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Ministry of Higher Education, Science, Research and Innovation

สวทช NSTDA

ANNUAL REPORT 2018

National Science and Technology Development Agency

This report is prepared according to the 2018 fiscal year of
the Royal Thai Government, from 1 October 2017 – 30 September 2018.

Annual Report 2018

National Science and Technology Development Agency

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NATIONAL SCIENCE AND TECHNOLOGY DEVELOPMENT AGENCY (NSTDA)

The National Science and Technology Development Agency (NSTDA) was established in 1991 under the National Science and Technology Development Act 1991. The agency is affiliated to the Ministry of Higher Education, Science, Research and Innovation and reports to the NSTDA Governing Board, chaired by Minister of Higher Education, Science, Research and Innovation.

VISION

To be a key partner for a knowledge-based society through science and technology.

CORE VALUES

N — Nation First

act in nation's best interest, be socially responsible and dedicated to the common goal

S — Science and Technology Excellence

committed to excellence, culminating from curiosity, initiative and creativity, in every aspect with the highest standards

T — Team Work

work cooperatively, be open to criticism and play a constructive role, subscribe to two-way communication

D — Deliverability

deliver quality output as promised, contribute to a stimulating and agile workplace

A — Accountability and Integrity

adhere to morality, ethics and transparency; stand up for a good cause

CONTENTS

MESSAGE FROM NSTDA BOARD CHAIRMAN

Ministry of Higher Education, Science, Research and Innovation (MHESI) is a main driver to transform Thailand into an innovation-driven economy. In the past year, the ministry implemented policies and actions in accordance with the 20-year National Strategy and Thailand 4.0, two main policies aiming to transformThailand into the 21st century with the key element of developing people and technologies. The ministry's top priority is to promote technology development and utilization and therefore our S&T programs are being employed to create jobs, reduce disparity, strengthen the nation and enhance the country's competitiveness. In addition, we ensure that science, technology and innovation truly provide solutions and can be applied to the real world, resulting in tangible impacts. The ministry also fosters public-private partnership towards sustainable development and to lead Thailand out of middle-income trap.

As a leading science and technology agency, NSTDA has played an important role in creating valuable innovations that benefit Thai economy and society. A number of NSTDA innovations have been widely adopted by the industry, agricultural sector and local communities. These achievements demonstrated NSTDA's commitment to its four missions, namely to perform research, development, design and engineering that will result in applicable innovations for advancing the economy and society, as well as develop human capital and infrastructure to enhance the nation's competitiveness and for sustainable development.

On behalf of NSTDA Governing Board, I would like to congratulate NSTDA on its continual success in promoting Thailand's science and technology, and hope that NSTDA will continue to be a major pillar guiding the nation to attain Thailand 4.0 vision and leading the country to stability, prosperity and sustainability.

(Dr. Suvit Maesincee)
Minister of Higher Education, Science, Research and Innovation
Chairman of NSTDA Governing Board

MESSAGE FROM NSTDA PRESIDENT

The Thai Government has set a clear vision in the 20-year National Strategy to employ science, technology and innovation (STI) to drive the country's economy and society. NSTDA is committed to strengthen STI in all sectors in the Thai society as reflected in our vision to be a key partner for a knowledge-based society through science and technology and our missions to conduct research, development, design and engineering; transfer technologies; promote manpower development; and establish and maintain S&T infrastructure. Throughout FY 2018, we continued to deliver useful innovations in five targeted areas, creating an impact of over 45 billion baht. NSTDA also employed our expertise in research and technology management to support the Government's initiatives such as Big Rock Project.

Prompted by rapid changes in economy, society, environment and technologies at the global scale, NSTDA has adjusted our strategy to direct our expertise in five core disciplines to effectively drive 10 technology development groups (TDGs). We plan to establish five new centers to serve as "National Science and Technology Infrastructure" -- National Biobank of Thailand, National Omics Center, NSTDA Supercomputer Center, Center for Cyber-Physical System and Technology and Informatics Institute for Sustainability – as well as set up "National Quality Infrastructure (NQI)" for testing and certification that meet international standards in order to expedite the exports of Thai products. Our strategy also aims to create an innovation ecosystem, build up capacity of entrepreneurs and startup companies and promote the utilization of technologies in local communities and society.

I would like to express my appreciation to all NSTDA staff for their hard work and creation of innovations that make real impact to our economy and society. NSTDA is fully committed to work collaboratively with our partners to unlock STI potential to support every sector and lead Thailand out of middle-income situation into Thailand 4.0 era with stability, prosperity and sustainability.

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

EXECUTIVE SUMMARY

The National Science and Technology Development Agency (NSTDA) is committed to develop capability in science and technology and employ innovation to attain Thailand 4.0 vision. In FY 2018, NSTDA's key performance highlights are as follows:

Research, Development and Technology Transfer. NSTDA published 546 articles and over one-fourth of these publications were in world-class journals and cited more than the national average. There were 383 applications for intellectual property rights and 261 technology transfer projects with 335 recipient organizations. The agency was able to generate a 45-billion-baht economic and social impact and was instrumental in a 14-billion-baht investment in science, technology and innovation made by manufacturing and service sectors.

These are some research highlights in five targeted areas in 2018.

- Functional Ingredient & Food Innovation: eLysozyme™: Food Preservative Derived from Egg White and Food Texturing Agent.
- Modern Transportation: Electric-vehicle Battery Prototype and Lithium-ion Battery Testing Services.
- Health & Quality of Life: Captioned Phone Service and Remote Real-time Transcription System.
- Biochemical & Biofuels: H-FAME Technology and Wastewater Treatment System for Biogas Production.
- Innovation for Sustainable Agriculture: Mobile Application for Diagnosing Rice Diseases and Genome-wide Association Mapping of Virulence Gene in Rice Blast Fungus.

In addition, NSTDA also took part in the Big Rock Project which was established by the Thai Government to support initiatives to employ science, technology and innovation to build quality human capital, tackle poverty and enhance economy. Initiatives carried out by NSTDA include Coding at School Project to enhance coding skill among young Thai generation; Fabrication Lab Project to develop activities for students and teachers to acquire creativity and skills in design, research and engineering; Establishment of National Biobank of Thailand and Plant Factory to support sustainable development and enhance competitiveness; and Promotion of DentiiScan, a locally developed and manufactured 3D dental scanner, in Thai Hospitals.

Competitiveness Enhancement. NSTDA implements several incentive programs to promote R&D investment in the private sector. Thailand Tech Show, the flat-rate 30,000-baht technology disclosure fee program, has attracted 485 applications for technology license. A total of 404 projects were certified for 300% R&D tax exemption program with the total value of 1,313 million baht. For the Innovation List, NSTDA committee has approved 270 innovations and 226 of these have been published in the Innovation List. Startup Voucher program has disbursed

64-million-baht fund to 87 business operators to be used towards marketing activities, resulting in 915-million-baht earnings made by those businesses. The Innovation Technology Assistance Program (ITAP) has supported 1,610 SMEs in Thailand. With an investment of 730 million baht, ITAP has generated over 3.039-billion-baht impact. NSTDA testing centers and labs have performed over 50,000 tests, worth approximately 125 million baht. Electrical and Electronic Products Testing Center (PTEC), one of NSTDA testing centers, has been listed as the testing laboratory for the electrical and electronic equipment for ASEAN member countries according to the ASEAN Sectoral MRA for Electrical and Electronic Equipment (ASEAN EE MRA).

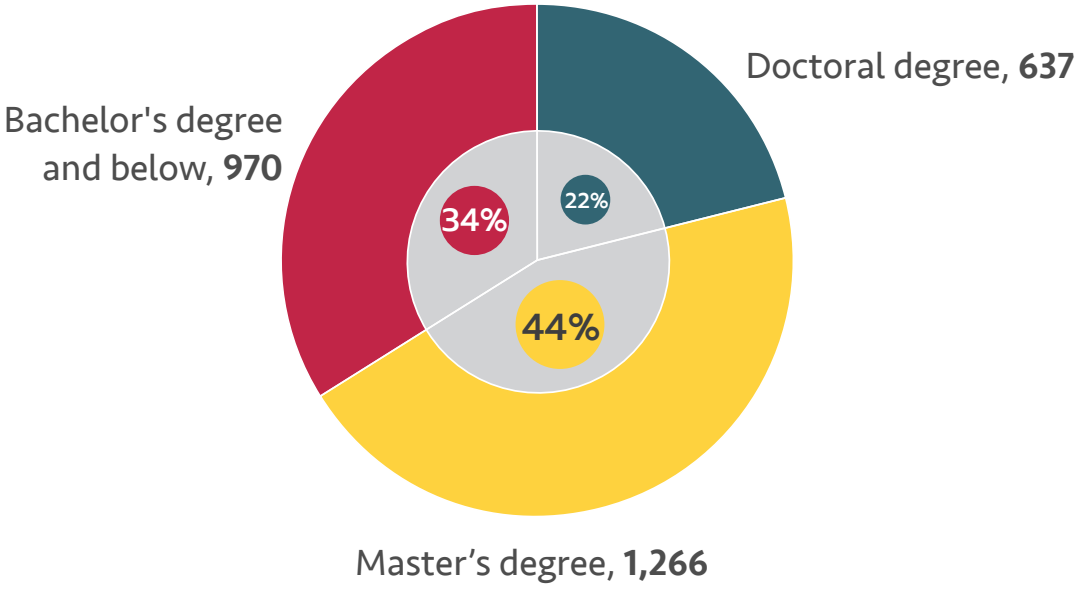
Technology Transfer to Farming Communities. NSTDA carried out the transfer of technologies to 6,781 farmers in 264 communities in 42 provinces. Examples of activities included technologies for cassava productivity improvement and an entrepreneurial bootcamp for rice-processing community enterprises. A project to upgrade skills of organic farmers in Ban Nong Mang village, Ubon Ratchathani province was participated by 825 farmer leaders and entrepreneurs who will ensure the sustainability of this endeavor.

STI Human Resource Development. A total of 790 scholarships have been granted to develop students and science professionals to boost the quality and quantity of manpower in science, technology and innovation. NSTDA national research centers hosted 324 students and non-NSTDA research staff from Thailand and overseas in their laboratories in 2018. In addition to its normal programs, NSTDA also hosted the 15th Asia-Pacific Conference on Giftedness in 2018.

Management and Promotion of Innovation Hubs. NSTDA is committed to nurture and grow tech-related companies located in Thailand Science Park. Examples of tenants include T-NET Co., Ltd. (an internet security service provider); Betagro Science Center (a research center of Thailand's leading agribusiness conglomerate); Diagnostic Lab of Zoetis Thailand (a global animal health company); ASEAN Polyplastics Technical Solution Center (an ASEAN center of a Japanese manufacturer of engineering plastics). NSTDA has been entrusted by the Thai Government to establish the Eastern Economic Corridor of Innovation (EECi) and lead the activities of BIOPOLIS and ARIPOLIS through the coordination with local and international partners. The EECi masterplan and the construction plan of Phase 1A have been developed. To strengthen companies and communities in the EECi area, NSTDA worked with 101 SMEs and 63 communities to enhance their technological capacity.

These are just some examples of our work derived from collaborative effort of NSTDA staff and our partner organizations. Our goal is to develop innovations that will improve the quality of life of Thai people and enhance competitiveness of our agricultural, manufacturing and service sectors.

HUMAN RESOURCES (AS OF 30 SEPTEMBER 2018)



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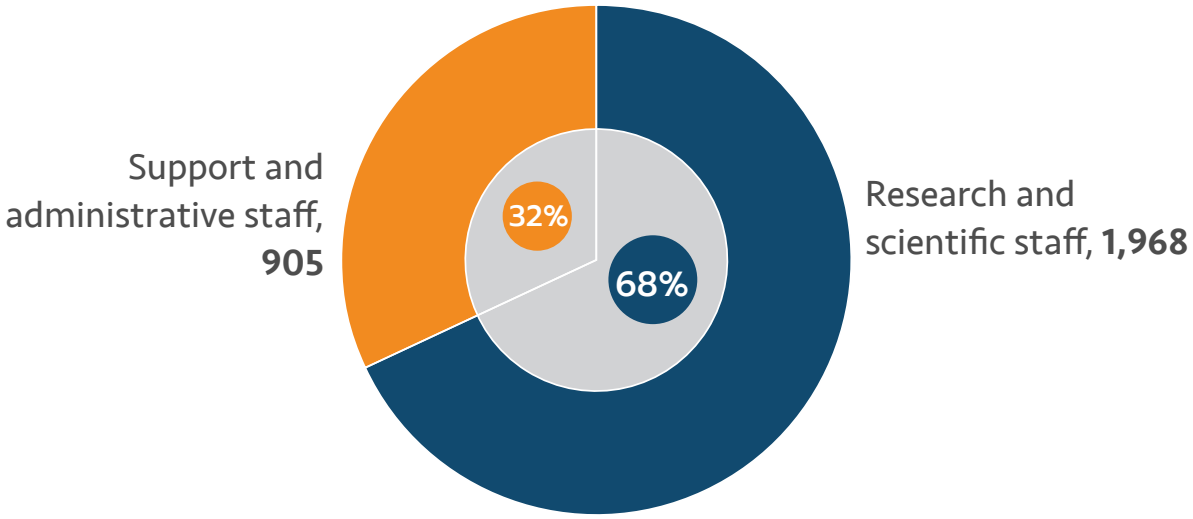
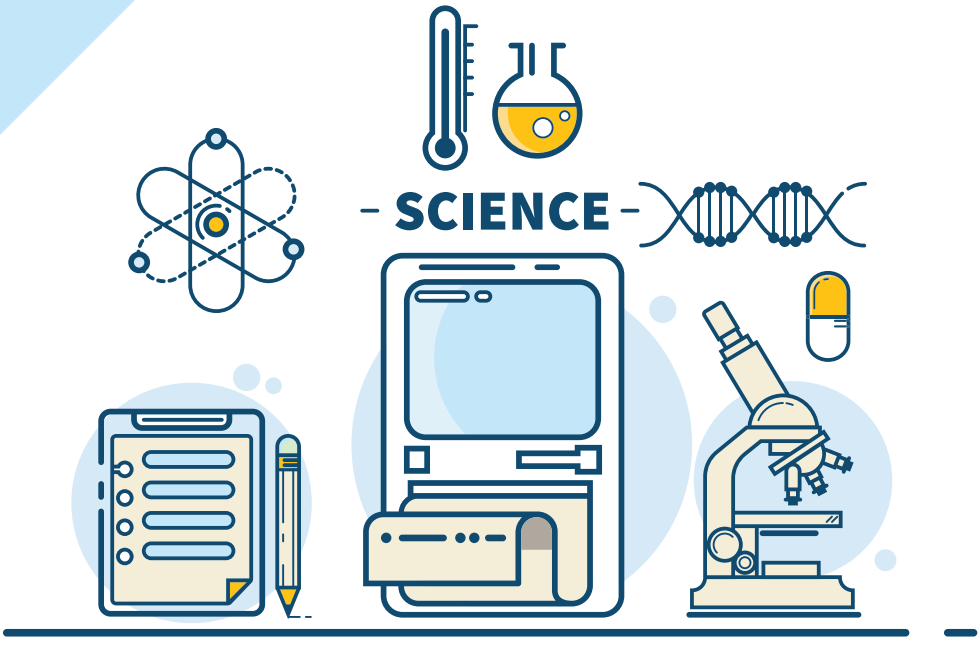


By job function

RESEARCH, TECHNOLOGY AND INNOVATION



FUNCTIONAL INGREDIENT & FOOD INNOVATION

Functional Ingredient & Food Innovation

eLysozyme™: Food Preservative Derived from Egg White Protein

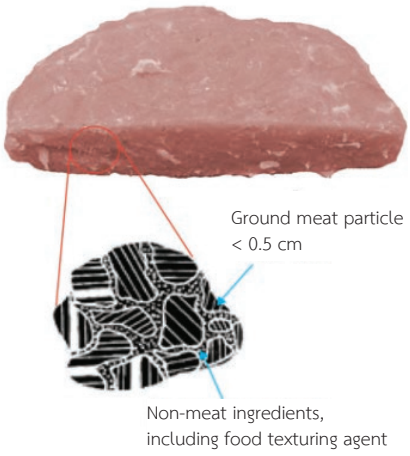
Lysozyme is a type of protein found in egg white and functions as a protection for the embryo from pathogens. Lysozyme has been used as a natural preservative in the food industry. It is considered safe for consumption by the Food and Agriculture Organization (FAO), the World Health Organization (WHO) and relevant authorities in several countries in Europe and Asia, and has been approved for applications in food, medicine and some types of therapy.

