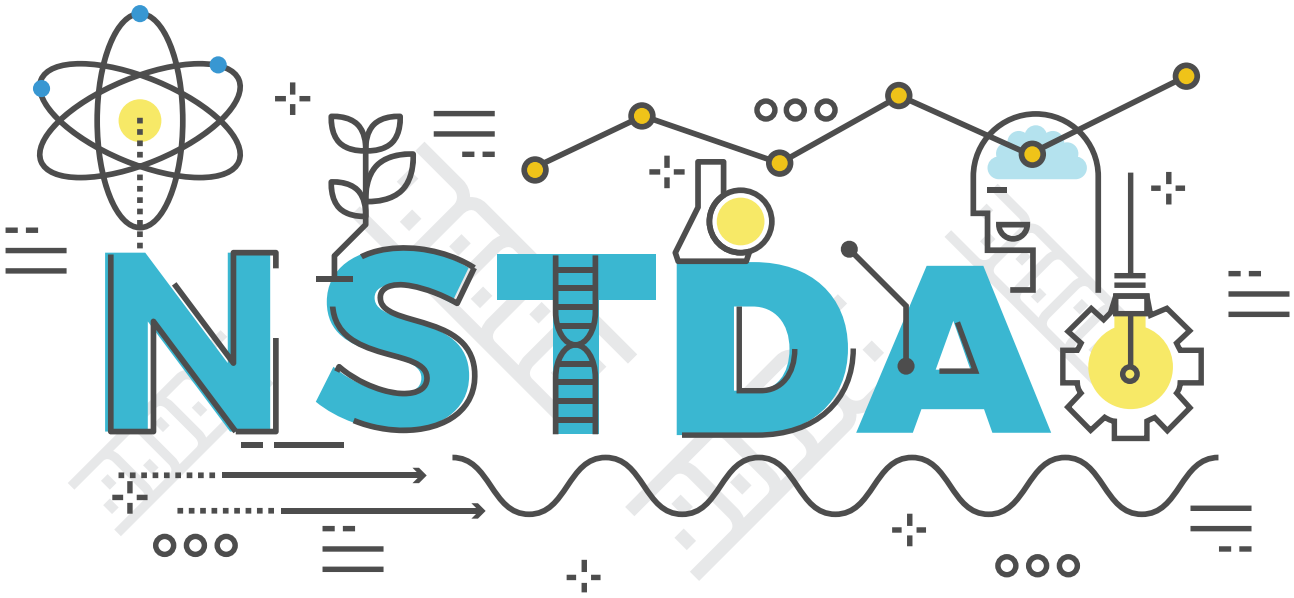
Annual Report 2017

National Science and Technology Development Agency (NSTDA)



