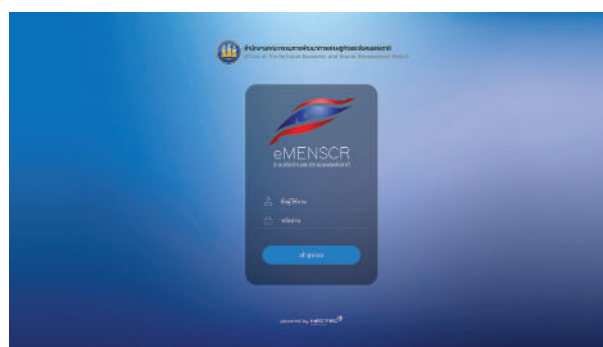
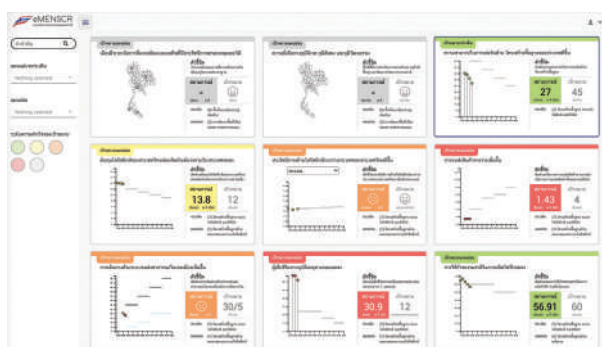
Thai School Lunch was honored with Thailand ICT Awards 2019 in public sector and government category, presented by the Association of Thai ICT Industry.

eMENSCR: Electronic Monitoring and Evaluation System of National Strategy and Country Reform

As the Secretariat of the National Strategy Commission and the Country Reform Commission, the Office of the National Economic and Social Development Council collaborated with NECTEC-NSTDA to develop an Electronic Monitoring and Evaluation System of National Strategy and Country Reform, or **eMENSCR** as a tool to drive the 20-year National Strategy and the National Reform initiatives.

eMENSCR serves as a central reporting database that analyses data from government agencies,

thus enabling it to track the implementation of national strategies, master plans and projects under the 20-year National Strategy and the National Reform. Data and information in eMENSCR are made accessible to government agencies to facilitate inter-agency cooperation and avoid duplication of projects. An open data portal has been created for public access to data and information created from projects corresponding to the 20-year National Strategy, thus promoting government transparency and engaging people in public policy.



TPMAP: Thai People Map and Analytics Platform



Developed by NECTEC-NSTDA in collaboration with the Office of the National Economic and Social Development Council, Thai People Map and Analytics Platform or **TPMAP** is a government big data system that creates accurate poverty maps. The first version TPMAP 1.0 was introduced in 2018.

TPMAP uses the Multidimensional Poverty Index (MPI) developed by Oxford Poverty and Human Development Initiative (OPHI) and the United Nations Development Programme (UNDP) to

analyze poverty in 5 key areas: healthcare, standard of living, education, income and access to public services. The Basic Minimum Needs (BMN) data from the Interior Ministry's Community Development Department is used as the core dataset. The system also integrates data from other different government agencies such as registration records of the disabled maintained by the Ministry of Social Development and Human Security, database of recipients to disability and old-age allowances maintained by the local administrative offices, and health insurance database maintained by the National Health Security Office.

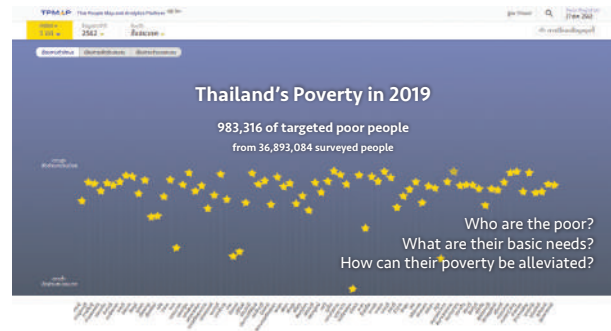
The system continues to incorporate other types of data beyond poverty. The latest version TPMAP 2.0 is a comprehensive tool supporting lifelong human development.

While overall data is made available for public access at <https://www.tpmmap.in.th/>, NECTEC further developed **TPMAP Logbook** for government agencies to use as a supporting tool for targeted poverty eradication. TPMAP Logbook contains in-depth information at individual and household levels, providing an insight into the problems that contribute to poverty in each region, which in turn helps policy makers and government agencies formulate and implement solutions more precisely. Improvement on poverty conditions can also be monitored through the system. TPMAP Logbook has been implemented in

AI for Thai: Thai AI Service Platform



Artificial intelligence (AI) possesses great potential to improve people's quality of life and make significant contribution to industrial development. Launched in 2019 by NECTEC-NSTDA and its partners, **AI for Thai** is as a platform providing AI services to users in the manufacturing and service industries. The platform helps promote research and development in AI and machine learning and enables Thai industry to employ AI and machine learning tools to improve their products and services.



several provinces including Sakon Nakhon, Samut Sakhon, Khon Kaen, Mukdahan and Nakhon Ratchasima.

AI applications can be seen in various sectors. AI-powered chatbots are used to replace human customer service in retail, whereas facial recognition is used for detecting truck driver fatigue, thus reducing fatigue-related accidents in the logistics sector. AI is increasingly applied in healthcare sector for tasks such as predicting risk of an individual patient or performing X-ray diagnosis.

In July 2020, NECTEC and the State Audit Office of the Kingdom of Thailand set out to create an AI-powered system to increase productivity and accuracy in the auditing process.



NATIONAL SECURITY

NSTDA applies its expertise in core technologies to create innovative responses to threats to national security. These threats can be social, such as domestic insurgency and terrorism, or economic based. In other cases, threats can be natural, such as floods, landslides or viral pandemics. As national security is one of the key areas in the 20-Year National Strategy (2018-2037) and the government plans to develop domestic defense industry, NSTDA sets dual-use technology in its research strategy, aiming to develop technologies that can be used for civilian purposes as well as military applications and promote defense industry.

Jamming Devices for National Security

In 2001, insurgency in southern Thailand became increasingly violent with attacks such as shootings and bombings taking place frequently. Mobile phone jamming devices were used by the military for safety of patrols and the public against explosives by intercepting the signal sent by a mobile phone to trigger explosive devices. In early 2000s, mobile phone jamming devices were all imported, thus limiting the deployment of such devices to provide safety for the public. NECTEC-NSTDA and the Ministry of Defence came together to develop a mobile phone jamming device **T-Box**. The first model, T-Box 1.0b, was introduced in 2005 and 40 units were used in actual sites in the South. T-Box is 2-3 times cheaper than an imported product. Because T-Box is manufactured in Thailand, parts can easily be sourced, and maintenance services can be provided locally. The devices have also been used extensively in official functions including the royal ceremony celebrating the 60th anniversary of King Bhumibol Adulyadej's accession to the throne in 2006. In 2007, the cabinet allocated 42 million THB fund for R&D and the manufacturing of T-Box devices to support national security effort in the three southern border provinces.

Improvements have constantly been made to the device, resulting in the release of new models and products including T-Box 2.0, T-Box 2.5 and the latest ones, T-Box 3.0 and T-Box 3.0R, as well as a radio frequency jammer **WT- Defender**. T-Box 3.0, T-Box 3.0R and WT- Defender have been licensed to a company for commercial production.