Naturally, chicken egg white lysozyme is most effective against gram-positive bacteria and lactic acid bacteria. Research team from BIOTEC-NSTDA was able to develop lysozyme extracted from chicken egg white to be effective against both gram-positive and gram-negative bacteria, thus covering a wide spectrum of foodborne pathogens, bacteria causing food spoilage, as well as zoonotic and aquatic pathogens. This technology has been licensed to DMF (Thailand) Company Limited and Ovo Foodtech Company Limited for commercialization. Two commercial products have been released to the market -- eLysozyme™ (eLYS-T1) for food preservative and eLysozyme™ (eLYS-T2) for feed preservative.

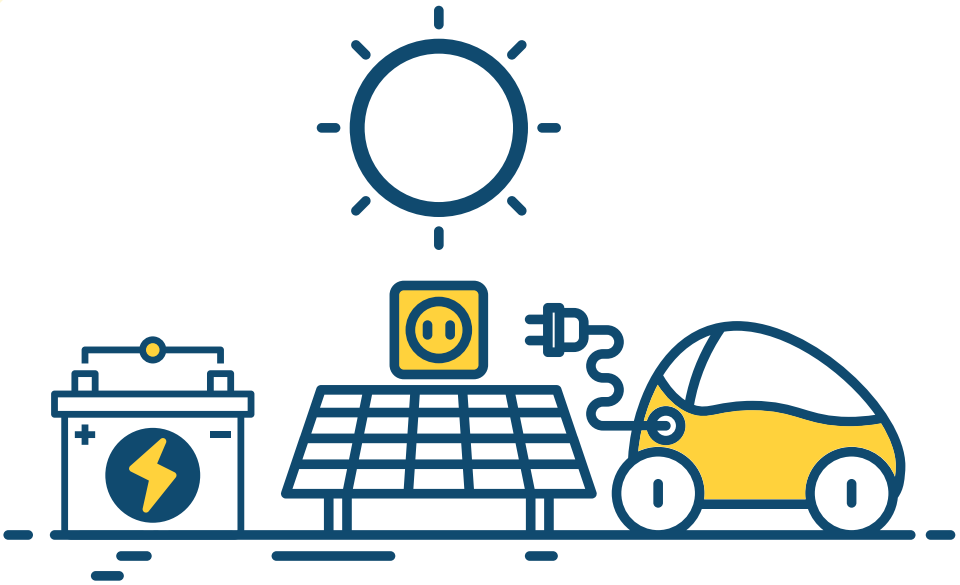
Food Texturing Agent

Research team at MTEC-NSTDA employed knowledge in food materials science to develop a food texturing agent for pre-cooked beef and pork patties. This hydrocolloidal texturing agent functions as a gelling and texturing agent, as well as a fat replacer. It was designed for ground beef and ground pork patties containing more than 70% meat by weight and less than 5% fat, making them more tender while maintaining the meaty texture and therefore suitable for people wearing braces or with orthodontic problems.

This technology is now being further developed in collaboration with a company into food products for the elderly, opening up an untapped niche market for Thai food industry.



MODERN TRANSPORTATION



Modern Transportation

Electric-vehicle battery prototype

Thailand automotive and auto parts industry is one of the top contributors to the country's GDP. As the global trend is moving towards clean technology and an electric vehicle (EV), NSTDA has set up research agenda to develop technologies used in EV, and one of the topics is EV battery.

NSTDA research team has developed a battery pack for an electric passenger vehicle. One battery pack contains 4 modules and 1,408 battery cells. It has a capacity of 228.8 ampere hours. When installed in an electric passenger vehicle, it can provide a range of 160 kilometers. As most of the battery components can be manufactured in Thailand, this innovation has great potential to support the development of Thai-made EV in the future.

The battery prototype, installed in a compact EV, is currently being evaluated and has been presented to the Thailand Automotive Institute, a co-sponsor of this project.

Lithium-ion Battery Testing Services

Thai government's commitment to promoting and supporting the electric vehicle (EV) industry has resulted in significant growth of this industry throughout the value chain, and EV battery industry is no exception. Although Thailand does not yet manufacture lithium-ion batteries, its battery pack assembly industry is on the rise. This expansion leads to substantial demand for battery testing services to ensure the product's safety during shipping and in consumer use, as this type of battery contains a highly flammable substance.

Electrical and Electronic Products Testing Center (PTEC) of NSTDA has established an array of testing services to support the growing EV industry. PTEC now offers testing services for safety and efficiency of lithium-ion battery cells and modules according to international standards, including UN ECE R100, IEC 62660, UL 2580, SAE J2929, RTCA DO-311 DO-160, ISO 12405-3 and IEC 62619, as well as requirements set by car manufacturers such as Toyota Motor, Honda Motor, BMW Motorrad and Ford Motor.

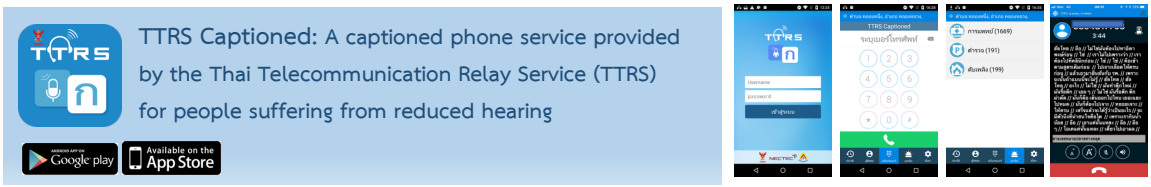
HEALTH
& QUALITY OF LIFE

Health & Quality of Life

Captioned Phone Service

Captioned phone service is designed to assist people suffering from reduced hearing to communicate with others more effectively on the phone. To use this service, people with reduced hearing place an outgoing call to a service center, where an operator connects the call to a person on the other end and transcribes the voice of people on the other end into text which is then displayed on the captioned telephone of people with reduced hearing. The service enhances the communication ability of people with reduced hearing by allowing them to have the full benefit of listening and have the captions for words they cannot hear clearly.

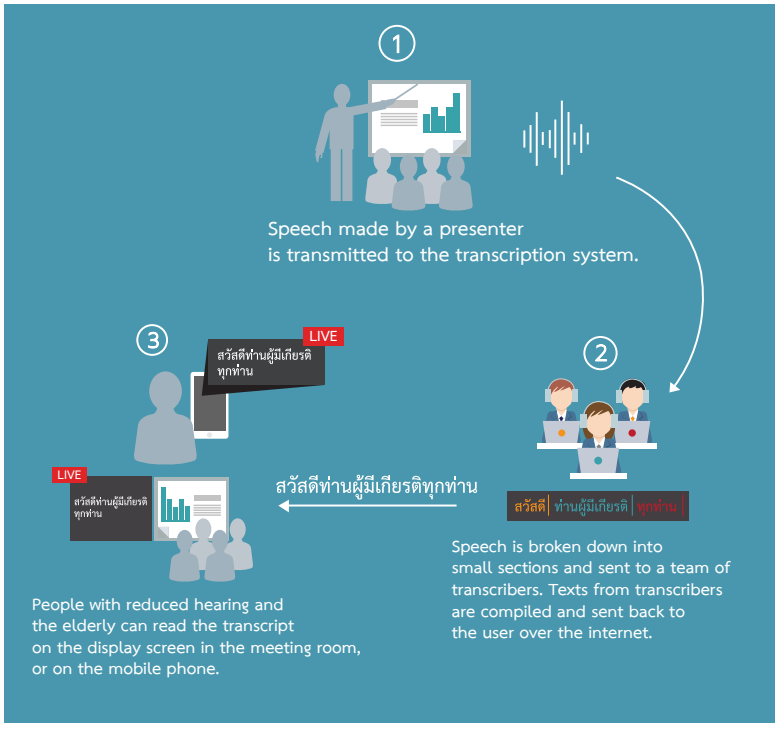
The system comes with special features such as interactive voice response (IVR), real-time text (RTT), real-time speech-to-text system and customer relationship management (CRM). This system has already been implemented at the Thai Telecommunication Relay Service (TTRS) where the captioned phone service has been made available.



Remote Real-time Transcription System

A remote real-time transcription system converts spoken speech into written text, enabling people with reduced hearing and the elderly to access a meeting or television programming more easily. With this system, voice is transmitted over the internet to a center, where speech is broken down into small sections and sent to a team of transcribers. The system then compiles text from transcribers, re-arranges the transcription accordingly, and sends the transcription back to the user over the internet. Users have options of viewing the text on a monitor provided in the meeting room, or on his/her mobile phone using a mobile application which can display text in a text-only mode or a video mode with superimposed text. The system can also be used with a subtitle feature on a television to provide closed captioning on digital television programming.

This remote real-time transcription system is currently available for trial in classroom and seminar settings, as well as closed captioning on digital television programming.



BIOCHEMICAL & BIOFUELS

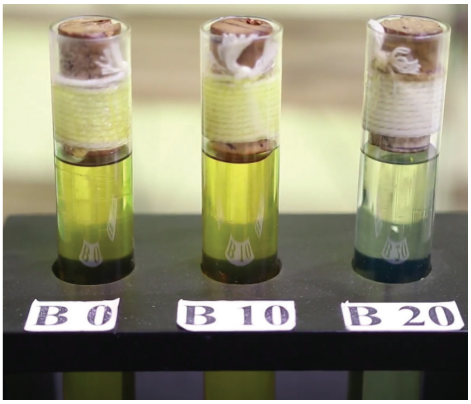
Biochemical & Biofuels

H-FAME Technology

With financial support from the Energy Conservation Fund, MTEC-NSTDA and the Department of Alternative Energy Development and Efficiency (DEDE) implemented a collaborative project to boost biodiesel blend. Currently, the maximum biodiesel blend in Thailand is 7% blend, or B7, but this number will soon be increased to 10%. To achieve the higher blend, the quality of pure biodiesel, B100, needs to be improved. The joint project therefore supported the use of H-FAME technology, an innovative technology that improves biodiesel quality, in the production of B100. H-FAME technology was developed under a Thai-Japanese project funded by Science and Technology Research Partnership for Sustainable Development (SATREPS) Program.

Under the joint MTEC-DEDE project, two companies were selected to implement a pilot-scale production of biodiesel with H-FAME technology. The quality of biodiesel was tested and met the requirements of Japan Automobile Manufacturers Association (JAMA). The biodiesel was blended to B10 for a 100K-km on-road test of 8 pick-up trucks. Feasibility study of H-FAME technology and long-term impact of B10 on cars were also investigated in this project.

H-FAME technology has been included in the Alternative Energy Development Plan 2015-2036 as a measure to increase biodiesel blend to B10 and even B20, supporting the Government's energy security policy.



Wastewater Treatment System for Biogas Production

Biogas presents high potential for alternative renewable energy for Thailand due to abundant availability of agricultural waste and high intensity of agroindustry. Biogas can be produced from a number of raw materials such as animal wastes and wastewater from agriculture and agroindustry.

BIOTEC-NSTDA has been engaging in research and development of biogas production technology and as a result has developed an anaerobic fixed-film reactor wastewater treatment system. Inexpensive and locally-made materials such as nylon nets or yarns are used to support the formation of biofilms containing microorganisms, and thus retaining microorganisms within the reactor to provide process stability. This system has demonstrated high efficiency in wastewater treatment and biogas production and requires much less space than a conventional open pond wastewater treatment system.

This anaerobic fixed-film reactor wastewater treatment system has already been installed in several types of industry, including cassava starch factories, palm oil factories and dry fruit/canned fruit factories. The system is resilient to the sudden change in temperature and types of wastewater and can accommodate wastewater with high level of suspended solids. The system is easy to maintain and does not create odor problem. Biogas produced can be used in place of fuel oil for boilers and electric generators.

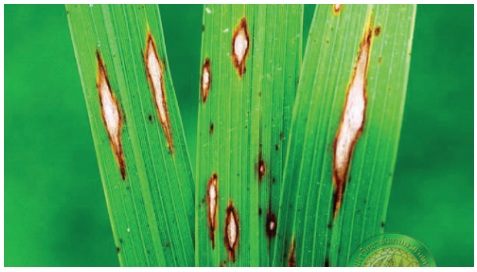
INNOVATION FOR SUSTAINABLE AGRICULTURE

Innovation for Sustainable Agriculture

Genome-wide Association Mapping of Virulence Gene in Rice Blast Fungus *Magnaporthe oryzae*

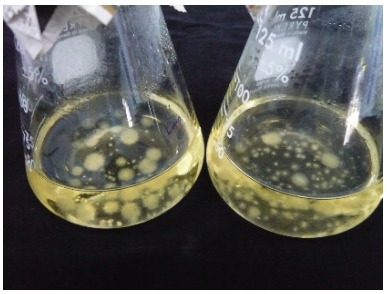
To improve broad and durable resistance of blast resistance in rice breeding program, BIOTEC-NSTDA is conducting a study to identify SNP associated with virulence genes in blast fungus corresponding to resistance genes in blast-resistant rice varieties through the analysis of association between genetic variation and disease reaction.