Annual Report 2017

National Science and Technology Development Agency

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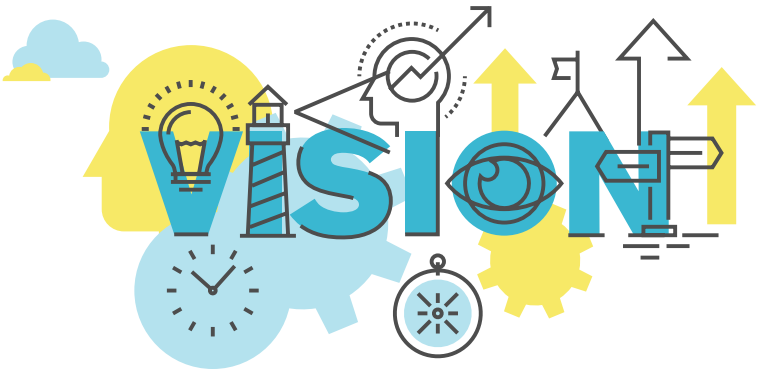
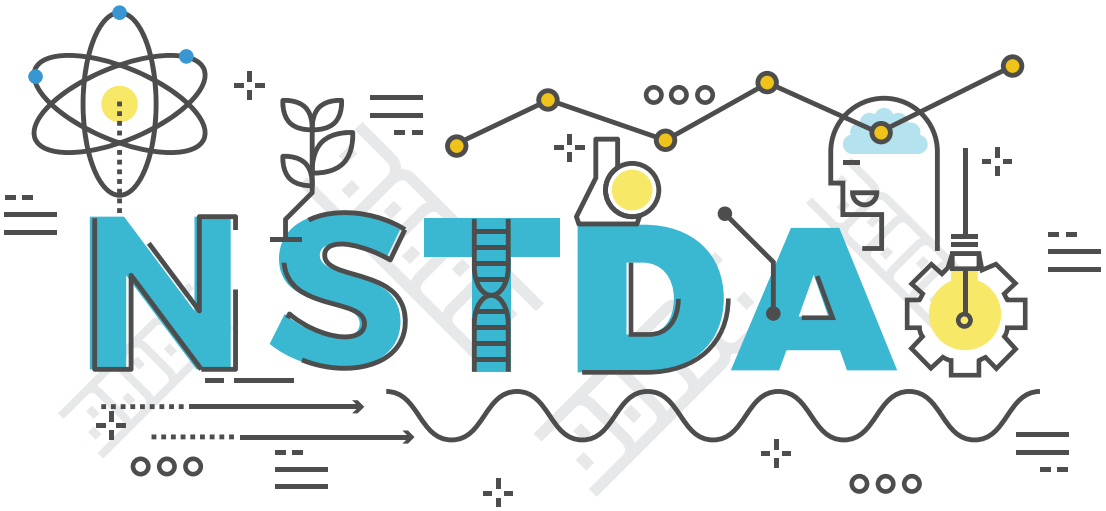
The National Science and Technology Development Agency (NSTDA)
was established in 1991 under the National Science and Technology Development Act 1991.
The Agency is affiliated to the Ministry of Science and Technology and reports
to the NSTDA Governing Board, chaired by Minister of Science and Technology.



NSTDA is a key partner for a knowledge-based society through science and technology.

Research, Development, Design and Engineering (RDDE)
Technology Transfer (TT)
S&T Human Resource Development (HRD)
S&T Infrastructure Development (INFRA)



Nation First

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

Science and Technology Excellence

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

Team Work

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

Deliverability

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

Accountability and Integrity

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

CONTENTS

MESSAGE FROM NSTDA BOARD CHAIRMAN

Mr. Suvit Maesincee
Minister of Science and Technology
Chairman of NSTDA Governing Board

The Ministry of Science and Technology has been implementing measures and activities in accordance with the Government's policy to transform the country with science, technology and innovation (STI) in order to thrive in the 21st century. The Ministry will continue to play a major role in the transformation to Thailand 4.0 by concentrating on the following 6 issues, namely; (1) connecting STI to target groups by making STI accessible, comprehensible and part of people's lives; (2) embracing open collaboration by engaging all sectors — ministries, the public, global communities — to work towards a common goal "science for Thailand's development"; (3) developing expertise to become a leader in selected fields, moving from "something in everything" to "everything in something"; (4) adopting sufficiency economy philosophy in the policy implementation by building national technological capability to become self-reliant in science and technology; (5) advancing together, not leaving anyone behind by employing STI to reduce social disparity and heighten potential of every group in the society; and (6) strengthening mechanisms to apply STI in responding to the nation's challenges, developing the future industry, fostering innovation-based community enterprises and preparing Thai people to thrive in the 21st century.

NSTDA is a key S&T organization in Thailand, with over 3,000 employees, two-thirds of which are research staff. The Agency is a major driving force in creating innovations that significantly make an impact on the economy and people's quality of life. Many of NSTDA's innovations have been widely put in great use and commercialized. These are, for instance, the locally-made dental scanner DentiiScan, Agri-Map that provides suggestions to farmers on the most profitable crops to grow in particular areas, and packaging that can prolong the freshness of fresh produce.