T-Box3.0 meets the quality and safety standards as tested by the Electrical and Electronic Products Testing Center (PTEC) and is registered on the Thai Innovation List. Patent and petty patent applications have been filed.

With technological advancement in unmanned aerial vehicle (UAV), drones become more accessible and therefore can be exploited in terrorist activities. The research team further developed an **anti-drone system** for drone detection, monitoring and control and drone jammer. The system was put into use during the royal cremation ceremony of King Bhumibol Adulyadej in 2017.

Research on jamming devices is now under the responsibility of the National Security and Dual-Use Technology Center, one of NSTDA focus centers.



Materials Technology for Military Application



National security is one of the priority areas in Thailand's 20-Year National Strategy (2018-2037). The government has a strong policy to support research and innovation for military applications and promote the defense industry in order to increase self-reliance in defense technology. NSTDA has long been engaged in research and development for military applications with a number of successful outputs.

MTEC-NSTDA and Mahidol University have developed a **bullet-proof vest** made from 96% alumina ceramic and polyethylene composite. The vest weighs 8 kg. and provides the level III protection according to the NIJ (National Institute of Justice) standard for ballistic protection. A total of 100 units were manufactured for police and military forces working in the three southern border provinces. This research was funded by PTT Polymer Marketing Company Limited.

An **armor plate for a military truck** was developed by MTEC-NSTDA and Chulalongkorn University.

The armor plate is made from 96% alumina ceramic and Kevlar composite and offers the level III protection according to the NIJ standard for ballistic protection. An **armor plate for an assault boat** was also developed by MTEC in collaboration with Chulalongkorn University, King Mongkut's University of Technology Thonburi, Prince of Songkla University, and the Royal Thai Navy.

With its expertise in rubber technology, MTEC-NSTDA collaborated with the Royal Thai Naval Dockyards on a number of projects to develop rubber parts and equipment for the application of naval force. Examples include prototypes of a **rubber propeller, marine rubber fender** and **flexible coupling for a patrol boat**, as well as **nitrile rubber composition for bearing production**. All parts and equipment from research and development have been put into use by the Royal Thai Naval Dockyards, enabling the saving in imported parts and convenient maintenance of naval vessels as parts can be procured locally.

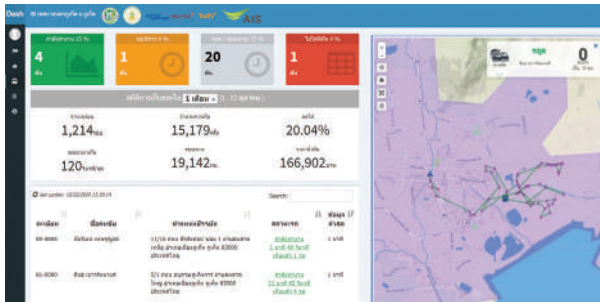
In addition to armors and rubber products, other inventions that combine NSTDA's scientific expertise with user's requirement identified by the army are:

- **Battery pack** for replacing original batteries used in military equipment. Developed by MTEC and NECTEC for the Royal Thai Army, the battery pack has triple battery capacity and costs 4 times less than imported battery.
- Prototype **lightweight energy bar** for field rations developed by MTEC.
- **E-nose** developed by NANOTEC to perform detection (sniffing) tasks of military dogs.

Traffy Application Platform for Smart City

Before the popularity of Google Map, Thai commuters were using **Traffy** to plan their trips. Developed by NECTEC-NSTDA, Traffy is an application reporting road traffic conditions in real time. The application was further augmented to a series of systems that support smart city initiative by utilizing sensor technology and artificial intelligence (AI). **Traffy Waste** is an intelligent garbage monitoring and management system. The





system tracks the positions of trash collecting vehicles and plans efficient collection routes.

Traffy Fondue is a municipality complaint reporting and management system. The system enables citizens to report city problems to and get an update on the case from the city administration via a mobile application. People can send a report of city problems - ranging from waste to potholes, broken footpath and streetlights - together with photos and GPS locations. The report will then be directed by the system to concerned departments to fix the problems. The department in charge

provides an update on the case, which can be viewed by the person who files the report. The system comes with a dashboard that allows government authorities to access statistical data for performance improvement as well as budget and manpower planning.

Traffy Fondue has been implemented in several districts under the collaboration with the Department of Local Administration. In addition, it was used by Ministry of Interior to engage citizens in reporting forest fire incidents in 50 provinces.

During the COVID-19 pandemic, Traffy Fondue was applied to support the effort to curb the spread of COVID-19 through people migrating across cities. The system was built on a chatbot platform to enable citizens to report on people coming into the province from COVID-19 affected areas. The report is sent to the Ministry of Interior and alerts local authorities to investigate and conduct proper health screening and monitoring on the reported case accordingly.

Safety-enhanced Ambulance Cabin

Ambulance crashes are among hazards faced by Emergency Medical Services (EMS). Incidents of ambulance crashes have been increasing throughout the world including Thailand, posing a threat to the safety of patients and medical staff. To alleviate this problem, MTEC-NSTDA in collaboration with Suprera Innovation Company Limited designed and developed the **composite superstructure of ambulance cabin** to enhance rollover safety for passengers. The design was made to meet the requirements of two international standard tests: the dynamic rollover test according to UN-ECE Regulation 66 (ECE-R66) and the static rollover test according the Federal Motor Vehicle Safety Standard 220 (FMVSS 220). The proposed cabin structure was tested for rollover strength on computer simulation and the full-scale prototype was also tested in the field.

Built with lightweight composite materials, the newly developed ambulance cabin complies with the UN ECE R66 and FMVSS 220. The modular



body design allows for an independent manufacturing process of the body and variation of the body dimensions based on the applied vehicle type.

Currently, Suprera Innovation utilizes this innovation to manufacture ambulances and mobile X-ray vehicles.

SOS Water: Solar Powered Water Purification Unit

In 2011, Thailand was faced with a severe flood. Thousands of people had to move from their flooded homes to evacuation shelters. Access to clean water became a challenge for flood victims. NANOTEC-NSTDA built a solar powered water purification unit called **SOS Water** utilizing antibacterial nanocoating technology. Silver nanoparticles were impregnated onto porous surface of ceramic water filters to remove bacteria from the water and prevent the growth of mold and algae in the body of the filter. In addition to silver nanoparticle-impregnated ceramic water filter, SOS Water employs additional five stages of filtration: sand filter for removing sediment and large particulate matter; resin filter for removing calcium and magnesium causing water hardness;

activated carbon filter for removing odor, residual chlorine and organic matters; manganese zeolite filter for removing heavy metals; and ultrafiltration for removing 10nm nanoparticles.

At a 200L/hr capacity, an SOS Water unit can serve 1,000 people. Field testing of SOS Water performed in collaboration with the Thai Red Cross Society demonstrated that the unit worked well on-site and the quality of drinking water met the drinking water standard of the Ministry of Public Health.

Although SOS Water was initiated as a solution to natural disaster, the innovation is suitable for rural communities and remote areas where access to electricity is limited.



COVID-19 Vaccine Development

Since the outbreak of COVID-19 in 2019, attempts have been made around the world to develop drugs and vaccines against the disease. The focus of BIOTEC vaccine research team was on SARS-CoV-2 spike protein containing a receptor-binding domain (RBD) that allows it to gain entry into cells and lead to infection. The team constructed the gene for SARS-CoV-2 spike protein. This spike protein is an antigen that triggers the immune system to produce the antibodies blocking the entry of SARS-CoV-2 virus. The constructed gene is then used to develop vaccine candidates. Five different vaccine technologies were employed: recombinant subunit vaccines, influenza A virus-based vaccines, nucleic acid-based (DNA- or RNA-based) vaccines, virus-like particles and recombinant viral vector vaccines.