In this study, a genome-wide SNP discovery will be performed using genotyping-by-sequencing (GBS) technique on blast isolates infecting KDML105 and RD6 collected from different regions in Thailand. The SNP data will be used to elucidate the population structure of blast fungus. Moreover, leaf blast screening on rice varieties containing different of blast resistance genes will be performed under greenhouse condition to identify disease reactions for each isolate-rice variety pair. Disease reactions will be used in the analysis of the association between genetic relatedness and virulence of blast fungus by employing association mapping approach.



The information of genome regions associated with virulence in blast fungus will be useful to develop gene specific markers for detection virulence genes, and then define their corresponding resistance genes in rice. Moreover, understanding virulence genes present in each region will provide information to design an appropriate breeding program by using optimal resistance genes for resistance to rice blast disease in Thailand.

Currently, 96 blast fungal isolates have been selected for this study, 94 of which were collected from 41 provinces in Thailand and 2 from overseas. DNA extraction will be performed on these isolates for GBS library construction.

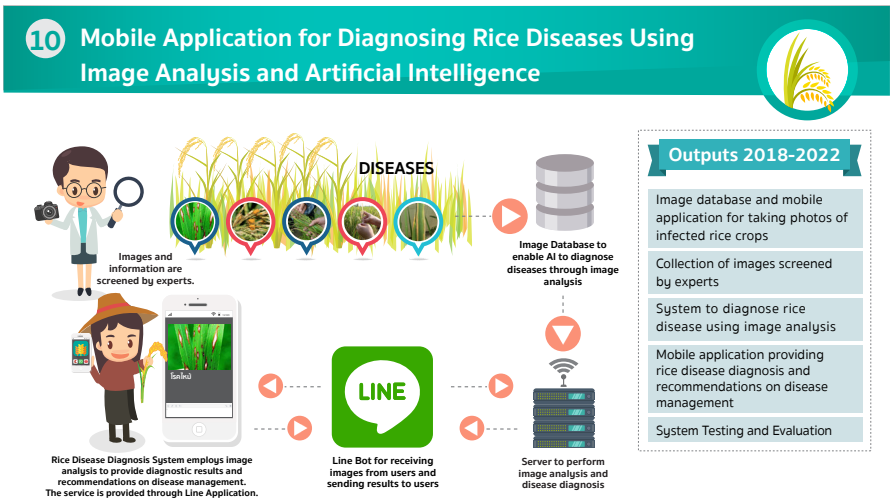


Mobile Application for Diagnosing Rice Diseases

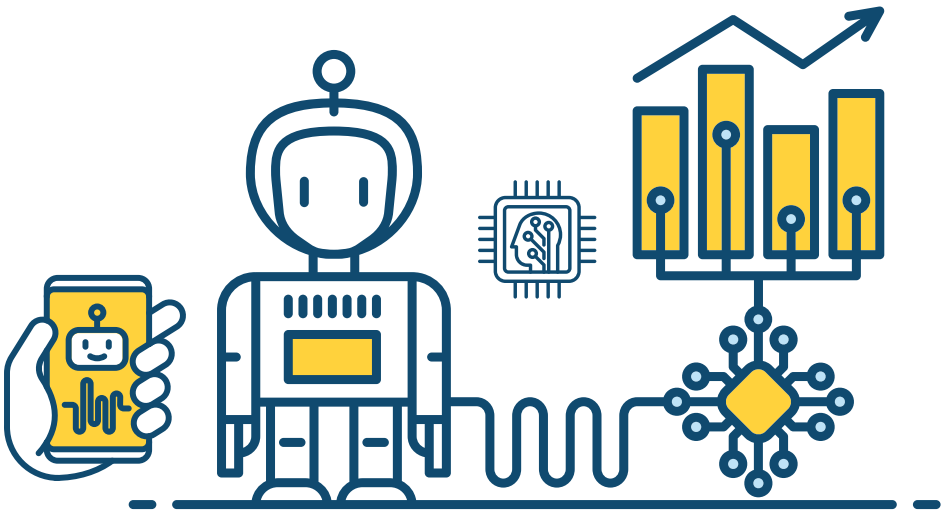
IT tools for diagnosing rice diseases normally come in the forms of web-based information and databases that require users to study and understand the information, and thus are not popular among Thai farmers. To improve this situation, NSTDA sets goal to develop a mobile application that allows users to identify rice diseases using their smartphones. Users can upload an image of infected crop and the app will provide a diagnosis, along with suggestions on disease management. The application also enables users to contact experts for additional inquiries.

To realize this goal, a system has been established and consists of an image database of rice diseases, a server for processing images and classifying rice diseases, Line Bot for automatic messaging response, and Line group of the rice disease experts who can screen and provide advice on the system's prediction results. These services are operated via a mobile application for classifying rice diseases in an open field. A team of researchers from NECTEC, BIOTEC and Kasetsart University has developed a prototype of mobile application for rice disease survey. The application enables researchers to upload images and epidemiology information collected from the survey to the database via their smartphones.

This system will enhance the disease diagnosis capability of farmers, provide access to technical experts and improve disease management. Data obtained from the survey will be used to develop an alert system for emerging and re-emerging diseases.



2018 BIG ROCK PROJECT



2018 Big Rock Project

Coding at School Project

Coding at School is a project designed for Thai children to learn about computer programming. Under this project, KidBright, an embedded board, was developed 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 (IoTs).

With KidBright, children can develop logical thinking process and creativity through the "Learn and Play" concept. The board consists of two parts: the coded sets of command and the embedded board which has a display screen, a speaker and basic sensors for detecting lighting and temperature, for instance. 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.

Achievement in FY 2018

160,000 boards were manufactured and distributed to 1,340 schools nationwide, and 3,293 teachers/educators participated in "train-the-trainer" sessions. KidBright contest was held with participation of students across the country. Furthermore, KidBight has been incorporated to other inventions such as MuEye, RoboKid, ChemKid, PM2.5 Detector and TuktukKid.

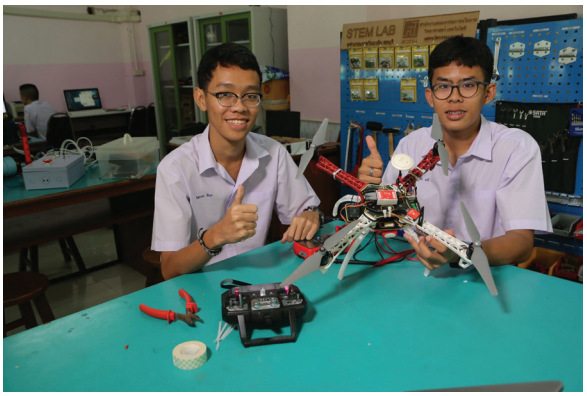
Fabrication Lab Project

Fabrication Lab is a project to set up fabrication labs, fully equipped with engineering and measuring tools and instruments, in schools and learning centers nationwide, and develop activities for students and teachers to acquire creativity and skills in design, research and engineering through the creation of innovations in the fabrication labs. The project aims to inspire students to become engineers and innovators – essential professionals for an innovative economy.

Fabrication Lab project is implemented in collaboration with the National Science Technology and Innovation Policy Office and ten universities providing mentorship to schools and learning centers across the country. Ten universities are (1) Rajamangala University of Technology Krungthep, (2) Rajamangala University of Technology Lanna, (3) Rajamangala University of Technology Thanyaburi, (4) King Mongkut's University of Technology Thonburi, (5) King Mongkut's Institute of Technology Ladkrabang, (6) King Mongkut's University of Technology North Bangkok, (7) Burapha University, (8) Chiang Mai University, (9) Thammasat University, and (10) Prince of Songkla University. A fabrication lab is also set up at Sirindhorn Science Home at Thailand Science Park for the working group to develop curriculum and design activities and for children and teachers to build projects.

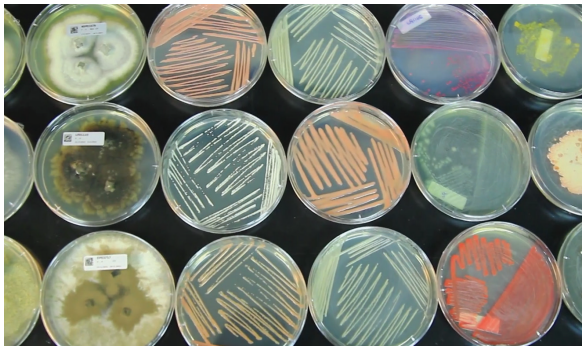
Achievement in FY 2018

NSTDA executed an MOU with ten universities serving as mentors to schools and technical colleges and welcomed participation of 150 schools and technical colleges into the project. Fabrication Lab workshops and activities have been organized with attendance of 1,453 students and 387 teachers.



Establishment of National Biobank of Thailand

Due to the surge in demand for biological materials in industry, NSTDA initiated a project to establish the National Biobank of Thailand for preserving biological resources with strict quality control and storing complete scientific information of each material. The facility will support the utilization of biological resources at the community and industry levels, and therefore serve as an essential infrastructure for the nation's sustainable development.



Achievement in FY 2018

The National Biobank of Thailand is set to occupy the space on the 1st, 3rd and 4th floors of Tower A, Incubation Cluster 2 building at Thailand Science Park. The construction work was carried out in 2018. DNA barcoding was performed on specimen to be stored. Barcode data has been generated for 7,898 microbial strains, 200 herbal plant species and 20 animal cell lines. Digital Biobank of microorganisms and herbal plants has also been set up.

To promote the preservation of bioresources at the national scale, the National Biobank of Thailand has formed partnerships with several organizations through an MOU establishment. These organizations include the Biodiversity-Based Economy Development Office (Public Organization), the Botanical Garden Organization, Thailand Institute of Scientific and Technological Research (TISTR), Khon Kaen University, Rajamangala University of Technology Lanna, Maejo University, the University of Phayao and Rice Science Center of Kasetsart University.

Plant Factory for Herbal Production

Plant production technology is the key for the production of food and medicine. Improvements in crop quality, productivity and resource use efficiency are among new requirements in today's agriculture. Recognizing the potential of plant factory in meeting such requirements, NSTDA proposed an establishment of Plant Factory Facility, a closed facility utilizing artificial control of light, temperature, moisture, and carbon dioxide concentrations 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. At the early stage, NSTDA Plant Factory Facility will target at the production of high-value herbal plants. As Thailand currently imports 1 billion-baht worth of herbal plants and herbal products annually, this facility will greatly support the Thai herbal industry.

Achievement in FY 2018

To be located on the 7th floor of Tower A, Incubation Cluster 2 building at Thailand Science Park, the facility was under construction and major equipment was procured in 2018.

Promotion of DentiiScan in Thai Hospitals

To improve the affordability and availability of the dental CT system, NSTDA researchers from NECTEC and MTEC jointly developed DentiiScan 2.0, a cone-beam computed tomography (CBCT) scanner. It is the first cone-beam CT scanner for dental and maxillo-facial imaging developed and manufactured in Thailand. The machine takes 18 seconds to provide 3D internal anatomy images of dental and maxillofacial structures, without distortion and superposition of anatomic structures. High quality data enables accurate diagnosis and safe treatment planning.

Achievement in FY 2018

An order to manufacture 50 units of DentiiScan 2.0 was placed with Pixamed Company Limited and 2 units have been delivered. MOUs to have DentiiScan installed have been executed with a number of hospitals affiliated to universities, the Royal Thai Army, the Royal Thai Air Force and the Ministry of Public Health. Training sessions will be organized for dentists and technicians of these hospitals.

COMPETITIVENESS ENHANCEMENT

Mechanisms to Support Research and Development in the Private Sector

Thailand Tech Show 2018: Flat-rate disclosure fee of 30,000 baht/technology

More than 485 applications for technology license received

Startup Voucher

87 business operators granted financial support of 64 million baht in total, 915-million-baht revenue earned by grant recipients

300% Tax Exemption for R&D Expenses

404 projects certified with a total value of 1,313 million baht

Innovation Technology Assistance Program

1,610 SMEs supported, generating a 3.04-billion-baht impact and a 730-million-baht investment

Innovation List

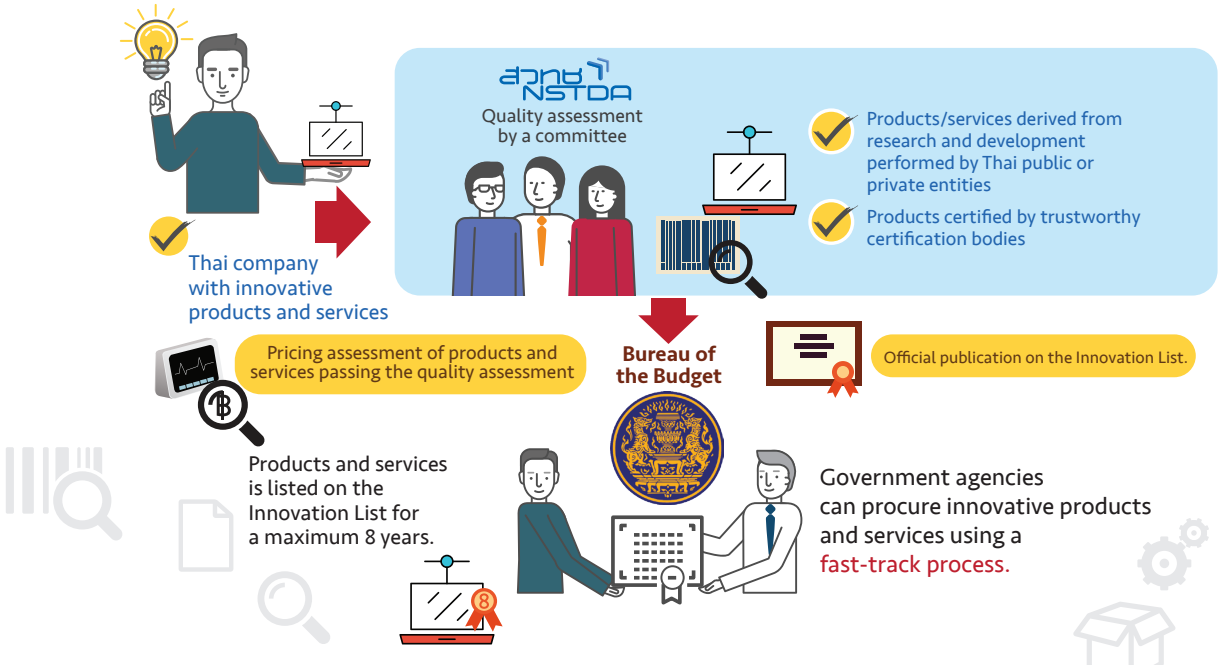
270 inventions passing assessment, 226 inventions listed

Testing Services

Over 50,000 tests performed, worth 125 million baht

Innovation List

The Cabinet has approved the establishment of Thai Innovation List containing innovations (products and services) entitled to the fast-track treatment in the government procurement process. Thai companies are encouraged to register their innovative products and services resulting from research and development performed in Thailand. NSTDA has been tasked to assess the applications by evaluating the quality of those products and services; whereas the Budget Bureau checks on the pricing and officially publishes the innovations on the Innovation List. As of 12 October 2018, 529 applications were received; 270 innovations passing the evaluations and 226 innovations were published on the Innovation List. A total of 1,337-million-baht procurement were made on items published on the Innovation List by government agencies, according to the survey conducted between January 2016 - December 2017.