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

MESSAGE FROM NSTDA PRESIDENT

Mr. Narong Sirilertworakul
President of NSTDA

NSTDA is tasked with the mission to conduct research, development, design and engineering; transfer technologies; promote manpower development; and establish and maintain S&T infrastructure with the ultimate goal to enhance the country's competitiveness. In FY 2017, we are proud to be entrusted by the Government with several important causes, in particular taking part in the development of the national research system which has evolved into the 20-year Research and Innovation Strategy. Over the past year, much of our work has come to fruition and become innovations and solutions that satisfactorily meet the demand of the local agricultural, manufacturing and service sectors. A number of mechanisms have been made available in order to promote the utilization and commercialization of research, development and innovation. These mechanisms are, for example, the flat-rate 30,000 baht technology disclosure fee program, Startup Voucher, the 300% R&D tax exemption program and the Innovation List; all of which have been well received by the private sector.

NSTDA places great emphasis on enhancing Thailand's competitiveness. In doing so, we intend to drive this agenda with five priority areas as set forth in the 6th NSTDA Strategic Plan (Revised Edition, 2018 - 2022). Five priority areas were identified as areas that would create substantial social and economic impact and these are Food Innovation, Modern Transportation, Health and Quality of Life, Biochemicals and Biofuels and Innovation for Sustainable Agriculture. An Integrated Technology Platform has been established to promote multi-disciplinary research in order to discover new knowledge and create novel technologies for applications in the future. Building upon the expertise of our four national research centers, three new platform technologies have been introduced which will have applications in a wide range of industries and they are Sensors, High-performance Computing & Data Analytics (HPC & DA), and Bio-based Materials.

At NSTDA, we focus on working collaboratively with partners from the public and private sector, and forming strong partnerships with alliances domestically and internationally. We are fully committed to unlock STI potential to support every sector and lead Thailand out of middle-income trap into Thailand 4.0 with stability, prosperity and sustainability.

EXECUTIVE SUMMARY

The National Science and Technology Development Agency (NSTDA) is an organization under the purview of the Ministry of Science and Technology, tasked with a responsibility to develop competency in science and technology for the nation. In FY 2017, NSTDA's key performance highlights are as follows:

Research, Development and Technology Transfer. NSTDA published 578 articles and over one-third of these publications were in world-class journals and cited more than the national average. There were 301 applications for intellectual property rights and 255 technology transfer projects with 311 recipient organizations. The Agency was able to generate a 27,546 million baht economic and social impact and was instrumental in a 9,456 million baht investment in science, technology and innovation made by manufacturing and service sectors.

These are some **research highlights** in FY 2017.

- **Smart Farm:** nutritious and anti-oxidant rich Riceberry, flash-flooding tolerant Homcholasit rice for the community, diagnostic kits for shrimp diseases to minimize risk and increase farmers' income, and Agri-Map: a tool for agricultural management.
- **Smart Food: Dezigner-8:** an innovative delivery system to enhance egg quality, low-fat frankfurter, and ActivePAK™ fresh produce packaging.
- **Smart Health:** DentiiScan: a scanner for dental and maxillofacial structures, safety-enhanced ambulance cabin to save lives and medical equipment, and Thai School Lunch to help schools prepare lunch menus to meet nutritional requirements and available budget.
- **Smart Energy:** nanomaterial coating and coating technique to enhance solar thermal energy efficiency.
- **Smart Industry:** NETPIE: a platform to facilitate interconnecting IoT devices, and ENZease: a duo-activity enzyme for one-step biodesizing and bioscouring process of cotton fabric, 100% replacement of chemicals.

In FY 2017, a new organization, **Agricultural Technology and Innovation Management Institute (AGRITEC),** was founded under NSTDA, to **facilitate the transfer of technologies to farmers.** AGRITEC now works with 220 communities in 45 provinces, covering 36 key technologies. Some outstanding projects include organic rice cultivation in Yasothon province and greenhouse technology with photoselective plastic covering.