Three **COVID-19 vaccine candidates** - recombinant subunit vaccine, influenza A virus-based vaccine and DNA-based vaccine – are in the preliminary stage of immunogenicity study on laboratory animals. NSTDA is committed to raise fund and find partners to advance vaccine candidates to preclinical and clinical stages.

In addition, NANOTEC researchers have developed **delivery systems for mRNA and nucleic acid-based vaccines**. Lipopolyplex, lipid nanoparticle (LNP) and polymer-lipid nanoparticle (PLN) have been designed to protect mRNA and DNA from being

digested by enzymes in the body, thus enhancing vaccine effectiveness. Each system is being tested for performance and toxicity. Promising systems will be tested in lab animals in collaboration with BIOTEC and Chulalongkorn University.

SARS-CoV-2 RNA Extraction Kit

Real time RT-PCR is the gold standard for COVID-19 testing. To prepare RNA extract for the test, an automated RNA extraction machine and an imported reagent costing around 120-300 THB are required. To circumvent the costly reagent and the reagent shortage due to the pandemic, the National Omics Center of NSTDA developed a **magnetic bead SARS-CoV-2 RNA Extraction Kit**. The performance of this method has been verified with samples provided by the Faculty of Tropical Medicine of Mahidol University and the Department of Medical Sciences and demonstrated to be as efficient as imported extraction kits, but much cheaper and can be manufactured locally.



This extraction method can be applied to other pathogenic viruses infecting human, plant and animal and therefore has a wide range of applications beyond the COVID-19 management.

COXY-AMP: Rapid One-step COVID-19 Colorimetric Detection Kit



Despite being the gold standard for COVID-19 detection due to its accuracy, specificity and sensitivity, RT-PCR method requires expensive laboratory equipment available in large hospitals and trained technicians to perform and interpret results, making the platform inaccessible to the wider population, thus crippling the ability to contain the spread. A rapid COVID-19 colorimetric detection kit called **COXY-AMP** was introduced by BIOTEC-NSTDA in collaboration with Mahidol University as a screening tool prior to the application of a time- and resource-consuming RT-PCR method, enabling a better management.

The assay employs loop-mediated isothermal amplification (LAMP) technique to amplify genetic

materials of SARS-CoV-2, the causative of COVID-19. The test is a simple one-step method and the result, indicated by the color change, can be visualized with naked eyes. COXY-AMP offers multiple advantages over a PCR method. Its reagent is 3 times cheaper and the equipment required costs around 10,000 THB, whereas the price of a PCR machine ranges from 600,000 -1,000,000 THB. At 75-min assay time, the test is twice as fast as an RT-PCR method. Compared to an imported LAMP-based test kit, COXY-AMP costs 1.5 times less. This rapid test is Thai FDA-approved.



Girm Zaber UV-C Sterilizer



Developed by the National Security and Dual-Use Technology Center of NSTDA and the Institute of Biotechnology and Genetic Engineering of Chulalongkorn University, **Girm Zaber UV-C Sterilizer** utilizes powerful UVC rays to deactivate all kinds of pathogens - including viruses, bacteria and fungi - present in the air and on object surfaces. It works effectively in disinfecting rooms and equipment that cannot be cleaned with chemical disinfectants or exposed to liquid cleaning agents. Unlike chemical disinfectants, Girm Zaber UV-C Sterilizer does not leave chemical residues. It also reduces the risk of exposure for cleaning staff.

Girm Zaber UV-C Sterilizer is available in two models. Girm Zaber Station is a unit that can be manually wheeled to an area required sterilization,



whereas Girm Zaber Robot is a mobile robot navigated via a remote control. Both models are used in the area where no people and animals are present as UV radiation causes damage to organic cells. The sterilization takes 15- 30 minutes, covering an area of 1-2 m. radius. Girm Zaber UV-C Sterilizer meets the requirements of TIS 1955/EN 55015 standard for lighting equipment as tested by the Electrical and Electronic Products Testing Center (PTEC).

Girm Zaber prototype was tested at King Chulalongkorn Memorial Hospital. The technology has been used at establishments such as IMPACT Muang Thong Thani - an exhibition and convention center, Chulalongkorn University Laboratory Animal Center and Rayong Hospital.

DDC-Care: Application for Monitoring and Assessing Health of Individuals at Risk of COVID-19



DDC-Care is a system developed by Assistive Technology and Medical Devices Center and NECTEC of NSTDA, in collaboration with the Department of Disease Control (DDC) and relevant agencies. The application enables DDC officials to monitor and assess health of individuals at risk of COVID-19, as well as to control and assess the spread of COVID-19. DDC-Care system consists of three parts:

1. DDC-Care REGISTRY is a web-based application for registration sent to individuals identified by officials as persons at risk of COVID-19.
2. DDC-Care APP is a mobile application allowing individuals at risk of COVID-19 to make a daily health self-assessment and

receive health consultation. The application is available in four languages, Thai, English, Chinese and Burmese. The app uses GPS for contact tracing and the dispatch of medical assistance if needed.

3. DDC-Care DASHBOARD is data visualization for officials to monitor and visualize real-time data.

DDC-Care system was first implemented in early 2020 at Bamrasnaradura Infectious Diseases Institute. The system is subsequently used in more

than 60 hospitals and health centers and 20 disease prevention and control offices throughout the country. The research team has made improvement on the system to support various cases such as home quarantine, bubble and seal measure for factory workers, and high-risk groups such as truck drivers working along the border.

DDC-Care was presented with an award for outstanding research and innovation for the new normal by the Ministry of Higher Education, Science, Research and Innovation.

PETE: Patient Isolation and Transportation Chamber

Isolation chamber is a personal protective equipment that prevents the transmission of airborne pathogens during the transport of infectious respiratory patient and reduces infection rate of medical staff. Driven by the rapid progression of COVID-19 pandemic, researchers at MTEC-NSTDA designed a patient isolation and transportation chamber called **PETE** with multiple key features that overcome shortcomings of products currently available in the market which include an inability to use in an ambulance, X-ray machine and CT scanner.

PETE has two main components: a chamber and a negative pressure unit. The chamber is collapsible enabling portability and contains no metal parts, thus allowing it to be used in a CT scanner. The chamber has eight built-in glove portals allowing medical workers to access the patient and a

connector port for respiratory and IV tubes. The negative pressure unit creates a condition that allows air to flow into the chamber but not leaking out to keep the medical workers safe. Air from inside the chamber is cleaned and sanitized by HEPA filters and UV-C prior to release out. The unit is equipped with a smart controller allowing it to perform under varying pressure conditions, i.e., moving patients from on ground to in flight, and comes with pressure alarm and filter reminder features. PETE is ISO 14644 certified, meeting the standard for air cleanliness.

The production cost of PETE is less than the price of imported isolation chambers in the market ranging from 150,000 to 800,000 THB. As the innovation is developed in Thailand, it is eligible for Thai Innovation List registration to benefit from the government procurement program.