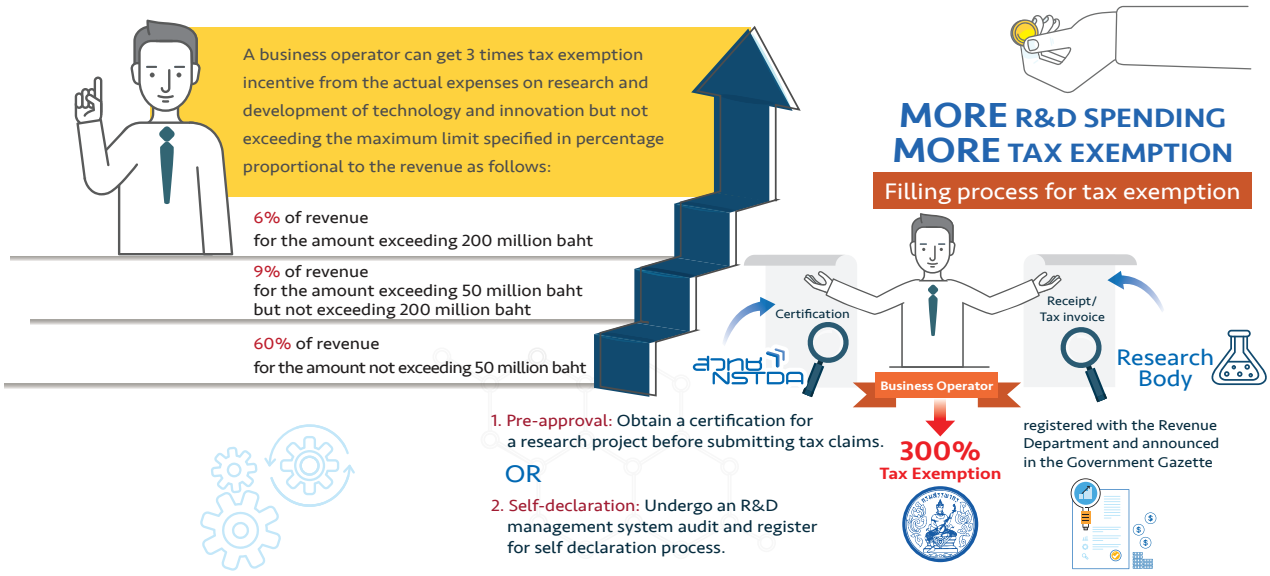


Status	Total	2018	2017	2016
Number of applications*	529	217	144	168
Number of Innovations passing the assessment	270	137	61	72
Number of Innovations published on the Innovation List	226	145	47	34

* 26 applications were ineligible, and 83 applications were withdrawn.

300% Tax Exemption for R&D Expenses

NSTDA has been appointed as a certifying body for research, development and innovation projects submitted for tax privileges by companies since 2002. Since the inception until 30 September 2018, 508 companies have submitted tax claims under this program, with a total of 4,519 projects submitted and 3,951 projects certified. Records show that companies submitting claims have a tendency to return the following years with more projects. In 2017, NSTDA started to offer the certification of RDIMS (Research, Development, Innovation Management System). An RDIMS-certified company with a registered account with NSTDA can self-declare a research and development project to receive this type of tax incentive, provided that the project does not exceed 3 million baht. Since the launch of self-declaration scheme, one company, Siam Cement Group (SCG), has successfully been certified. In 2018, no new company applied for certification, and a certified company underwent its first surveillance audit. The impact of this tax incentive scheme is estimated to be 4 billion baht in 2018.



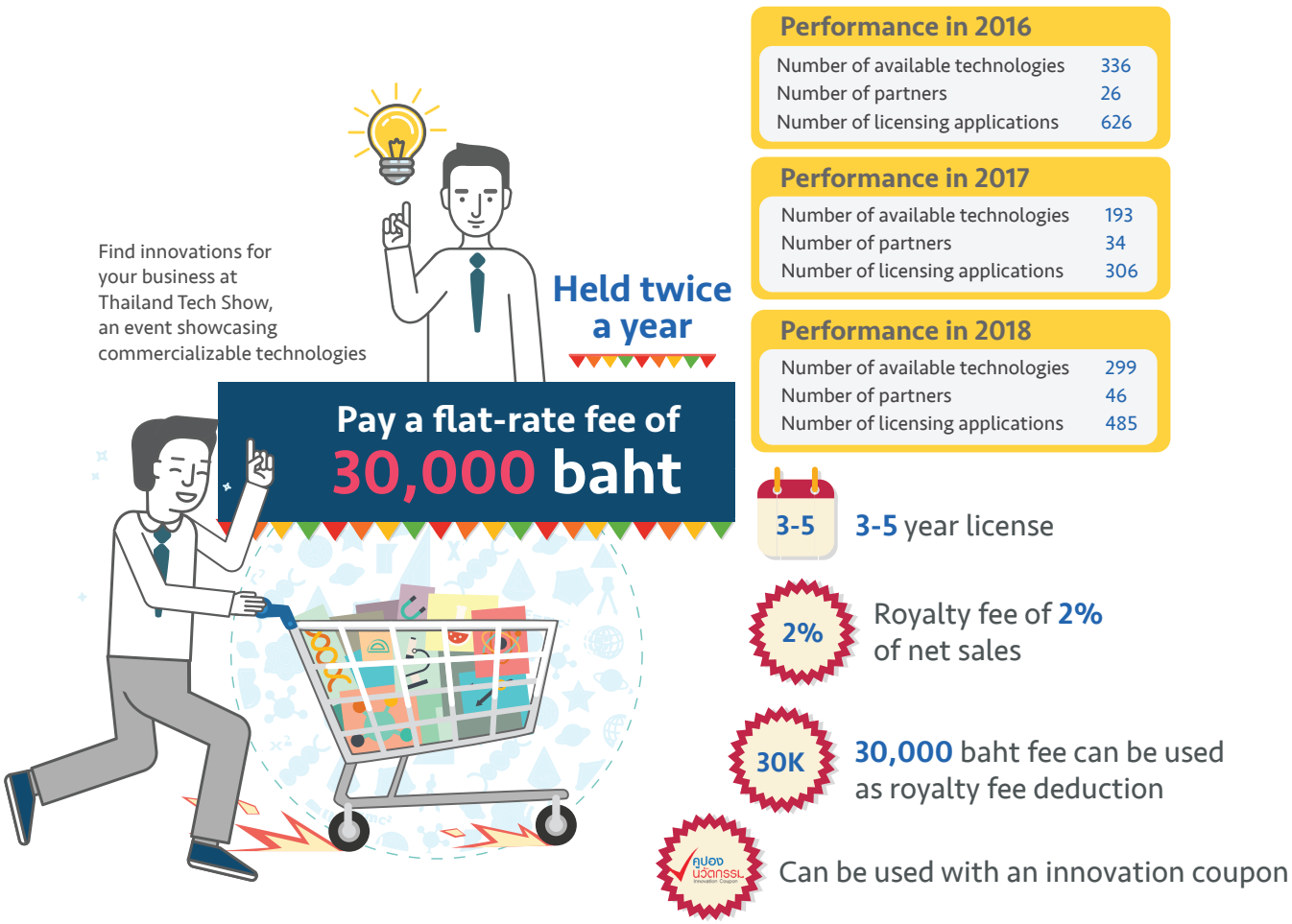
Performance from FY2002-2018 (as of 30 September 2018)

Fiscal Year	Pre-approval						Self-declaration	
	No. of projects applied for certifications	Project value (million baht)	No. of assessed projects	No. of certified projects	Project value (million baht)	No. of companies	No. of companies applied for an audit	No. of companies received a certification
2002-2014	2,844	10,391	2,720	2,572	8,337	281	-	-
2015-2018	1,675	7,638	1,562	1,379	5,827	227	1*	1*
2018	447	2,355	550	404	1,313	113		

Note:* In 2018, no companies applied for self-declaration and one certified company underwent the 1st surveillance audit.

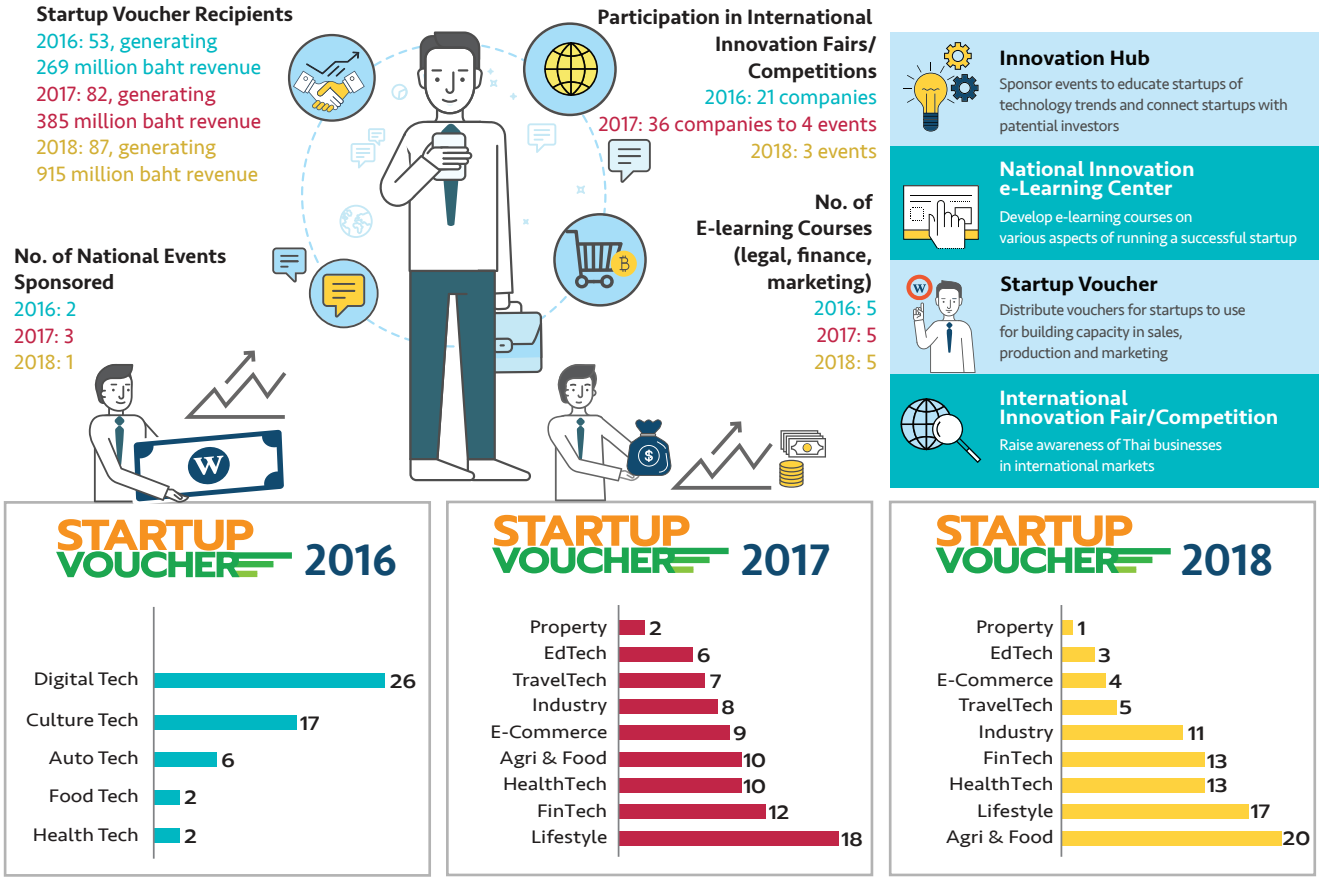
Thailand Tech Show 2018

NSTDA, in collaboration with universities, continues to implement "Thailand Tech Show" into the third year. Thailand Tech Show provides SMEs with easy access to intellectual properties owned by public research and academic institutes by offering a license to an IP to interested SMEs at a flat-rate fee of 30,000 baht per IP and a royalty payment of 2% of net sales. In addition to attractive fees, the licensing process has also been streamlined to expedite the exploitation of local inventions. Thailand Tech Show 2018 was held on 4-8 July 2018 at Bangkok International Trade & Exhibition Centre (BITEC), showcasing over 300 inventions to prospective entrepreneurs with engaging activities such as business pitching, seminar and consultation services. The event attracted over 14,000 business operators and entrepreneurs. 485 licensing applications were received, and 48 licensing agreements were executed in 2018.