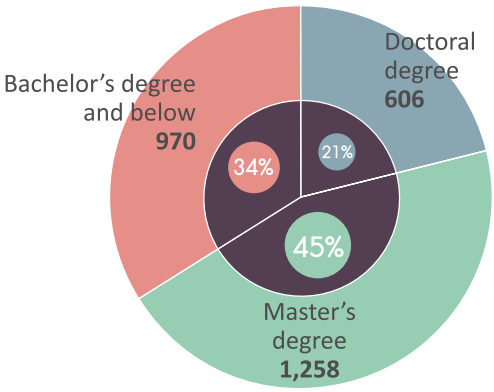
Promoting Research and Development in Thai Industry. NSTDA implements several incentive programs to promote R&D investment in the private sector. For the Innovation List, NSTDA committee has approved 136 innovations and 105 of these were published in the Innovation List. A total of 385 projects were certified for 300% R&D tax exemption program with the total value of 1,299 million baht. The flat-rate 30,000 baht technology disclosure fee program has attracted 306 applications for technology license. Startup Voucher program has allocated 60 million baht fund to 82 business operators to be used towards marketing activities, resulting in an 80 million baht earning made by those businesses. The Innovation Technology Assistance Program (ITAP) has supported 1,551 SMEs in Thailand. Under ITAP, it was estimated that for every baht invested by the company, a 7.64 baht impact was generated to the economy. And lastly, NSTDA testing centers and labs have performed over 43,000 tests, worth more than 115 million baht.

STI Human Resource Development and Public Communications. A total of 730 scholarships have been granted to develop students and science professionals to boost the quality and quantity of manpower in science, technology and innovation. Activities such as youth camps, science contests and competitions have been organized to promote science learning and stimulate interest in science and technology among young minds. In addition, the TAIST-Tokyo Tech engineering graduate program has produced 280 graduates since its inception. These graduates are equipped with skills and knowledge to help drive Thai innovative industry.

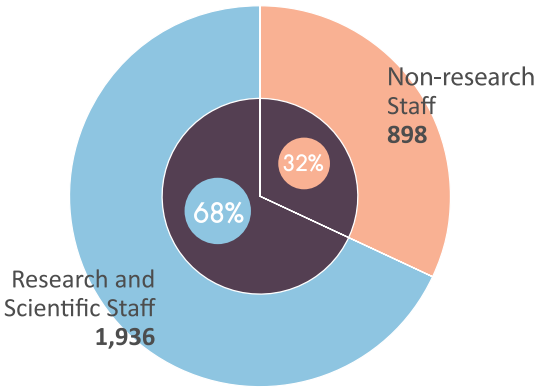
In addition, NSTDA was proud to **contribute to the success of our tenants in the Thailand Science Park.** Our highly successful tenants include Gravitech (Thailand) that incubates electronic startups for the design and development of electronic circuits; CDIP (Thailand) that performs contract research and development in food supplements; Green Innovative Biotechnology engaging in research and development of products for agricultural application with an emphasis on the use of natural products in place of chemical pesticides and antibiotics; and Haydale Technologies (Thailand) manufacturing the world's first transparent graphene conductive ink under the brand name "PHENE Plus".

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 in the global market and drive the nation into Thailand 4.0 era.