MagikTuch: Touchless Elevator Control Panel

MagikTuch is a touchless elevator control panel invented to facilitate low-touch interactions and avoid cross-infection as frequently touched surfaces such as elevator buttons have the potential for infection. It employs motion sensors to operate an elevator by having users holding their hand over the floor button at a distance of 1-2 cm instead of traditionally pushing the button. MagikTuch can be installed in existing elevators without any modification made to the elevator unit and thus will not affect the product warranty program. It is designed to accommodate elevators serving different number of floors and support both alternating current and direct current power systems.

MagikTuch has been installed and tested at Siriraj Hospital and IMPACT Muang Thong Thani - a convention and exhibition center.



COMPETITIVENESS ENHANCEMENT

NSTDA aims at enhancing the competitiveness of Thai businesses and industries through research and development program, upskilling program for industrial workforce, knowledge and technology transfer program to supply innovative technologies and solutions to enterprises and industries, and National Quality Infrastructure (NQI) to provide services such as product design, testing, calibration, conformity assessment, inspection and certification to industry. The agency also engages in the establishment and management of innovation hub that provides a dynamic innovation ecosystem to promote innovation in the private sector.

Unlocking Business Potential with Science, Technology and Innovation

Founded in 2000, **Innovation and Technology Assistance Program (ITAP)** is a mechanism that NSTDA employs to help Thai SMEs unlock their potential with the application of technology and innovation and build their long-term competitiveness. The program provides technical experts from a pool of over 1,500 highly experienced and qualified technical experts from universities and S&T agencies to assist businesses to increase its value through better product matching with the new market. The scope of ITAP program is to provide experts to identify technical solutions and consultation during the implementation to ensure successful design and implementation. The support ranges from product design, product development, product/process certification and qualification on industry standards, process improvement, and digital transformation. ITAP reimburses on the expert expenses of up to 50% of project cost with the maximum of 400,000 THB. Over 10,000 SMEs – majority of which are in the food and agriculture sector - have been assisted by ITAP since its inception.

Choknamchai Group participated in ITAP in 2011 and has since been a long-term partner of NSTDA. The company has transformed from an original equipment manufacturer (OEM) of automotive dies and parts to an innovation-based

manufacturer of aluminum-body buses and boats under its own brand and aims to become an electric vehicle manufacturer of buses and boats in the near future.

Royal Ceramics Company Limited received ITAP assistance in introducing new technologies and upgrading its manufacturing process. Through this project, the company was able to improve the production efficiency and lower the production cost by reducing time, energy consumption and waste, enabling it to compete in a global market. Its products can be found in stores in the US, France and the UK.



ITAP supported an expert team from King Mongkut's University of Technology North Bangkok to assist **KEMREX Company Limited** in designing and testing the performance of steel pile foundations suitable for different settings, as well as improving manufacturing quality control. The project enabled the company to manufacture steel pile foundations meeting the requirements of ASTM D1143 standard and to have its products registered on the Thai Innovation List.

ITAP-NSTDA partnered with Thailand Center of Excellence for Life Sciences (TCELS) launching a program to support research, development and clinical studies of functional food, aiming to enhance the capacity of Thai SMEs to develop functional food products with proven efficacy. Among companies participated in this program was **4care Company Limited** – a health food company. 4care was provided with funding and an expert to perform a clinical study to assess the efficacy of its product, dark chocolate mixed with organic cacao, in enhancing brain function.

During the pandemic, ITAP launched Fast Track for Medical Devices to Fight COVID-19 Program, aiming at accelerating the product development process to reach the market to help fight the COVID-19 pandemic. Financial support was provided to local companies to perform the quality and safety assessment of medical supplies

and devices. **AVS Innovation Company Limited** received funding from this program to evaluate the performance of its alcohol-free hand cleansing gel called Besuto12. Test results have shown that Besuto12 is effective against COVID-19 and various types of fungi and bacteria. With thin film forming technology, the hand gel can provide up to 12-hour protection in one application. Besuto12 won Canadian Special Award at International Invention Innovation Competition in Canada (iCAN 2020).

Loft Builder Company Limited, a construction company specializing in commercial buildings and warehouses, was looking for an opportunity to expand its business to building a plant factory - a closed system for growing crops under a controlled environment, i.e., light, temperature, moisture, and carbon dioxide concentration. ITAP provided an expert to assist the company in designing and constructing a plant factory prototype which can be operated, monitored and controlled via a mobile application. The project enables Loft Builder to offer service in building a plant factory.

ITAP supported an expert to assist **Beyond Café** in Udon Thani province in implementing an Enterprise Resource Planning (ERP) solution for inventory management in all the Beyond Café outlets. The ERP solution helps save the company 900,000 THB/year.

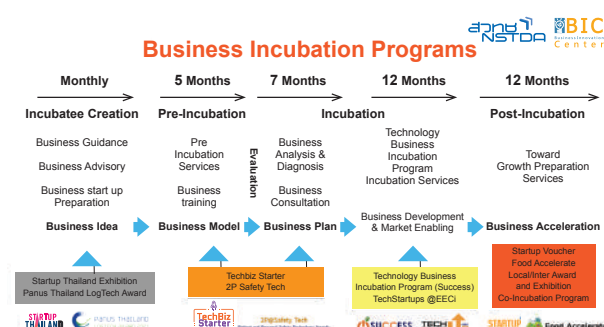


Fostering Technopreneurs with Incubation and Acceleration Programs

In 2002, NSTDA established **Business Incubation Center (BIC)** to offer integrated and comprehensive support to new tech business entrepreneurs. The center provides mentorship, business acumen workshops, connection to researchers, investors, funding and market, along with intensive project evaluation to help promising technopreneurs bring their ideas to products that can enter the market for traction and scale.

Over the course of 19 years since its inception, BIC has helped launch 2,700 tech startups contributing a combined 6 billion THB revenue and a 3 billion THB S&T investment to the economy. Its strategy focuses on 10 S-curve industries as targeted by the Thai government.

In addition, BIC has supported numerous entrepreneurs through multiple programs. **Taokaenoi Technology**, or Young Technopreneur, is a joint program with Samart Corporation, Thailand's telecommunication leader, designed for entrepreneurs in software and technology businesses. **SUCCESS** is a Technology Business Incubation Program that offers support to entrepreneurs in various fields, including biotechnology, healthcare, energy, digital technology, logistics, agroindustry and deep tech. **Food Accelerate** is an acceleration program providing entrepreneurs with access to experts to help enhance their business capability and matching fund to help expand their domestic and international market. The **2P Safety Tech** is a joint program with the Healthcare Accreditation Institute (Public Organization), aiming to support the creation and exploitation of healthcare innovations to enhance patient and personnel safety in hospitals. **Tech Startup @EECI** is a program targeting at entrepreneurs in any industry based in three provinces, Rayong, Chonburi and Chachoengsao. **Startup Voucher** is designed to assist startups to expand their market by providing funding support for marketing campaign, online and offline marketing and promotional channels including international events in order to scale up



businesses, create visibility in international market and initiate technological and business collaboration with international partners. **Panas Thailand Log Tech Award** was launched in collaboration with Panus Assembly, a leading manufacturer of transportation equipment including large trailers and tow trucks, and the Artificial Intelligence Association of Thailand as a competition opened to students and general public to demonstrate their AI skill. As a founding member of **ASEAN Business Incubator Network**, BIC helps link Thai startups to peers and related organizations in ASEAN to gain insights and expand their market in ASEAN region.