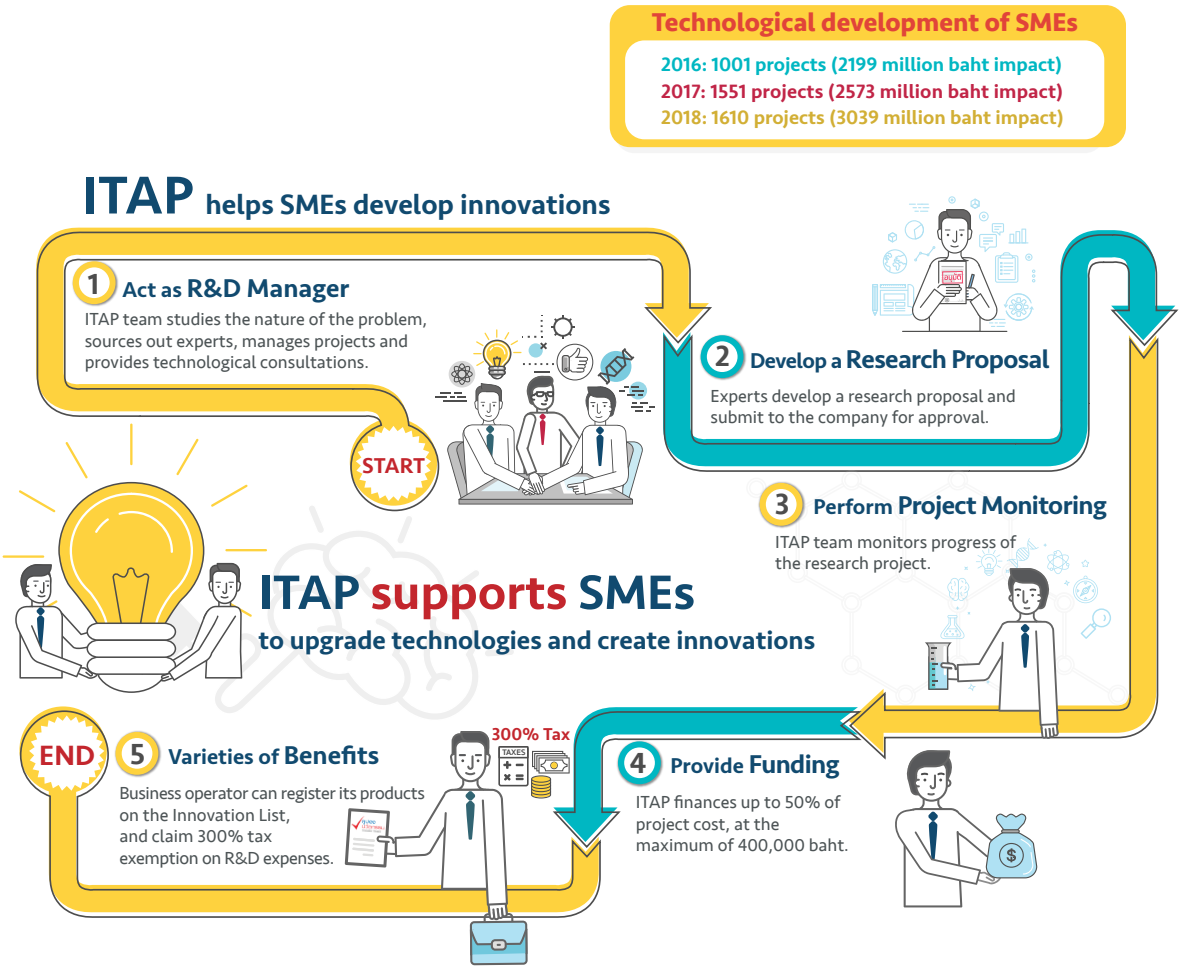
Startup Voucher

Startup Voucher, a collaboration between NSTDA and the Office of Small and Medium Enterprise Promotion (OSMEP) since 2016, is a scheme designed to assist startups to find and expand their markets. This is achieved through the development of e-learning courses, the organization of national events and supporting the participation of Thai startups in international events in order to create visibility in international markets and initiate technological and business collaboration with international partners. The scheme provides a voucher of 800,000 baht per project to support a marketing campaign. In 2018, 87 projects were funded with a total budget of 64 million baht. These grant recipients have credited the scheme for enabling them to develop products and expand their markets both domestically and internationally. Revenue worth 915 million baht has reportedly been earned by startups participating in the program.



Innovation Technology Assistance Program (ITAP)

Innovation Technology Assistance Program or ITAP is a main mechanism to provide technological assistance to Thai SMEs by sending an expert team to work cooperatively with companies to conduct research and develop projects that will provide solutions to the problems faced by the companies. With increasing support from the Government, ITAP has grown steadily in the past years, sponsoring 1001 projects, 1,551 projects and 1,610 projects in 2016, 2017 and 2018, respectively. These projects involve working with a network of 2,500 experts drawing from public and private domains, as well as domestic and international alliances. ITAP finances up to 50% of a project budget, at the maximum of 400,000 baht. This strategy aims to minimize the investment risk of SMEs in technology development, thereby building their confidence towards R&D adoption which shall enhance their competitiveness in the long run.



ITAP Project Highlight

POMO Kids Watch

Pomo House Company Limited is a Thai startup company manufacturing Internet of Things (IoTs) products for kids. Its flagship product is a smartwatch equipped with GPS for parents to track their kids and other features for kids to enjoy. In the past, the company was relying on imported technologies such as body construction and firmware, for instance, thereby rendering difficulty in product development and improvement.

Photo: https://www.pomohouse.com/

After participating in ITAP, Pomo House was able to develop its own capacity and technology, thus enabling the company to improve watch design and functions to meet consumers' aesthetics and requirements. Designed to offer parents peace of mind on the safety and security of their kids, POMO Kids Watch comes with outstanding features such as making and receiving calls, GPS locator, sensor to ensure secure buckle, SOS emergency button, and pedometer and anti mosquito functions.

The improvement attributed to ITAP has increased the company's revenue from 40 million baht in 2015 to 52 million baht in 2016 and doubled the proportion of the export income.

ที่มา : https://www.pomohouse.com/

NSTDA Testing Services

NSTDA offers public and private entities access to advanced technologies and scientific instruments by providing characterization and testing services to clients from both the public and private sectors. In 2018, NSTDA testing labs and centers performed over 50,000 tests and services for clients, valued at 125 million baht. To serve growing demand for high quality product testing in Thai industry, NSTDA services are provided through the following units: NSTDA Characterization and Testing Service Center (NCTC), Electrical and Electronic Products Testing Center (PTEC), Industrial Ceramic and Houseware Product Testing Center (CTEC) and National Advanced Nano-characterization Center (NANC).

NSTDA Testing Service Highlight

Electrical and Electronic Products Testing Centre (PTEC)

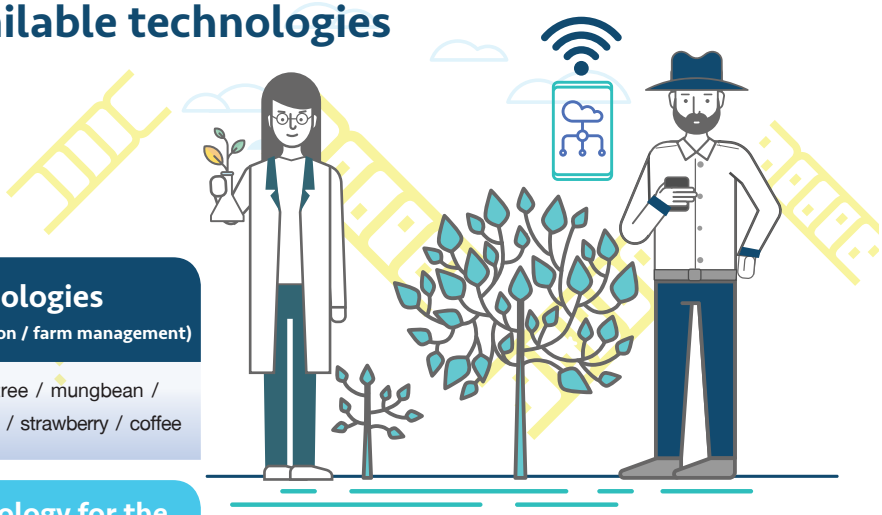
PTEC provides full services in testing, calibration and certification to ensure the product quality and safety and enhance the competitiveness of electrical and electronic industry in Thailand. Recently, PTEC has established a testing laboratory for 600 kW electric vehicle (EV) battery as regulated by UNECE R100 and other international standards. Daimler AG and its Thai partner, Thonburi Automotive Assembly Plant Company Limited, became the first customer of this testing service, as Daimler AG was to open a battery manufacturing facility in Thailand. This battery factory in Thailand will be Daimler's first in ASEAN and fourth in the world after plants in Germany, Japan and China. In addition to EV manufacturers, this testing facility also attracts interest from manufacturers of electric motorcycles, electric buses and other energy storage devices. This marks a monumental milestone for Thai EV industry with complete value chain of production, testing, certification and marketing.

PTEC has been listed as the testing laboratory for the electrical and electronic equipment for 7 countries -- Brunei Darussalam, Cambodia, Indonesia, Malaysia, Myanmar, Singapore and Vietnam – under the ASEAN Sectoral MRA for Electrical and Electronic Equipment (ASEAN EE MRA). In addition, PTEC provides electromagnetic compatibility (EMC) testing according to national and international standards, one of which is the standard of the Vietnam Certification Centre (QUACERT).

TECHNOLOGY TRANSFER TO FARMING COMMUNITIES

Agricultural Technology and Innovation Management Institute (AGRITEC)

Available technologies



Production Technologies
(crop varieties / seed production / farm management)

- Rice / cassava / rubber tree / mungbean / chili / tomato / mushroom / strawberry / coffee

Eco-friendly Technology for the Production of Natural Rubber

- TAP (an ammonia-free latex preservation agent) and GRASS (a sulfuric-acid-free process for recovery of rubber waste)

Biocontrol

- Beauveria for controlling aphids
- NPV for controlling armyworm
- Streptomyces for controlling fungi and bacteria infecting melons

Animal Production Technology
(rearing / feed)

- Fairy shrimp / Siamese plankton as aquaculture feed
- Closed-system shrimp cultivation
- Production of stingless bee queens / Quality improvement of honey
- Forage cane
- Silage
- Diagnostic kits for animal diseases
- Microorganisms for controlling foul odor in farms

Technologies for Soil and Water Management

- Compost from agricultural wastes
- Unturned composting
- Vermicomposting
- Irrigation systems

Processing Technologies

- Processing of Agricultural Produce
- Good Hygiene Practice for food processing

Equipment and Machineries

- Rice milling machine for community usage
- Greenhouse with photoselective plastic cover
- Drying machine/facility for agricultural products

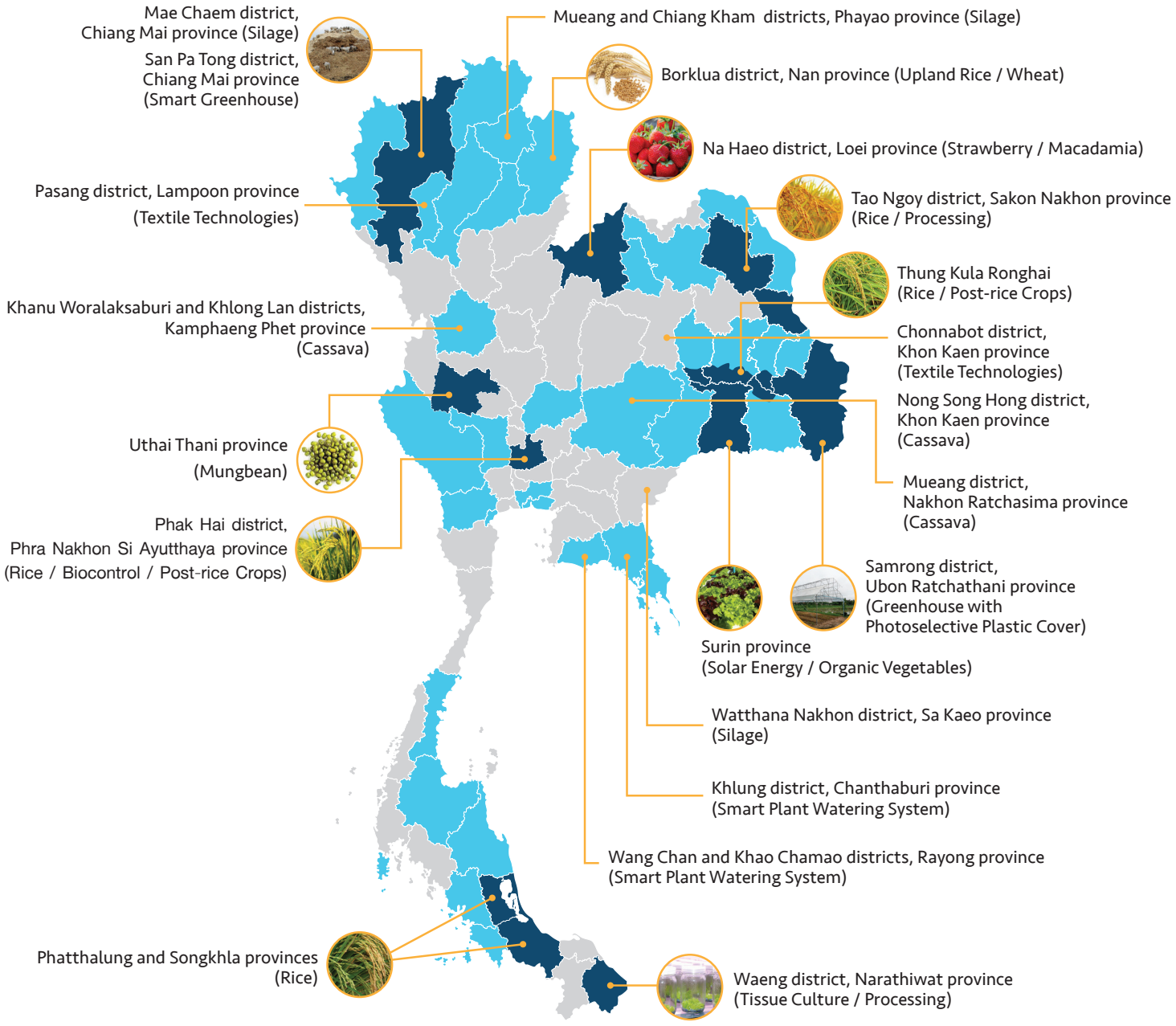
Smart Farm Technologies

- Smart greenhouse
- Meteorological station
- Smart watering system

Textile Technologies

- ENZease, smart enzyme for desizing and scouring of cotton fabric
- Preparation of natural dyes from local resources
- Nanotechnologies to impart special properties to the fabric

Areas of Technology Transfer in 2018



264 communities in 42 provinces (as of September 2018)

Kanchanaburi, Kalasin, Kamphaeng Phet, Khon Kaen, Chumphon, Chiang Rai, Chiang Mai, Trang, Tak, Nakhon Nayok, Nakhon Phanom, Nakhon Ratchasima, Narathiwat, Nan, Buriram, Pattani, Phatthalung, Phichit, Phrae, Phuket, Maha Sarakham, Mae Hong Son, Yasothon, Yala, Roi Et, Lampang, Lamphun, Sakon Nakhon, Songkhla, Satun, Surat Thani, Surin, Nong Bua Lam Phu, Udon Thani, Uttaradit, Ubon Ratchathani, Chanthaburi, Chachoengsao, Chonburi, Trat, Rayong, Sa Kaeo

Note: 220 communities in 45 provinces in 2017

Cassava Productivity Improvement

AGRITEC-NSTDA introduced a package of technologies to enhance cassava production to cassava farmers. These technologies -- which include the application of *Beauveria bassiana* to control mealybug, recommended cassava varieties for specific types of soil in Thailand as identified from field studies, and the use of disease-free cassava plants produced by tissue culture technique -- enabled farmers to increase their productivity from 3-4 tons/rai (18.75-25 tons/ha) to 5-6 tons/rai (31.25-37.5 tons/ha), resulting in a 9.34-million-baht increase in farmers' income in 2018, or 57% increase from the previous year.