HUMAN RESOURCES

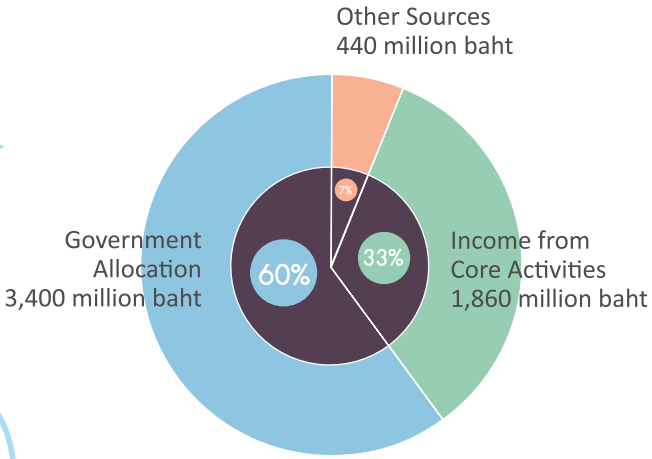


By education



By job function

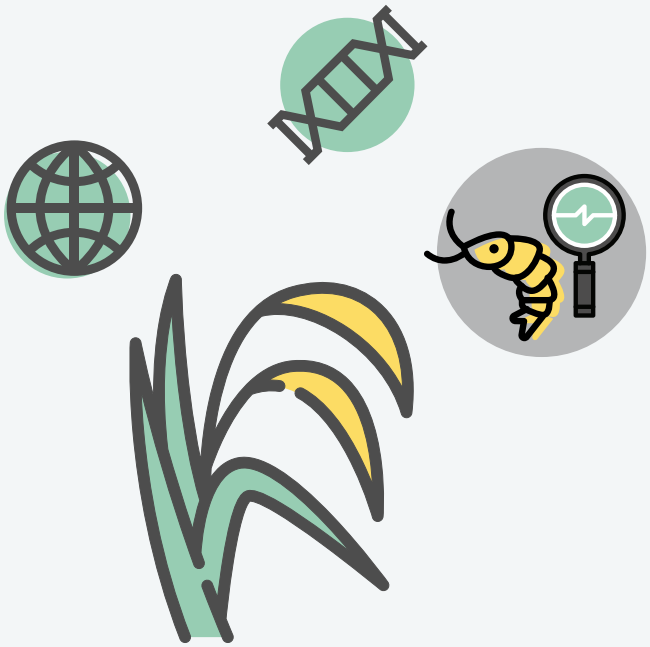
SOURCES OF INCOME



5,700 million baht

ENABLING RESEARCH AND INNOVATION

SMART FARM



ENABLING
RESEARCH AND INNOVATION

Homcholasit Rice

Flash-flooding tolerant rice for the community, generating over 41 million baht in impact

Flood is an inherent natural disaster taking place every year in Thailand. Rice paddy fields completely submerged under the water can be destroyed within a few days. BIOTEC researchers, in collaboration with researchers from Kasetsart University and the Rice Department, successfully developed Homcholasit rice with a quality for flash flooding tolerance and non-photoperiod sensitivity. Homcholasit, a cross between Khao Dawk Mali 105 and IR57514, was developed with a marker-assisted breeding technique to achieve the new rice with flood tolerant gene and superb cooking quality.

Homcholasit can survive under the water for 2 - 3 weeks. It has strong stems, can reach a height of 105 - 110 cm. and matures in about 120 days after seeding, providing an average yield of 800 - 900 kg/rai (5 - 5.625 tons/ha). One plant contains 15 ears on average, with an ear length of 15 cm. This non-photosensitive rice can be planted more than once a year. The cooked rice is soft and fragrant, like Khao Dawk Mali 105 (jasmine rice). The grain is 10.9 mm in length, 2.5 mm in width and 2.0 mm in thickness.

Phak Hai Agricultural Cooperative in Phra Nakhon Si Ayutthaya province has successfully built a business out of Homcholasit rice, producing a packed rice under a brand name “On-waan”. On-waan rice is now available in leading supermarket chains.

Riceberry

Nutritious rice that creates a 29-million-baht impact

Rice is staple food in Thai culture, packed with nutrition and energy. To enrich rice, by making it more healthy, the Rice Gene Discovery Unit, a research unit of BIOTEC-NSTDA, teamed up with the Rice Science Center of Kasetsart University, Kampaengsaen Campus, to develop Riceberry, a new highly nutritious rice, with research funding provided by the National Research Council of Thailand.