Queue Q (Thailand) Company Limited participated in the business incubation program and was a recipient of Startup Voucher. The company developed mobile app QueQ allowing users to book their appointment to enter an outlet. Through the incubation and startup voucher programs, Queue Q (Thailand) was matched to Railay Beach Tourism Business Club as the technology user, resulting in the application of QueQ in managing tourist capacity in Railay Beach after the COVID-19 lockdown was lifted.

BIC has been recognized by numerous accolades, including "Excellence in Science" awarded by the Senate of Thailand, "Incubator of the Year 2016" by the Asian Association Business Incubation and "Incubator of the Year 2016" by the Thai Business Incubators and Science Parks Association (THAI-BISPA).

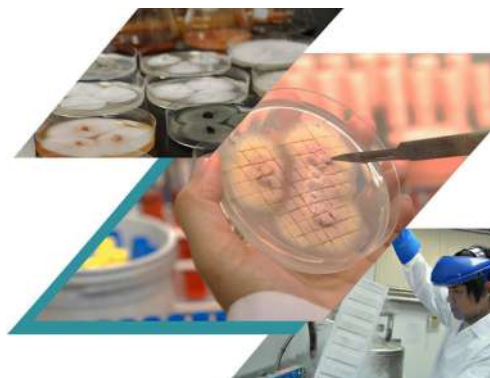
Harnessing the Potential of Bioresources

BIOTEC-NSTDA has long been engaging in microbial preservation and utilization study. The center founded BIOTEC Culture Collection (BCC) in 1996 as a depositary and distribution center for microorganisms. In 2015, **Thailand Bioresource Research Center (TBRC)** was established to provide full services in biological materials - encompassing microorganisms, plasmids, monoclonal antibodies, animal cells and plant cells - with international standards.

TBRC serves as a central body to preserve, provide and facilitate the coordination of exchange of biological information and resources and develop mechanisms enabled by information technologies to broaden access to biomaterials to the public and scientific community. The Center is fully equipped with a system that complies with international standards and protocols. Through the linkage developed with the Thailand Network of Culture Collections (TNCC) and academic and

research institutes, TBRC currently has more than 130 members from Thailand and overseas, and therefore is able to provide access to comprehensive and diverse biological materials to serve the needs of industries.

TBRC is an essential infrastructure that provides a foundation for the development of the nation's bio-industry and bioeconomy, supporting the Thai government's initiative on Bio-Circular-Green Economy (BCG).



National Biobank of Thailand: Key Infrastructure Underpinning Bioeconomy

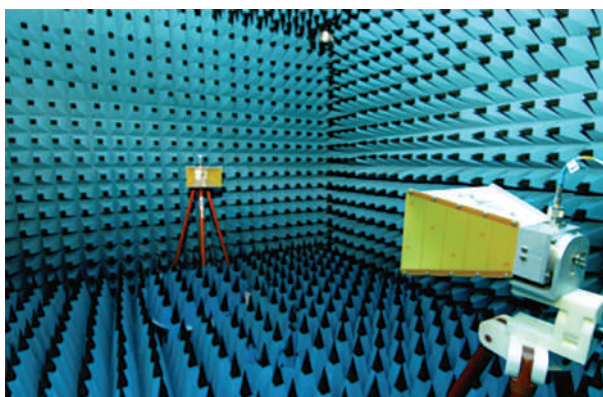
In 2018, the **National Biobank of Thailand (NBT)** was established as a national S&T infrastructure for long-term preservation of biomaterials and biodata with international standards to support research and Thai bioeconomy. Biological resources and biomaterials preserved at NBT are subjected to extensive taxonomic, molecular, genetic and bioactive screening studies to acquire information on their potential utilization. All the studies are supported by state-of-the-art research facilities and technology such as a Brooks Life Science Systems automated sample deep freezing storage and management systems, an advanced plant factory system providing a computerized-control cultivation environment, a plant tissue culture and cryopreservation system, a microbial identification platform, specimen information management

system, bioinformatics and high-performance computing (HPC) and big data storage and analytical systems.

NBT research team has embarked on a number of biodiversity exploration studies such as a project to collect and identify microorganisms in Satun UNESCO Global Geopark. Collaboration with other agencies include a project on plant genetic resources with the Botanical Garden Organization and a mangrove plant diversity study with the Department of Marine and Coastal Resources. NBT established genomic database that houses human genome data from the Genomics Thailand initiative that will further support the knowledge and technology creation for healthcare application.



Increasing Competitiveness of Thai Industry with National Quality Infrastructure



Recognizing that product quality is of prime importance to industry, NSTDA established **National Quality Infrastructure (NQI)** to provide services such as product design, testing, calibration, conformity assessment, inspection and certification to industry with an aim to increase competitiveness of Thai industry to meet international standards. Presently, there are five NQI centers under NSTDA's operation, namely Electrical and Electronic Products Testing Center (PTEC), NSTDA Characterization and Testing Service Center (NCTC), Design & Engineering Consulting Service Center (DECC), Industrial Ceramic and Houseware Product Testing Center (CTEC) and Toxicology and Bio Evaluation Service Center (TBES), covering key industries in Thailand. All NQI centers aim to be a one-stop-service center delivering exceptional quality and speedy services utilizing advanced instrument and technology. This commitment is

illustrated through the operation of PTEC, as an example.

PTEC provides professional testing, calibration, conformity assessment, inspection and certification of electrical and electronic products to be sold in Thailand, as well as imported and exported, using methods prescribed by international standards. The center is an ISO/IEC 17025 accredited laboratory and a testing and authenticating laboratory to support the consumer protection policy in Thailand. In addition, PTEC has worked with relevant agencies on establishing standards for electric vehicle (EV) components such as EV electrical connectors and charging stations, and constantly expanded its testing scope to cover new areas such as robotics and internet of things (IoT).

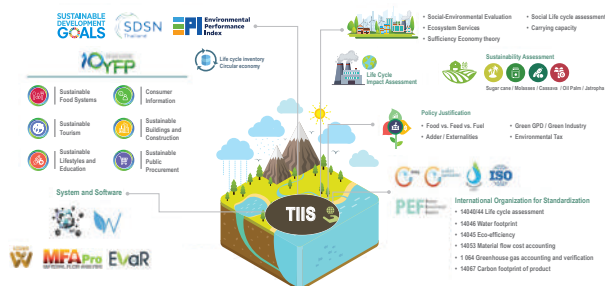
Apart from common electrical and electronic products, PTEC offers avionics part testing and the laboratory is AS 9001- and Nadcap-certified. PTEC provides testing of medical devices such as incubators, electric hospital beds and service robots used in the hospital. The center performed various tests - including electromagnetic compatibility (EMC), battery test and software and control system - on a service robot HAPYbot. HAPYbot became the first service robot that has been formally tested and met all safety requirements for hospital use in Thailand.



Thai National Life Cycle Inventory Database for Sustainable Development

NSTDA established **Technology and Informatics Institute for Sustainability (TIIS)**, aiming to be a leader in technology and informatics to support Thailand's transition to circular economy (CE). The

institute develops data (products and services) as well as data management system and methodologies to support sustainable growth and enhance the nation's competitiveness.



One of TIIS's important missions is the establishment of the **National Life Cycle Inventory (LCI) Database for Sustainable Development**. Thai National LCI Database has been created, containing data of resource utilization and emission into the environment for the production of a particular product or activity. National LCI Database for Sustainable Development will serve as a national infrastructure containing LCI information of various sectors including natural gas, oil refinery, petrochemical, agriculture and food, and transportation groups. TIIS has also been involved in the development of the Global LCA Data Access

network (GLAD). Datasets from Thailand will soon be shared for global access through GLAD.