In addition, a novel Pirun 4 cultivar, derived from a research collaboration between NSTDA, Mahidol University and the Department of Agriculture, has been promoted. This cultivar now occupies an area of 3,200 rai (512 ha) in Kanchanaburi, Kamphaeg Phet, Khon Kaen, Kalasin, Ubon Ratchathani, Nakhon Ratchasima, Lampang and Nakhon Sawan provinces. Pirun 4 cultivar provides high yield and low-cyanide-content roots, and therefore is suitable for processing into gluten-free cassava flour, a substitute of wheat flour in bakery products. To help expand the market for and add value to this new cultivar, AGRITEC-NSTDA facilitated a linkage formation between growers and food-processing community enterprises to use Pirun 4 cassava roots in the enterprises' food and snack products such as cassava chips, brownies and cassava balls.

Entrepreneurial Bootcamp for Rice-processing Community Enterprises

AGRITEC-NSTDA and the Bank for Agriculture and Agricultural Cooperatives organized a training workshop on business and technical skills for rice-processing community enterprises and SMEs. The workshop guided participants through the process of establishing new businesses, cost structure analysis and pricing strategy, and knowledge on rice value addition, as well as provided a platform for participants to share experience.

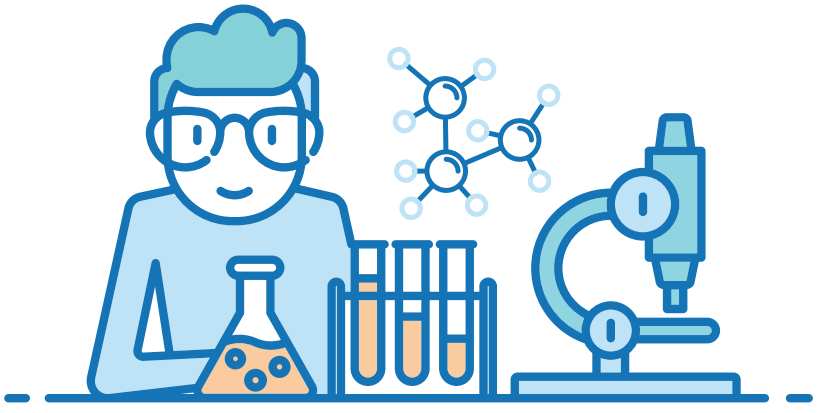
The workshop was attended by 51 participants from two community enterprises and one SME – an organic farming community enterprise in Niwet subdistrict, Roi Et province (producing facial serum containing organic jasmine rice oil), an organic farming community enterprise in Sanam Chai Khet district, Chachoengsao province (producing rice serum) and Ricey International Company Limited, an SME based in Tha Maka district, Kanchanaburi province (producing rice drink containing cordyceps and licorice). The workshop enabled participants to increase their profit by 4.65 million baht, or 82%, in 2018.

Capability Enhancement of Organic Farmers in Ban Nong Mang Village

For over a decade, NSTDA has been working with an organic farming community enterprise in Ban Nong Mang village situated in Non Klang sub-district, Ubon Ratchathani province to strengthen organic farming practice with science and technology. Through the capability enhancement program, the enterprise is able to make significant improvement in productivity and quality of their crops, as well as increase the quality of life of its members. Its organic products are warmly accepted by consumers in the area and can also be found in leading supermarkets in Bangkok. The enterprise has been awarded Organic Thailand seal and is in the process of acquiring PGS (Participatory Guarantee System) certification. A new generation of farmers and marketers has also been developed to advance the enterprise firmly and sustainably into the future.

Technologies introduced to Ban Nong Mang organic farmers include photoselective-plastic-film greenhouses, biocontrol agents (*Beauveria bassiana*, nuclear polyhedrosis virus (NPV) and nematode), vermicompost production from agricultural waste, new crop varieties such as snack-slim tomatoes, blast-resistant glutinous rice Thanyasirin, and post-rice crops (sesame and mung bean), and suggestions on value-added products such as red-jasmine-rice ice cream and toasted sesame. A total of 34 greenhouses have been built in this community. This program results in an estimated economic impact of 5.44 million baht annually.

STI HUMAN RESOURCE DEVELOPMENT



Recognizing the importance of competent and skilled manpower in driving forward science and technology in Thailand, 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 the target industry, 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.

Building critical mass of S&T students and professionals. NSTDA provides a total of 790 scholarships to high-school, undergraduate and graduate students, through various programs namely, Junior Science Talent Project (JSTP), Young Scientist and Technologist Program (YSTP), Thailand Advanced Institute of Science and Technology (TAIST), Thailand Graduate Institute of Science and Technology (TGIST), NSTDA-University-Industry Research Collaboration (NUI-RC), STEM Workforce program for promoting both manpower development and research in industry, and Food Engineering Practice School (FEPs). In addition, laboratories of NSTDA research centers also welcome university students and research staff from domestic and overseas collaborators to work on NSTDA active research projects. In the past year, 324 students/research staff have joined NSTDA workforce in various capacities, namely 53 collaborative research students, 230 research assistants and 41 co-investigators.

Inspiring children to pursue S&T education. NSTDA promotes science learning and stimulates interest in science and technology among young minds through activities such as Path-to-Researcher Camp, Young Makers Camp, Math and Science Camp and STEAM Summer Camp. A total of 4,817 children have participated in these camps.

Enhancing skills and capacities of STI manpower. To upgrade manpower working in science and technology fields as well as equip university students with the proper skills for industry, NSTDA regularly offers training courses in a variety of topics. In 2018, over 18,500 people participated in NSTDA training courses which included topics such as monitoring and maintenance of solar power system, management of an electric vehicle charging station, entrepreneurial skills for smart farming service providers, fundamentals of machine learning for trainers, and future trends in logistics and supply chain management.

The 4th Path-to-Researcher Camp

NSTDA organized the 4th Path-to-Researcher Camp on 9-12 October 2017, inviting 50 grade-7 students who won the 2016 Genius, a program implemented by the Institute for the Promotion of Teaching Science and Technology (IPST), to participate. Held at Sirindhorn Science Home, the camp was designed to stimulate science curiosity, engage students to learn science through STEM education, and practice scientific thinking. Students took part in fun activities which helped them learn physics and math, practiced coding with KidBright – an embedded board, and enjoyed an excursion to the Royal Thai Air Force Museum. A scientist, a mathematician and a programmer were invited to give inspiring talks about his/her career. The Path-to-Researcher Camp aims to inspire gifted students to continue to take part in science camp activities and explore a career in S&T.

The 15th Asia-Pacific Conference on Giftedness (APCG2018)

NSTDA, in partnership with several organizations, hosted the 15th Asia-Pacific Conference on Giftedness (APCG2018) on 20-24 August 2018 in Thailand. The event provided a platform for researchers and educators studying or working with gifted children to share experience and form a network to enhance their work, as well as to give inspiration to gifted children to reach their full potential. APCG2018 consisted of two main components -- the Conference which was held at the Queen Sirikit National Convention Center and the Youth Camp which was held at the Sirindhorn Science Home located at Thailand Science Park. Held under the theme "Inspiration, Motivation, and Creativity: Leading the Way to Giftedness", the Conference brought together 533 leading academic researchers, teachers, educators, and policy makers from 22 economies – 360 Thais and 173 foreigners. A total of 127 presentations were made at the Conference. The Youth Camp was attended by 255 gifted and talented children from 13 economies – 75 Thais and 180 foreigners. Children participating in the Youth Camp were gifted in science, mathematics, music, sport and art. The Camp was designed to encourage children to express their curiosity and creativity through a range of interdisciplinary activities, covering mathematics, science, language, art and dance. Visits to the National Science and Technology Fair and the Ancient City encouraged explorations in both science and culture, as well as fostered friendship and cross-cultural communication.

IDC RoBoCon 2018

MTEC-NSTDA, in collaboration with the Faculty of Engineering, Chulalongkorn University, led winners of RDC2018, the national robot design contest, to compete in an international design contest, IDC RoBoCon 2018, hosted by Tokyo Institute of Technology in Japan on 6-18 August 2018. Held under the theme "The World Star Hunting Swallow", the IDC RoBoCon 2018 attracted participation of 54 students from 8 countries, including the US, Singapore, Mexico, India, China, South Korea, Thailand and Japan. Eleven teams, each consisting of 4-5 members from different countries, were formed on site. Teams were asked to design and build two robots in ten days. Two Thai students were part of the winning teams. Mr. Pannatorn Treewattana from Thammasat University was part of the first runner-up team and winner of Creative Award. Mr. Weerayut Buapet from Rajamangala University of Technology Lanna was in the second runner-up team.

MTEC-NSTDA and partners has been organizing the national robot design contest and supporting winners to compete in the design contests at the regional and international levels, as part of its commitment to build a deep pool of workforce in automation and robotics to underpin the transition to Thailand 4.0.

NSTDA Annual Conference 2018 (NAC2018)

NSTDA Annual Conference 2018 (NAC2018) was organized from 9-13 March 2018 at Thailand Science Park, Pathumthani, under the theme “Targeted R&D: Tackling Thailand Challenges”. The opening ceremony which took place on 9 March was presided over by HRH Princess Maha Chakri Sirindhorn. NAC2018 showcased achievements of basic and applied research performed by NSTDA and partner organizations, focusing on its five target areas, including modern agriculture, biofuels and biochemicals, food for the future, enhancement of public health and quality of life, and next-generation automotive and logistics. The program consisted of 55 tracks of scientific conferences, seminars and workshops. On display in the exhibition zone were over 100 inventions developed by NSTDA and its alliances from public, private and academic domains, as well as by tenants of Thailand Science Park. An open house activity introduced visitors from the private sector to 37 NSTDA laboratories that can offer research and testing services; whereas the S&T job fair saw the participation of 88 companies. NAC2018 attracted a good number of visitors — 4,719 participants to the scientific seminars/workshops, 4,887visitors to the exhibition, 415 attendees to the open house activity, and 1,449 visitors to the job fair — an increase from the previous year.

MANAGEMENT AND PROMOTION OF INNOVATION HUBS

In an attempt to create the place, environment and interactive ground that generates, attracts and nurtures technology companies, NSTDA establishes and manages innovation hubs to support research and innovation with conducive ecosystem. NSTDA currently manages Thailand Science Park and Software Park Thailand and is in charge of establishing Eastern Economic Corridor of Innovation (EECi). Rental space in these innovation hubs is made available for private companies interested in conducting research and development, leading to the creation of novel technologies and innovations for societal and industrial applications, as well as the commercialization of technologies.

Thailand Science Park is the first park dedicated to science and technology in Thailand. Apart from being a base for national research centers, it provides lab and office spaces for lease with fully-integrated services to support technology businesses and companies looking to expand their R&D activities.

In 2018, Thailand Science Park was the home for 93 leading local and multi-national companies, accounting for 39,439.43-sq. m. rental space. In addition, Software Park Thailand hosted 56 companies occupying its 7,558.15-sq.m. rental space. Various types of lease space are available to meet client needs, ranging from office space, laboratories and pilot plant facilities. Examples of successful tenants include T-NET Co., Ltd. (an internet security service provider), Betagro Science Center (a research center of Thailand's leading agribusiness conglomerate), Diagnostic Lab of Zoetis Thailand (a global animal health company), ASEAN Polyplastics Technical Solution Center (an ASEAN center of a Japanese manufacturer of engineering plastics).

"I was given an opportunity by NETCEC-NSTDA to spin off my research under NSTDA scheme to promote new tech entrepreneurs to be equipped with both technical and business skills.

I would like to encourage researchers in the government sector to take on this challenge to spin off their technologies in order to expedite the lab-to-market process and enable the technology to reach its potential to make an impact to the society and economy."

T-NET
Founded by NECTEC

Dr. Komain Pilbulyarojana
Founder of T-NET Co., Ltd.
One of the first NECTEC spinoff companies

T-NET specializes in IT security and provides services in the following areas:
- **Vulnerability Assessment Service**
- **IT Security Plan Service**
- **IT Security Services**
- **Box Service**

BETAGRO

Vanus Taepaisitphongse,
Chief Executive Officer

"...establishing Betagro Science Center in Thailand Science Park (TSP) is another big step of Betagro Group investing in R&D. We chose TSP because of a potential on R&D collaboration with the four National Research Centers who have a large pool of human resources and state-of-the-art equipments. We strongly believe that the "science" atmosphere and "learning" environment in TSP will motivate our R&D staff to be able to deliver innovative outcomes within timely manner."

zoetis

Dr. Arkhom Cheewakriengkrai
General Manager-Southeast Asia

"Diagnostic Lab at Zoetis is a critical value adding support service to our customers. Previously having managed our diagnostic lab through our office building, we soon realized that a successful and reliable Diagnostic laboratory set up requires a high standard platform and conditions. Thailand Science Park was the obvious answer for all our requirements in terms of its state of the art facilities, high standards of technical know-how, quality and general environment. It has provided us with a sound base to further develop and strengthen our diagnostic capabilities and continue to provide highest levels of technologically advanced and innovative services to our customers."

"Thailand Science Park is a comprehensive innovation hub that enables Polyplastics to connect with researchers and access experts and state-of-the-art equipment at MTEC."