Riceberry is derived from a cross between Jao Hom Nin and Khao Dawk Mali 105. It is enriched with antioxidants such as carotenoids, gamma oryzanol and vitamin E, as well as being high in tannin, zinc and folate. It has a low to medium glycemic index. Its other properties include stimulation of collagen synthesis, anti-wrinkle and anti-aging. Its low to medium glycemic index indicates that Riceberry is suitable for people suffering diabetes and obesity. Its high iron content also makes this rice perfect for people with anemia.

Diagnostic Kits for Shrimp Diseases

Minimizing risk, increasing farmers' income, making 1- billion-baht impact

Screening for viral or bacterial pathogens in shrimp broodstock or seed prior to releasing into ponds is vital as it can hep minimize risk in shrimp farming. Conventional methods require equipment and experts to detect diseases, not to mention high costs and being time consuming. Researchers from BIOTEC-NSTDA have developed simple, rapid diagnostic techniques using loop-mediated isothermal amplification (LAMP) to detect shrimp pathogens, with high accuracy. Additionally, the methods do not require experts nor expensive equipment.

An example of these detection kits is "Amp-Gold", developed by Dr. Wansika Kiatpathomchai, BIOTEC researcher. Amp-Gold employs 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. Red color in the solution indicates positive result; whereas grey is negative. The test is highly specific and does not cross-react with other types of pathogens. It is suitable for small hatcheries and farms, and can be used with all stages of shrimp, including eggs, nauplii and broodstock.

Amp-Gold was honored with the 2017 Invention Award in Agricultural Science and Biology (Excellent Level) from the National Research Council of Thailand.

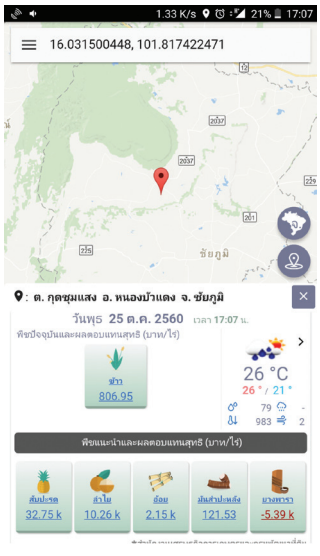
Agri-Map:
A Tool for Agricultural Management

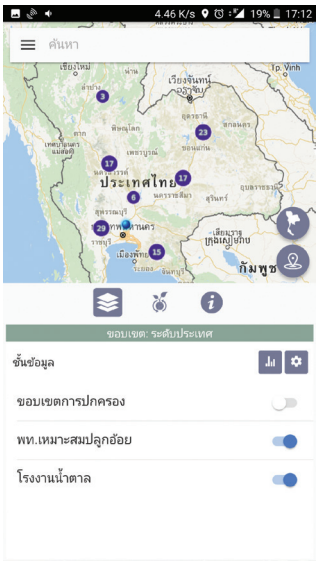
Saving 1.3 million baht in expenses

Thailand is an agricultural-based country with vast land dedicated to agricultural activities. However, agricultural land needs proper management to maximize its benefits. NECTEC-NSTDA, in collaboration with the Ministry of Agriculture and Cooperatives and the Land Development Department, has developed a tool for agricultural management. This tool collects and processes complex sets of geographical and economic data to provide accurate results for farmers in every dimension and covering the entire country.

Agri-Map Online is a web-based GIS (Geographic Information System) tool that can provide a list of recommended as well as substitute crops for the area. Users can conveniently access the online system anywhere and anytime. The system has been accessed 110,000 times (as of 26 October 2017).