Thai National LCI Database has been used extensively by organizations in both public and private domains. The database supports various government initiatives such as green growth policy, green public procurement, green GDP assessment and the Bio-Circular-Green Economy (BCG) national agenda. The database also helps manufacturers improve the production process to achieve green manufacturing and obtain an environmental label.



Thailand Science Park: The First Innovation Hub in Thailand



For nearly two decades, **Thailand Science Park** serves as a major S&T infrastructure supporting the long-term national economic and social development. The initiative to establish the first science park in Thailand was conceived around 1985. A feasibility study was conducted with the support of United Nations Fund for Science and Technology for Development. The Thailand Science Park project was approved by the cabinet in 1989 and NSTDA was assigned to lead the development. A 7-billion THB budget was allocated to the project – 4 billion for construction and 3 billion for S&T equipment procurement. The park was built on an 80-acre land adjacent to Thammasat

University Rangsit Campus and the Asian Institute of Technology (AIT). Thailand Science Park officially opened in 2002.

Thailand Science Park houses NSTDA headquarters, NSTDA's five national research centers – BIOTEC, MTEC, NECTEC, NANOTEC and ENTEC, pilot plants, testing laboratories and incubator space. With fully integrated services to support technology businesses and companies, Thailand Science Park is currently the base of more than 100 leading local and multi-national companies. Majority of companies are in automation, robotics & intelligent system sector and food & agriculture sector. Examples include an electronics board developer and manufacturer Gravitech Thai (Thailand), Grenades Biotech specializing in natural products for livestock industry and CP Food Lab conducting R&D and providing microbial testing service in food products. International presence at Thailand Science Park is also very strong with the opening of Kyoto University ASEAN Center and Haydale Technologies Thailand - a subsidiary of the UK-based Haydale Group - for graphene research.

Eastern Economic Corridor of Innovation: New Innovation Hub for Thailand and ASEAN



The Thai Government has established a special development zone called the Eastern Economic Corridor or EEC which covers three provinces in eastern Thailand namely Rayong, Chonburi, and Chachoengsao. The EEC is designed to be a new hub for trade, investment, regional transportation, and a strategic gateway for commerce and trade in ASEAN. In addition, the site serves as a focal point for the development of 10 strategic industries that will become the “New Engines of Growth” to drive the nation’s economy. In order to support innovative research and development in the EEC, the **Eastern Economic Corridor of Innovation (EECi)** was initiated and NSTDA was designated to spearhead the development. Built on a vast 1,365-acre land in Rayong province, EECi offers a complete ecosystem for innovation and a new economic estate to translate research to commercialization with comprehensive activities in R&D, technology demonstration, technology evaluation and technology localization, focusing on 6 industries: 1) modern agriculture, 2) biorefinery, 3) high performance battery and modern transports, 4) automation, robotics and smart electronics, 5) aviation and unmanned aerial vehicle (UAV), and 6) medical devices.

Construction of Phase 1 commenced in 2019 with the following progress.

1. **BIOPOLIS – Innovation Platform for Bioindustry.** The facilities will include Biorefinery Pilot Plant - expected to open for business in early 2024, Smart Greenhouse and Smart Farming Demo Site.
2. **ARIPOLIS - Innovation Platform for Automation, Robotics, and Smart Electronics Industry.** Sustainable Manufacturing Center (SMC) is being built to serve as a demonstration center for smart manufacturing and a platform bringing together stakeholders to collaborate through available tools and facilities. SMC is expected to open in mid 2022.
3. **SPACE INNOPOLIS - Innovation Platform for aerospace and aviation.** NSTDA is working with partners to develop a UAV sandbox.
4. **Synchrotron Light Source.** The synchrotron light source facility – the second one in Thailand - is being designed and the construction is expected to commence in 2022.

In addition to scientific infrastructure, EECi also operates platforms applying technology and innovation to strengthen communities and enterprises in the surrounding area. A total of 294 SMEs and startups have been assisted, resulting in a 201 million-THB profit increase and a 54 million-THB enterprise investment in technology and innovation. The platform has transferred knowledge and technology in agriculture to 191 farming communities and supported S&T education program benefiting 7,400 students in eastern Thailand. A new Deep Tech Acceleration Program will be launched in mid 2022.

Advancing Research to Market through IP Licensing

Technology Licensing Office (TLO) is responsible for IP policy development, filing and management of intellectual properties created by NSTDA and its national research centers – BIOTEC, MTEC, NECTEC, NANOTEC and ENTEC. TLO is a contact point for accessing NSTDA IP for licensing. The office also provides consultancy in IP policy and management to researchers in partner organizations.



NSTDA TLO has a number of technologies ready for licensing in the areas of food and agriculture, wellness and medicine, energy and environment, computer and software, manufacturing and service industry, polymer, textile and chemical industry. Examples include multifunctional fabric coating providing antibacterial property, UV protection and water repellence; biodiesel production catalyst derived from eggshell called Eco-Catal; Smart E-Nose; an onsite microbial reactor (OMR) for the production of microorganisms used in the wastewater treatment system; geopolymer composite aerated bricks and lightweight materials from glass waste.



Promoting Local Innovation with Government Procurement Program



To support local enterprises engaging in the commercialization of local innovations, the Government Procurement Program was introduced in 2015. NSTDA was tasked to lead the establishment of **Thai Innovation List** containing innovations (products and services) entitled to the fast-track treatment in the government procurement process. Government agencies are required to spend at least 30% of their budget purchasing goods and services on the Thai Innovation List.

Products and services qualified for Thai Innovation List must originate from R&D performed in Thailand and meet the requirements of applicable quality and safety standards. The innovations passing the technical evaluation by NSTDA and pricing assessment by the Budget Bureau are published in Thai Innovation List by the Budget Bureau for a maximum of 8 years.

As of December 2020, Thai Innovation List contains a total of 462 items. KEEEN is an example of



products on the list. It is a multi-purpose bio-based cleaning and bioremediation product, derived from a research project screening for oil-degrading bacteria.

Facilitating Technology Financing with Thailand Technology Rating System



NSTDA initiated the development of **Thailand Technology Rating System (TTRS)** which serves as a tool to evaluate a company in terms of technology and innovation, management, marketability and business prospect. TTRS helps Thai tech companies realize their business capability and potential and improve access to finance.

TTRS is modeled after KOTEC Technology Rating System (KTRS), through the knowledge transfer and collaboration received from KOTEC, short for Korea Technology Finance Corporation, starting in 2014. NSTDA launched the technology rating service on 1 March 2018.

The technology appraisal is performed by a team of experts with knowledge and experience in technology and innovation, finance, business and management. The rating results help companies realize their strengths, weaknesses and business opportunities so that they can seek necessary support in business, technology and finance to make improvement and accelerate their journey to success. Through TTRS program, companies also gain access to financial and non-financial assistance programs.



MANPOWER DEVELOPMENT

NSTDA implements a range of human resource development programs to serve various purposes, ranging from inspiring young children to pursue S&T education, to developing S&T workforce for new industry and upgrading skills of S&T workforce. Several strategies and mechanisms are devised to effectively carry out this mission such as providing scholarships and fellowships in certain disciplines, building partnership with academic institutes to develop new graduate programs in response to industry's need, employing new technologies to encourage creativity and learning ability, as well as using Sirindhorn Science Home as the learning center for developing human resources in science and creating science awareness.