Polyplastics is a pioneer in engineering plastics from Japan with over 50-year experience. Polyplastics established ASEAN Technical Solution Center in Thailand, the 2nd center in the world after China. TSC has been based in Thailand Science Park since 2008 to serve clients in ASEAN region and India.

MTEC a member of NSTDA — Analysis Equipment

Polyplastics — Injection Molding Facility

Polyplastics

ASEAN Technical Solution Center

Exchange and sharing are the key elements that attract Polyplastics to base its ASEAN Technical Solution Center in Thailand Science Park for over 10 years.

Eastern Economic Corridor of Innovation (EECi)

NSTDA is responsible for the establishment of Eastern Economic Corridor of Innovation (EECi) which will serve as an infrastructure to drive activities, in collaboration with domestic and international partners, of BIOPOLIS, ARIPOLIS and SPACE INNOPOLIS. EECi is located in Wangchan Valley, Rayong province. In 2018, NSTDA completed the preparation of management plan, staffing plan (short-, medium- and long-term plans), masterplan, construction plan and industrial technology roadmap. At the same time, NSTDA also strengthened companies and entrepreneurs, as well as communities in the EECi area through technology transfer and capacity building activities.

One of the key roles of NSTDA in EECi is to develop science, technology and innovation (STI) infrastructure in order to create innovation ecosystem that will make this area a new STI-intensive economic zone. The infrastructure comprises research facilities of the government agencies and private companies, testbeds, pilot and demonstration plants for accelerating the lab-to-market process, as well as quality testing and certification laboratories. EECi aims to become an ASEAN Innovation Hub, focusing on six industries targeted by the Thai Government, namely battery and next-generation automotive, automation and intelligent electronics, modern agriculture and biotechnology, biofuels and biochemicals, medical devices, and space and aviation. The construction of Phase 1A is expected to commence in early 2019 and complete in 2021.

In addition to the construction of EECi, NSTDA also recognizes the importance of communities and companies based in this area, thus attempts to enhance the capabilities of both groups. ITAP scheme, entrepreneur incubation and activities of AGRITEC to transfer agri-related technologies to farmers are main mechanisms employed. In 2018, the following has been achieved:

(1) SMEs and entrepreneurs. NSTDA assisted 101 SMEs in EECi area on the technology development, of which 60 are bio-based companies. In addition, 13 entrepreneurs participated in NSTDA incubation program. Technologies that have been developed with SMEs and entrepreneurs include process improvement, fermentation improvement, environmental impact assessment, wood processing, product packaging and food processing.

(2) Farmers and local communities. Agri-related technologies were introduced to 63 communities in 5 provinces – Chachoengsao, Rayong, Chanthaburi, Trat and Sa Kaeo. A total of 1,432 farmers participated in the program. Technologies transferred to the communities include production of *Beauveria bassiana,* production of organic soil supplements and fertilizers, Greenhouse with photoselective plastic cover, online marketing for agribusiness, production of feed silage from agricultural by-products, intelligent environment monitoring system for farm management, longan farm management, post-harvest technology of mango for shelf-life extension, intelligent environment monitoring and watering system for durian plantation, vermicomposting, shelf-life extension and processing technology of pineapple and foam-mat drying of longan.

INTERNATIONAL COLLABORATION

NSTDA places significant importance on establishing linkages, alliances and collaborations with international bodies to create visibility and acceptance of Thai research and development on the world stage, to develop and share knowledge and manpower, and to facilitate technology transfer in order to prepare and build up long-term S&T capacity for Thailand. In 2018, a number of activities have been carried out with the following examples.

Memoranda of Understanding and Agreements

Collaboration with Japan on Agriculture and Food

A Memorandum of Understanding between NSTDA and the National Agriculture and Food Research Organization (NARO), Japan was executed on 16 February 2018 in Tokyo, Japan. The MOU aims to foster collaboration on sustainable agriculture and food between Thailand and Japan. The collaboration is facilitated through activities such as joint research, exchange of information and staff, and joint seminars. The first joint project is the application of genetic engineering technology to economically-important ornamental plants such as orchid. Under this project, scientific seminar and workshop will be organized in Thailand with NARO researchers featuring as keynote speakers. In addition, NSTDA will establish a consortium to review the current status of genetic engineering research in Thailand.

Collaboration with Myanmar on Agricultural Science

A Memorandum of Understanding between NSTDA and the Department of Agricultural Research (DAR) was signed on 5 March 2018 in Nay Pyi Taw, Myanmar to advance the collaboration on agricultural technology. The MOU provides a framework for researchers from Thailand and Myanmar to carry out collaborative research, capacity building activities and technology transfer in order to strengthen agricultural science and technology of both countries. Furthermore, this collaboration will enhance the Molecular Rice Breeding for the Mekong Region, a project initiated by BIOTEC-NSTDA in 2004 with participation of rice breeders from Myanmar, Laos, Cambodia and Thailand aiming to employ genomics and biotechnology in the current rice breeding program.

Collaboration with China on Nanotechnology for Energy and Environment

NANOTEC-NSTDA entered into a Memorandum of Agreement with Nano-Science and Technology Research Center of Shanghai University (NTC-SHU) on 7 September 2018 at Thailand Science Park. The MOA focuses on joint research to develop green nanomaterials and serves as a platform for researcher exchange between the two organizations. Subsequently, Dr. Uracha Ruktanonchai, NANOTEC Deputy Executive Director, was invited to co-chair the International Roundtable Nanoscience and NanoTechnology hosted by Shanghai University on 27 September 2018. The event was a gathering of prominent scientists from the US, Sweden, Japan, Korea and Thailand to present current research and explore further collaboration.

Collaboration with Japan on Energy and Environment

On 28 September 2018, NSTDA and Kyoto University entered into a Memorandum of Understanding for Academic Cooperation and Exchange in a ceremony held in Bangkok. The MOU facilitates collaboration on biomass-to-energy and biorefinery and strengthens these research areas throughout ASEAN region. The partnership aims to establish a joint laboratory to foster research collaboration and strengthen capacity in science, technology and innovation for the whole region. This collaboration sets goal to develop innovations that will make an impact on the economy and society, improve the quality of life, and preserve natural resources and the environment. The success of this partnership will help advance sustainable development goals of Thailand, Japan and ASEAN region.

Scientific Conferences and Seminars

ASEAN/Japan e-ASIA JRP Workshop

MTEC-NSTDA, in collaboration with Waseda University, hosted an e-ASIA JRP workshop as part of a project titled “Feasibility Study on Social Implementation of Bioenergy in East Asia” on 30-31 October 2017 at Thailand Science Park. The workshop was attended by 35 participants from 6 countries, including Japan, Myanmar, Laos, Vietnam, Indonesia and Thailand. The objectives of the workshop were to analyze and discuss appropriate measures to promote the production and utilization of bioenergy and biomass in each country in order to support SDGs; to foster collaboration between researchers and industry in member countries; to engage young scientists in this project; and to update the community with latest development in technologies and policies concerning biomass and bioenergy of each country.

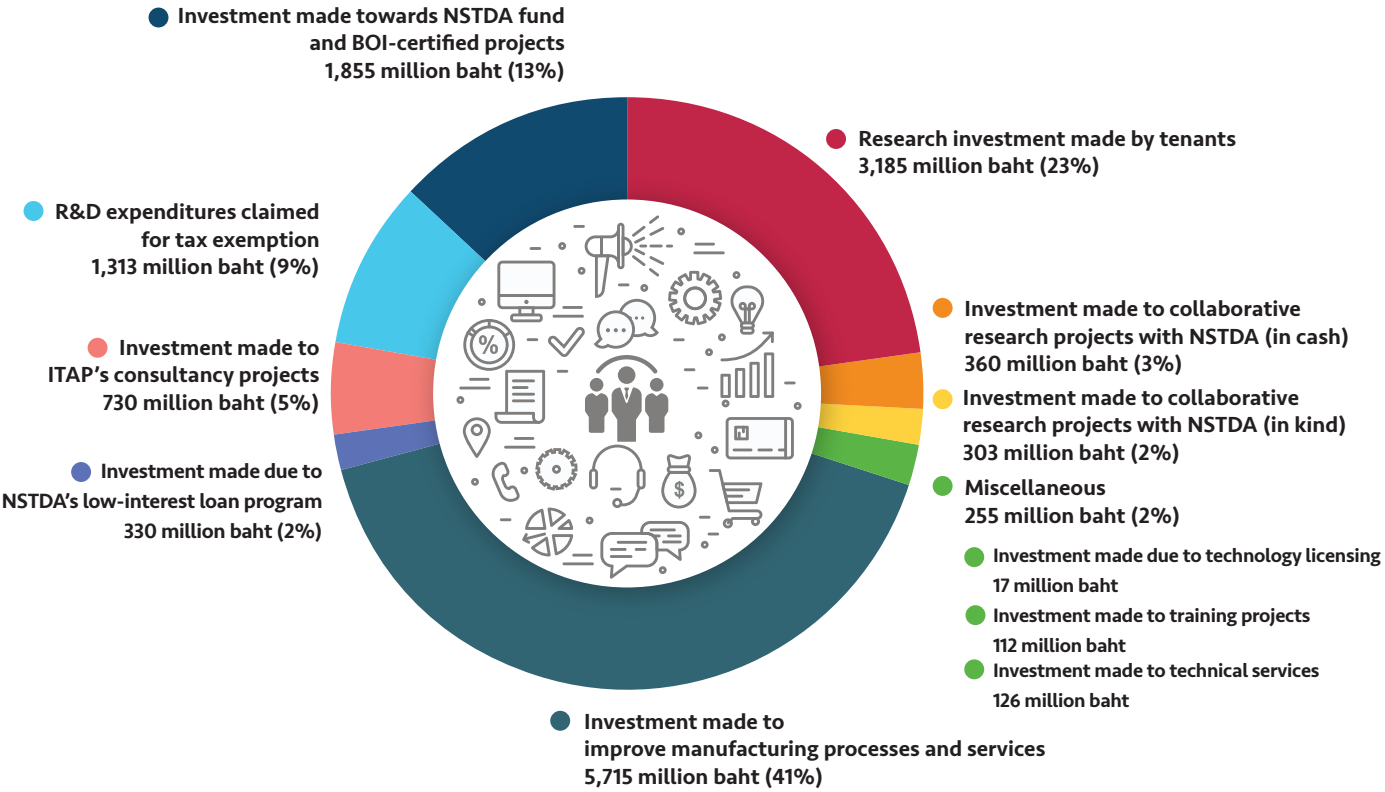
The Thai-Israeli Tomato Conference: The current status and the way forward

NSTDA, in collaboration with the Embassy of Israel in Thailand, organized the Thai-Israeli Tomato Conference: The current status and the way forward on 1 November 2017 at Thailand Science Park. The conference provided an opportunity for researchers and experts from Thailand and Israel to meet and exchange research and innovation related to tomato cultivation, as well as promoted research and commercial collaboration between Thailand and Israel. Interesting presentations from Israeli experts include the planning and design of nursery and greenhouse for tomato cultivation given by Dr. Nir Atzmon from New Grow Plant Company in Israel, tomato breeding program and pest/disease management by Dr. Avner Levy from Noga AgroTech Desert Agriculture. The conference was attended by 90 participants from public and private sectors.

SOCIO-ECONOMIC IMPACT

NSTDA strives to enhance the nation's competitiveness on the global scale based on strength in science and technology with intensive research and development. This is reflected in our vision that positions the agency to be a key partner supporting every sector — manufacturing, service and agriculture — in applying science and technology to improve efficiency. This performance is therefore measured in the form of S&T investment made by our partner organizations. In 2018, this S&T investment totaled 14,046 million baht with details as follows:

S&T Investment made by NSTDA partner organizations



1. After acquiring technologies from NSTDA, partner organizations made an investment to improve or expand their manufacturing processes and services, procure machineries and equipment, and increase their employment, totaling 5,715 million baht.
2. R&D investment made by the private sector through participation in NSTDA schemes designed to support enterprises, e.g. R&D investment made by tenants in Thailand Science Park and Software Park Thailand, donations to NSTDA fund and investment made to BOI-certified projects, R&D expenditure claimed for tax exemption, investment made to ITAP's consultancy projects and investment made on projects seeking low-interest loan, totaling 7,413 million baht.
3. Investment made to collaborative research projects with NSTDA by both public and private sectors was 663 million baht, comprising 360-million-baht in-cash investment and 303-million-baht in-kind investment (facilities, equipment and R&D personnel).
4. Investment made to other S&T services offered by NSTDA including analytical/ technical services, training and technology licensing, totaling 225 million baht.

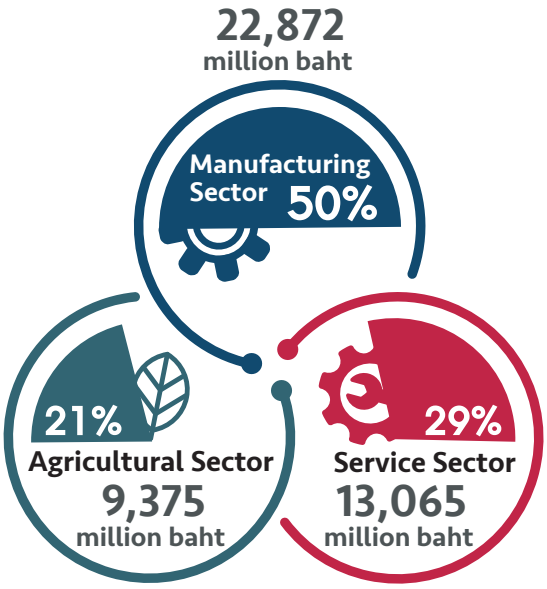
NSTDA is committed to conduct research and development to create S&T innovations to benefit the nation. In 2018, data collected from beneficiaries of NSTDA's projects/ programs showed an economic impact of 45,310 million baht. Beneficiaries of NSTDA's innovations are categorized into the manufacturing sector, service sector and agricultural sector.

Economic benefit to the manufacturing sector was 22,870 million baht. This number was mainly contributed to by the research and development projects resulting in new products or solutions to improve product quality fulfilling consumers' requirements and meeting industry standards. An outstanding example is a mycotoxin binder derived from protease used as a feed additive. Mycotoxins are toxic substances produced by fungi. This mycotoxin binder can effectively adsorb several groups of mycotoxins present in animal feed. The technology has been licensed to a Singaporean company and has generated an economic impact of 3,188 million baht in 2018.