Agri-Map Mobile is a mobile application designed to improve users' experience in efficient agricultural management. It covers useful land-specific information for crop cultivation such as soil, water, irrigation system, weather, commodity prices, etc., both current and forecast. Launched in May 2017, the application can be accessed via an android mobile phone anywhere and anytime, covering all 76 provinces and the Bangkok Metropolitan Area.





SMART FOOD

ENABLING
RESEARCH AND INNOVATION

Dezigner-8

Innovative delivery system to enhance egg quality, generating 20 million baht in product sales

Eggs are an important source of protein and functional nutrients in human diet. Quality of eggs depends heavily upon the poultry rearing system, including feed. Avian digestive system is comparatively short, and therefore nutrients are not efficiently absorbed. Researchers from NANOTEC-NSTDA have developed a way to improve nutrient absorption to yield better quality eggs.

Researchers employed a unique target delivery system and the latest chelation innovation to mobilize bioactive ingredients directly to the gastrointestinal system, greatly enhancing the efficiency of digestion and nutrient absorption in poultry. In addition, nano-encapsulation technology is applied to contain strong odor of oregano and sweet basil oils in order to appeal to flocks when mixed with feed. These technologies were utilized to develop Dezigner-8, an effective poultry feed supplement enriched with oregano and sweet basil oils providing antibiotic and antioxidant properties. This innovative feed supplement yields 80 - 90% fresher eggs meeting an AA-grade quality standard such as hard shell and clear and firm albumen. Eggs also contain 20 - 40% more nutrients. Farmers are able to earn more income with these high quality eggs.

Dezigner-8 received a Gold Award and a Special Award from Romania at the 11th International Warsaw Invention Show (IWIS 2017) in Warsaw, Poland.

Low-fat Frankfurter

Healthier option, generating 17-million-baht income and 10-million-baht investment

Currently, consumers are becoming more health conscious and therefore demand for healthy food is on the rise. However, healthy food does not always come with good flavor.

MTEC-NSTDA and Betagro Science Center has developed a low-fat frankfurter. This is achieved through the replacement of animal fat with a mixture of fat replacer, plant fiber and rheology modifier. It is made from organic pork and natural ingredients, and free from MSG, artificial food coloring and preservatives. It becomes the first frankfurter in Thailand that contains 4 times less fat when compared to full-fat counterparts. Despite containing only 75.3 kcal, this frankfurter is full of flavor and has great texture, just like the full-fat version. It comes in five flavors to choose from. This innovative product offers healthier alternative to consumers, without sacrificing taste. It is available in leading supermarkets across the country.

ActivePAK™ Packaging

Fresh produce packaging, prolonging freshness, reducing food waste, creating 92-million-baht impact

Quality and freshness of fruit 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. Today, there is a "breathable packaging" available to keep fruit and vegetables fresh and maintain the quality for a longer period. The transparent film also enables you to see the object inside clearly.

ActivePAK™ is an innovative fresh produce packaging film with Equilibrium Modified Atmosphere (EMA) technology. It can keep fruit and vegetables fresh for 2 - 5 times longer compared to standard perforated plastic bags, or simply put, 7 - 8 days as opposed to 3 days. Even better, this packaging is reusable.

Furthermore, MTEC-NSTDA has partnered with Central Food Retail Company Limited to evaluate and make improvement on ActivePAK™ to meet user requirements and enable industrial-scale production. ActivePAK™ is proven to be effective in prolonging the freshness and quality of fresh produce on the supermarket shelves, minimizing loss through spoilage, resulting in 10-billion-baht saving annually.

SMART HEALTH

ENABLING
RESEARCH AND INNOVATION

DentiiScan 2.0

360-degree dental scanner, installed in 7 hospitals, generating 2.6-million-baht impact

Accurate dental and oral information of patients enables dentists to diagnose correctly and prescribe proper treatments. However, most dental x-ray machines only provide 2D images, missing out the depth and overlapping objects.