Nurturing the Best and the Brightest



Junior Science Talent Project (JSTP) aims to groom high potential students into top scientific talents. Every year, approximately 100 gifted students are recruited from a national open call to participate in JSTP that helps develop their scientific skills through activities such as science camps, science project contests and mentoring programs by top scientists from NSTDA and



universities. After one year, top 10% of these students, called genius, are provided with long-term scholarships and mentorship by top scientists until completing PhD education. Since its inception in 1998, JSTP has nurtured a total of 2,394 gifted students and 347 geniuses. More than 50% of these students are working in the science and technology fields.



Assoc. Prof. Nuttee Suree, JSTP Year 1, completed PhD study in biochemistry and molecular biology from the University of California, Los Angeles. He is now teaching at the Department of Chemistry, Chiang Mai University, with research interest in HIV drug development. Nuttee also became a mentor to young JSTP students, including Mr. Patcharapong Thangsunan, JSTP Year 9, who was the 2nd runner-up of the Merck Young Scientist Award 2015 and is now a postdoctoral researcher of the Department of Veterinary Microbiology, Chulalongkorn University.



Dr. Thanyaporn Wongnate, JSTP Year 4, obtained her PhD from the Department of Biochemistry, Mahidol University and completed her post-doctoral study in biological chemistry from the University of Michigan. Currently a faculty member of School of Biomolecular Science & Engineering at Vidyasirimedhi Institute of Science and Technology (VISTEC), Thanyaporn was awarded the 2019 L'Oréal Thailand For Women in Science Fellowship.



Dr. Charupong Saengboonmee, MD, JSTP Year 9, received his PhD and MD from Khon Kaen University. He is currently a lecturer and researcher at the Department of Biochemistry, Khon Kaen University. Charupong was among young Thai scientists selected to participate in the 63rd Lindau Nobel Laureate Meeting in 2013 and received a prestigious Prince Mahidol Award Youth Program Scholarship that sponsored his research study at the Department of Genetics, Harvard Medical School and the Dana-Farber Cancer Institute in 2020.



Assoc. Prof. Taweetham Limpanuparb, JSTP Year 4, obtained his doctoral degree in chemistry from Australian National University. He was the winner of Young Scientist Competition (YSC) and National Software Contest (NSC) for three consecutive years from 2002-2004 and received a Special Award presented by the Association of Computing Machinery at the 2004 Intel International Science and Engineering Fair (ISEF). Currently the Program Director of Chemistry, Mahidol University International College and JSTP mentor, Taweetham was the recipient of the 2020 Young Scientist Award presented by the Foundation for the Promotion of Science and Technology under the Patronage of His Majesty the King.

Encouraging University Students to Do Research



Initiated in 2005, **Young Scientist and Technologist Program (YSTP)** aims to promote career path in research and development by providing research fund to 4th-year university students to conduct senior projects under the co-supervision of NSTDA researchers and university faculty members. Over a 15-year period, YSTP has supported 671 students from 38 universities (as of 2020). Records have shown that 45% of YSTP students have pursued graduate studies and many have become successful in their S&T career.



Dr. Teerapong Yata is a lecturer at the Faculty of Veterinary Sciences, Chulalongkorn University and former researcher at NANOTEC-NSTDA. He was awarded Young Scientist 2019 and Young Technologist 2020 (group category), both by the Foundation for the Promotion of Science and Technology under the Patronage of His Majesty the King. As an alumnus of Imperial College London, Teerapong was honored with UK Alumni Awards 2019 (Entrepreneurial Award).



Mr. Poramin Insom earned his master's degree in cyber security from Johns Hopkins University. He founded Satang Corporation, a digital asset exchange operator in Thailand with ISO /IEC 27001:2013 certificate, and established Thailand Digital Asset Exchange (TDAX), an online platform for buying, selling, transferring, and storing digital currency.

Leveraging Capacities of NSTDA and Universities for Manpower Development

With over 300 PhD researchers, 30 research units and 32 joint laboratories located at universities throughout Thailand, NSTDA brings its strength to fortify S&T graduate programs in Thailand through **Thailand Graduate Institute of Science and Technology (TGIST)**. TGIST offers scholarships for university students to study in the master's and doctoral programs under the co-supervision of NSTDA researchers and university faculty members. Since 1998, TGIST has produced 812 graduates. As of 2020, 392 TGIST alumni were working in the field of S&T as researchers, lecturers or technologists in the public and private enterprises and 221 were pursuing higher education. TGIST is proud to help build a career of young talents to support the national S&T development.





Dr. Prasit Thongbai, a TGIST alumnus, is an associate professor at the Department of Physics, Khon Kaen University. His achievements include 2013 Young Scientist Award (Physics) presented by the National Research Council of Thailand (NRCT), 2019 TRF-OHEC-SCOPUS Research Award for Mid-career Scholar (Physical Sciences) and 2017 The World Academy of Science (TWAS) Physics Prize for Young Scientists in Developing Countries. Prasit later served as an advisor to six TGIST students.



Dr. Nattapon Chantarapanich received a YSTP grant during his undergraduate study and a TGIST scholarship for his doctoral study. He is currently an associate professor at the Department of Mechanical Engineering, Faculty of Engineering at Sriracha, Kasetsart University. He is a co-inventor of “Patient Specific Drill-Guide for Assisting Shoulder Arthroplasty Surgery” winning a silver medal at the 43rd International Exhibition of Inventions Geneva in 2015. In collaboration with an MTEC researcher, Nattapon co-supervised two YSTP students and three master’s degree students under STEM program.



TGIST scholar **Ms. Sirikorn Kitiyodom** is currently a PhD candidate at the Faculty of Veterinary Science, Chulalongkorn University under the co-supervision of YSTP alumnus Dr. Teerapong Yata and Assoc. Prof. Nopadon Pirarat. Their work on mucoadhesive-enhanced immersion fish vaccine against a columnaris disease in red tilapia won two awards at the Higher Education Innovation Contest organized by the National Research Council of Thailand (NRCT) in 2020 and the 2020 Young Technologist (group category) award presented by the Foundation for the Promotion of Science and Technology under the Patronage of His Majesty the King. The technology has been patented and licensed to a company.

Building Skilled Workforce through International Programs

TAIST-Tokyo Tech is a graduate program established in 2007 under the collaboration between NSTDA, Thai universities and Tokyo Institute of Technology (Tokyo Tech), with a prime objective to produce world-class researchers and high-level engineers. Thai universities joining TAIST-Tokyo Tech are King Mongkut’s Institute of Technology Ladkrabang, Sirindhorn International Institute of Technology, King Mongkut’s University of Technology Thonburi and Kasetsart University. TAIST-Tokyo Tech currently offers three master of engineering programs representing the future



trends: automotive and advanced transportation engineering, artificial intelligence and internet of things, and sustainable energy and resources engineering. In addition to coursework, students also work on research projects in NSTDA laboratories under the support and direction of NSTDA researchers.