NSTDA's R&D projects/programs have benefited the service sector — public and independent organizations, public health service, academic institutes and mass communication services — at the value of 13,065 million baht. A highlight of innovation in this category is Thai School Lunch. Developed by NECTEC-NSTDA and Institute of Nutrition of Mahidol University, Thai School Lunch is an automated system employing artificial intelligence to provide recommended school lunch menus. The system is a useful tool to help schools self-plan nutritious school lunch menus at an optimal budget. With proper planning, school lunch budget can be managed more effectively, and fund can be saved. With the collaboration of the Office of the Basic Education Commission (OBEC), Thai School Lunch has been implemented in all OBEC's primary schools throughout the country. Many schools under the Office of the Private Education Commission, the Local

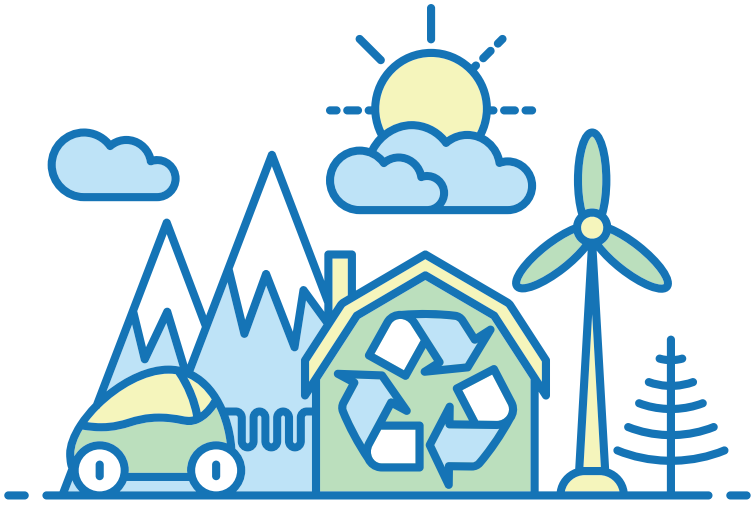
Administrative Organizations and the Border Patrol Police have requested the use of this system. Economic impact of Thai School Lunch was estimated to be 2,788 million baht in 2018.

Some of NSTDA's projects have resulted in a productivity improvement in the agricultural sector and the economic impact of these projects was approximated to be 9,375 million baht. One notable example is a project to evaluate elite sugarcane clones for their suitability for growing. Sponsored by NSTDA, the project was led by Prof. Dr. Peerasak Srinives of Kasetsart University. In this project, elite sugarcane clones were identified for sugarcane growing areas in Thailand through multilocation trials conducted in collaboration with research stations of public and private sectors in 38 locations in central, northern, eastern and northeastern regions of Thailand. Elite varieties were promoted among sugarcane farmers. The project enabled farmers to earn more income from higher productivity and quality, and sugar mills to obtain better quality and continuous supply. Economic impact of this project was estimated to be 4,400 million baht.



Economic impact by beneficiary in 2018

SAFETY AND ENVIRONMENT MANAGEMENT



Enculturing Safety and Environment

NSTDA recognizes the importance of workplace safety, responsibility for our environment, and sustainable use of resources. The Occupational Health and Safety Management System: OHSAS 18001 is implemented in all of our activities and workplace. NSTDA safety management is led by a NSTDA senior executive and implemented by the Safety and Environment Working Group and the Safety, Health and Environment Division according to the health, safety and environmental policies of NSTDA and its national centers. Hazard identification and risk assessment are routinely performed at the start of fiscal year and the results are used to define control measures and set an annual work plan, operational control plan for safety, as well as monitoring and evaluation. The working group and staff of the Safety, Health and Environment Division meet monthly to update on their work and discuss issues that may arise. For emergency situations, NSTDA has an emergency response plan and procures proper equipment for handling situations such as fire, chemical spills and gas leaks. A total of 24 drills were conducted throughout the year and NSTDA representatives also participated in drills organized by tenants of Thailand Science Park. A number of automated external defibrillators have been installed throughout Thailand Science Park.

In FY 2018, NSTDA underwent the 2nd surveillance audit performed by the Management System Certification Institute (Thailand) for the compliance with TIS 18001:2011 and BS OHSAS 18001:2007 standards. The current certificate is valid until 25 August 2019. While NSTDA has constantly made improvements on occupational health and safety management systems conforming to TIS 18001 for the past 11 years, the agency is preparing to migrate to ISO 45001. NSTDA strategic and action plan for safety and environmental management (2018-2020) was developed aiming to improve management system and the performance on occupational safety and health and to mitigate, control and prevent risks in the workplace. Essential deliverables of this plan include acquiring ISO 45001 certification, establishing a safety database system and constructing an integrated wastewater treatment system that can accommodate various types of wastewater from diverse laboratories. For long-term occupational health and safety management, NSTDA continues to create and maintain the culture of safety by engaging its employees. Employees are encouraged to monitor and report on unsafe actions taking place.

Potential impact to the environment caused by NSTDA's operation is of paramount concern. Environmental quality conditions are constantly monitored, including quality of discharged wastewater, levels of heavy metals in treated wastewater, quality of wastewater from individual buildings, air quality in Thailand Science Park, quality of emissions from an incineration plant, quality of groundwater in Thailand Science Park, quality of water in the reservoirs in the vicinity of Thailand Science Park and levels of heavy metals in soil. In FY 2018, 113,885 cubic meters of wastewater were produced in Thailand Science Park. We ensure that wastewater in Thailand Sci-

ence Park — whether from office, laboratories or tenants — is effectively treated, and the discharge quality meets the regulatory standard. Treated wastewater is reused for cleaning and watering plants in Thailand Science Park. The goal is to become a zero-discharge facility. Sewage sludge is used as a soil amendment in Thailand Science Park and also distributed to employees.

A total of 62,429.73 kg of hazardous waste were generated from laboratories and tenants, a mere 0.11% increase from the previous year. Hazardous waste is segregated into incinerable hazardous waste and non-incinerable hazardous waste. Portion of incinerable hazardous waste is handled by NSTDA's incineration plant; the rest is sent to incinerators operating outside the premises in order to minimize the risk of NSTDA employees. NSTDA hazardous waste management complies with ISO 9001 standard, ensuring proper incineration and proper treatment of flue gas so as not to impact air quality. There is a unit within NSTDA assigned to manage non-incinerable hazardous waste by contracting an external treatment facility to remove and treat this type of waste.

Carbon Footprint for Organization: CFO

In FY 2018, NSTDA was awarded a certificate verifying that its quantity of greenhouse gas in FY 2017 (1 October 2016 - 30 September 2017) met the requirements of TGO Guidance of the Carbon Footprint for Organizations (CFO) for the third consecutive year. This certificate covers NSTDA facilities located in and outside Thailand Science Park. The total greenhouse gas emission in FY 2017 was 22,616 tons of CO_2e. In FY 2018 (1 October 2017 - 30 September 2018), the total greenhouse gas emission was measured at 22,442 tons of CO_2e, a 0.77% decrease from the previous year.

Scope*	FY 2017		FY 2018		Remark
	Green-house gas emissions	Percentage	Green-house gas emissions	Percentage	
Scope 1	2,431	10.75	3,142	14.00	An increase in greenhouse gas emissions in FY 2018 is attributed to the R314 refrigerant, chemical (nitrous oxide) used in laboratories, and diesel cars.
Scope 2	19,285	85.27	18,334	81.70	A decrease in greenhouse gas emissions is due to the switch in an electricity provider to Nava Nakorn Electricity Generating Company Limited which has a lower EF** than the Electricity Generating Authority of Thailand. However, overall electricity consumption has increased in FY 2018, largely attributed to newly opened multi-purpose building, more working space opened in the Innovation Cluster 2 Building, and events/activities held at Sirindhorn Science Home and TSP Convention Center.
Scope 3	900	3.98	965	4.30	An increase in greenhouse gas emissions in FY 2018 is caused by an increase in paper usage, water consumption, and the amount of hazardous waste treated by external incineration facilities.
Total	**22,616**	**100**	**22,442**	**100**	

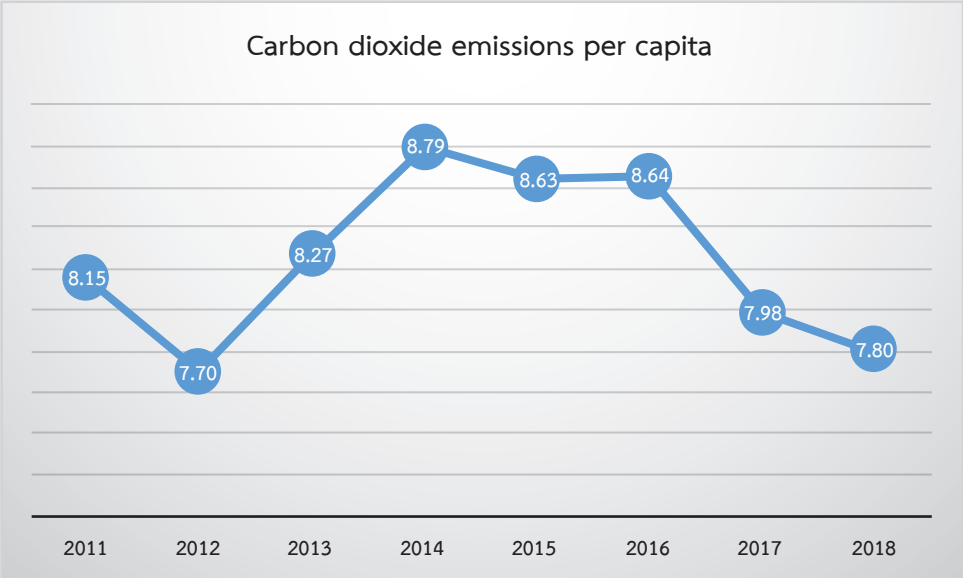
Note: * Three scopes are:

Scope 1: Greenhouse gas emissions from the consumption of fuel in general activities such as LPG consumption in laboratories and by electricity generators; diesel consumption by electricity generators, fire-fighting pumps and incinerators; gasoline consumption by electricity generators, floor grinders, water pumps and lawn mowers; fuel consumption in transportation such as NSTDA's vehicles (gasohol-diesel), vehicles operated by sub contractors used in NSTDA's activities (diesel-NGV) and NSTDA executives' cars (gasohol); carbon dioxide generated from fuel combustion in laboratories; SF6 consumption in switchgear and substations; consumption of chemicals such as R134 and R410A refrigerants, lab chemicals (carbon dioxide and nitrous oxide) and fire suppression agents (CO_2, HFC-227ea); N_2O from urea fertilizers and toilet usage; and greenhouse gas (methanol) generated by NSTDA's incineration plant.

Scope 2: Greenhouse gas emissions from the consumption of electricity.

Scope 3: Greenhouse gas emissions from vehicle transportation such as office shuttle buses (diesel-NGV); the usage of consumables such as papers and toilet papers; the consumption of resources such as water and drinking water; and hazardous waste treatment such as the consumption of fuel by external incineration facilities.

** Emission Factor (EF) is the quantity of carbon dioxide released per output unit in an organization.



(unit: tons of CO_2 eq)

With the number of 2,873 employees in FY 2018, the greenhouse gas emission was 7.80 tons of CO_2 eq/person, a decrease by 0.18 tons of CO_2 eq/person from the previous year.

RISK MANAGEMENT

NSTDA set its risk management system in accordance with the ISO 31000:2009 enterprise risk management framework. Effective since FY 2012, NSTDA risk management consists of three levels: Enterprise Risk Management (ERM), Strategic Business Unit (SBU) and Major Program and Project (MPP). The goal is to seamlessly incorporate risk management into all work processes so that it eventually becomes part of the organization's culture.

A Sub-committee on NSTDA Risk Management has been established by the NSTDA Governing Board with the role to give advice on appropriate policy and actions on the enterprise risk management as well as to regularly provide an update and a performance report on risk management to the NSTDA Governing Board. NSTDA Risk Management Working Group was set up to develop policy, work plan and system for risk management. NSTDA Risk Management Committee, chaired by the NSTDA President, was established with the responsibility of managing ERM, taking actions to prevent and mitigate potential impacts of risk factors, reviewing and revising risk management process at an appropriate frequency, and communicating and raising awareness on risk management to employees at all levels.

NSTDA risk management methodology follows the ISO 31000:2009 enterprise risk management framework which consists of cause analysis, impact assessment, identification of actions to take and weaknesses to overcome, and subsequently assessment on the occurrence likelihood and impacts before and after the action of risk management. Bow Tie Diagram is used as a tool for analyzing causes, impacts and measures to control/mitigate risks which lead to evaluating options and identifying risk response. The diagram is used for meetings, reports, consultations and communication with NSTDA Risk Management Committee and stakeholders.

In FY 2018, seven risks were identified, covering four aspects: Strategy (S), Operation (O), Finance (F) and Compliance (C). Out of seven risks identified, four were scored very high, two were scored high, and one was medium. Risk control plans were developed for all seven risks. The plan was executed and as a result the score of one risk was reduced and met the target, whereas the scores of six risks were reduced and exceeded the target. The risk meeting the target was RES-5 Inability to achieve the goal of EECi (Eastern Economic Corridor of Innovation) development. Six risks that the reduction exceeding the target were (1) RES-6 Inability to adapt to change; (2) RES-4 Collaboration with key strategic partners not achieving the goal of NSTDA mission; (3) REF-1 Inadequate income to execute activities under the set mission; (4) RES-1 Impact generated by R&D outputs not meeting the target; (5) REO-4 Inability to provide continuous ICT system; and (6) REC-1 Damaged reputation caused by mis-management or mis-governance.

After reviewing the risk management performance and examining the internal and external factors, NSTDA Risk Management Committee decided on risk management plan for FY 2019 by continuing to work on six risks and keeping one risk, REO-4 Inability to provide continuous ICT system, under monitoring. FY 2019 risk management plan covers the following eight factors:

Strategic Risk

(1) RES-1 Impact generated by R&D outputs not meeting the target

(2) RES-4 Collaboration with key strategic partners not achieving the goal of NSTDA mission

(3) RES-5 Inability to achieve the goal of EECi (Eastern Economic Corridor of Innovation) development

(4) RES-6 Inability to adapt to change

(5) RES-7 Inability to meet the target on the preparation of manpower to drive Thailand 4.0 agenda

Operational Risk

(6) REO-6 Inability to create new financing mechanisms to encourage technology utilization

Financial Risk

(7) REF-1 Inadequate income to execute activities under the set mission

Compliance Risk

(8) REC-1 Damaged reputation caused by mis-management or mis-representation in the public media

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