JAIST–NSTDA–SIIT is a dual doctoral degree program offered by Sirindhorn International Institute of Technology (SIIT) and Japan Advanced Institute of Science and Technology (JAIST), aiming to produce workforce in the areas of science,



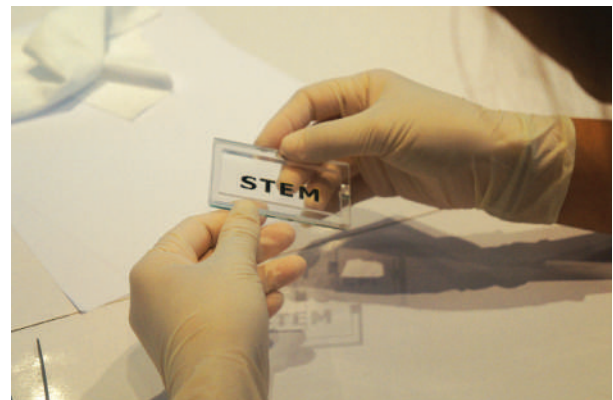
engineering and technology management. NSTDA researchers serve as co-supervisors to students' dissertations alongside faculties of JAIST and SIIT.

Preparing Workforce for Advanced Industry

STEM Workforce is a program aiming to produce STEM professionals to meet the requirements of 10 S-curve industries – first S-curve and new S-curve - targeted by the government. The 5 first S-curve industries are next-generation automotive, smart electronics, affluent & wellness tourism, agriculture & biotechnology, and food processing, whereas the 5 new S-curve industries include robotics, aviation & logistics, biofuels & biochemicals, digital, and medical hub. The program provides grants to master's and doctoral

students and faculties to conduct joint projects in collaboration with industry partners in 10 target industries.

The program was implemented in 2017-2018, during which 273 grants were provided. In addition to preparing qualified workforce for target industries, the program also helps build sustainable networks of academia, NSTDA and industry to facilitate the development of innovation-driven economy.



Inspiring Young Talents with World-Class Enrichment Programs



As an avid patron of science education, HRH Princess Maha Chakri Sirindhorn has initiated several programs giving young talents an exposure to world-class scientists and top-notch research under the Information Technology Foundation under the Initiative of HRH Princess Maha Chakri Sirindhorn which is implemented by NSTDA in its capacity as the foundation secretariat.

Princess Sirindhorn's visits to CERN, the European Organization for Nuclear Research, has forged invaluable collaboration between CERN and Thai academic and research institutes, resulting in capacity building of Thai research community in the field of physics. Activities include the participation of Thai students and teachers in **CERN Summer Programs for Student and High School Teacher**, scientific meetings, a fellowship program sending Thai students and researchers to perform research at CERN and multiple academic and research agreements between CERN and Thai institutes.

On the occasion of her visit to the Deutsches Elektronen-Synchrotron (DESY) - German Electron



Synchrotron – on 21 August 2002, Princess Sirindhorn was presented with scholarships for Thai students to participate in **DESY Summer Student Program**, an annual program offering undergraduate students in physics and natural science disciplines from around the world an opportunity to take part in research activities of DESY research laboratories. Since then, NSTDA and the Synchrotron Light Research Institute jointly select Thai university students to attend the DESY Summer Student Program every year, and 49 students have been presented with this unique opportunity.

Princess Sirindhorn's passion in science education inspired NSTDA to establish a scholarship program for science students and young scientists from Thailand to participate in **Lindau Nobel Laureate Meetings**, an annual scientific conference held in Lindau, Germany, inviting Nobel prize winners to present to and interact with young researchers from all over the world. Since the inception of the scholarship program in 2009, a total of 69 students, young lecturers and scientists have represented Thailand at the prestigious event.

Permanent Science Camp

In 2005, the cabinet approved NSTDA's proposal to establish a permanent science camp at Thailand Science Park. **Sirindhorn Science Home**, named after Princess Sirindhorn, opened in 2009.

Sirindhorn Science Home is fully equipped with facilities for hosting science camps, training workshops and exhibitions, including houses for visiting professors, student dormitory, exhibition



hall, lecture and workshop rooms, Fabrication Lab, plant biotechnology laboratory and recreational sports facility. More than 10,000 students participate in science and technology learning activities at Sirindhorn Science Home annually.

Sirindhorn Science Home served as a site for Cozy Mark IV Thailand Project. Cozy Mark IV is the first aircraft designed and built by Thai students. The project took 7 years to complete, involving 3,105 secondary-school students from around the country in developing the body structure, installing the engine and completing the electrical and



electronic systems. Cozy Mark IV aircraft was presented to Rajamangala University of Technology Krungthep in 2017 to serve in an aircraft-maintenance crew training course offered by the university. During the COVID-19 pandemic in 2020, over 3,000 3D-printed face shields were manufactured in the Fabrication Lab for hospitals and health centers. A number of major international activities were held at Sirindhorn Science Home, including the 4th APEC Youth Science Festival (AYSF 2011), the Asian Science Camp 2015 (ASC 2015) and the 15th Asia Pacific Conference on Giftedness (APCG 2018).



Learning Science beyond the Classroom



Thailand Children's University Project was initiated in 2011 with an aim to encourage youths in primary and secondary schools to become involved in science-learning activities by creating awareness of the importance of science studies and developing science teaching. The project was piloted by adapting the curriculum designed by Prof. Dr. Katharina Kohse-Höinghaus of Bielefeld University, Germany.

Since 2015, Chevron Enjoy Science has been a primary sponsor of Thailand Children's University

Project which is now actively run by a network of 19 universities throughout the country, along with NSTDA and the Institute for the Promotion of Teaching Science and Technology (IPST). New experiments are regularly created by the network members, some of which have been further re-designed for youths with disabilities.

Prompted by the COVID-19 pandemic, NSTDA established a website called Fun Science @Home by NSTDA (<https://www.nstda.or.th/sciencecamp/funscience/>), compiling science experiments that kids could do at home safely with their families.



Expanding Creativity with Science Contests



Contests are a platform that NSTDA creates for children to exercise their creativity and innovation. In 1994, NECTEC-NSTDA started a software contest which turned into the **National Software Contest (NSC)** in 1999. Winners of NSC are supported to enter international contests including the Asia Pacific ICT Alliance (APICTA) Awards.

In 1998, NECTEC-NSTDA launched **Young Scientist Competition (YSC)** expanding the scope to encompass all scientific disciplines and engineering. Every year, YSC is organized in four regions of Thailand and regional winners compete in Bangkok for the national title. National winning teams represent Thailand at the International Science



and Engineering Fair in the US – known as Intel ISEF or Regeneron ISEF since 2020.

Thailand Robot Design Camp (RDC Thailand), previously known as Robot Design Contest, is an annual program operated by MTEC-NSTDA in collaboration with Chulalongkorn University, Chiang Mai University, Prince of Songkla University and Suranaree University of Technology and supported by the Electricity Generating Authority of Thailand (EGAT) and Pantip Plaza. Since 2008, RDC Thailand has been participated by 1,813 students from 76 colleges and universities. A total of 78 RDC Thailand winners have participated in the International Design Contest RoBoCon (IDC RoBoCon).

Reskilling and Upskilling Workforce for Future Industries

Career for the Future Academy has primary mission to provide comprehensive training and advanced professional development in science and technology. The academy was originated from NECTEC industry software development project in 1988, evolving into NECTEC training unit in 1994 and NSTDA Academy in 2010. In 2019, the new name called Career for the Future Academy was adopted.

Career for the Future Academy offers public classes, e-learning courses, Information Technology Professional Examination (ITPE), and tailor-made courses. The academy strives to develop courses dealing with advanced technology and best practices taught by experts in the fields for S&T professionals working in public and private sectors



to refresh and upgrade their knowledge. “Mastering Vertical Farming System in 2 Days” is an example of available courses.



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