Researchers from NECTEC and MTEC, in collaboration with partner organizations, successfully developed the first cone-beam computed tomography (CBCT) scanner (DentiiScan) in Thailand. The machine has been tested for the radiation safety by the Bureau of Radiation and Medical Devices, Ministry of Public Health, and the electrical and electronic product safety by the Electrical and Electronic Products Testing Center (PTEC). Currently in its 2nd generation, DentiiScan 2.0 takes only 18 seconds to provide 3D internal anatomy images of dental and maxillofacial structures, without distortion and superposition of anatomic structures. High quality data facilitates accurate diagnosis and safe treatment planning, as well as more effective communication with patients.

Two generations of DentiiScan, DentiiScan 1.1 and DentiiScan 2.0, have been released since 2007. Both models have been installed and used in hospitals across the country, performing over 4,000 scans. The machine has provided both economic and social benefits.

Safety-enhanced Ambulance Cabin

Strengthening rollover safety, over 50 units sold, creating 196-million-baht impact

Incidents of ambulance crashes have been increasing in Thailand and overseas, posing a threat to the safety of patients and medical staff. One way to alleviate this problem is the proper design of the ambulance cabin.

MTEC and Suprera Innovation Company Limited set out to design and develop the composite superstructure of ambulance cabin to enhance rollover safety for passengers. The design was made in accordance with international standards. The proposed cabin structure was tested for rollover strength on computer simulation and the full-scale prototype was also tested in the field.

Manufactured 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.

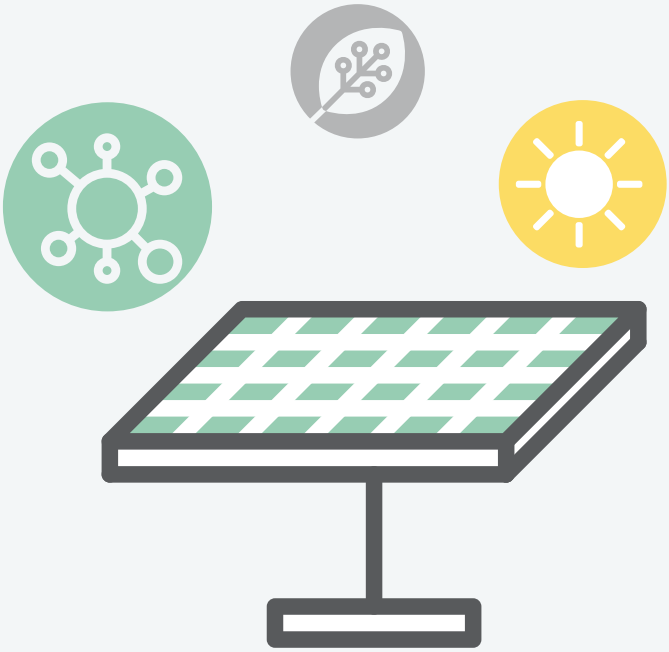
Thai School Lunch

Helping schools prepare lunch menus to meet nutritional requirements and available budget, saving 1,700 million baht on staff and budget

The Institute of Nutrition, Mahidol University has established a database of nutritional requirements for school age children and developed the INMU SchoolLunch, a computer software that enables users to check whether their proposed menus meet the nutritional requirements and make improvement on the menus accordingly. The software could not directly provide lunch menu suggestions. Hence, a nutritionist is still needed to plan the menu. Furthermore, INMU SchoolLunch is a standalone software, requiring installation on the computer and the database was not designed for updates.

NECTEC-NSTDA and the Institute of Nutrition therefore formed a partnership to develop an automated system to provide recommended school lunch menus. By employing artificial intelligence, the newly-developed system called Thai School Lunch is a useful tool to help schools self-plan nutritious school lunch menus according to the requirement for each school age group and available budget. For each recommended lunch menu, the system provides a list of ingredients, the amount of ingredients required to purchase, the budget per person and total nutritional value. Menus can be planned in advance and shared with other schools to use or modify. It is a versatile system to promote quality lunch for school age children.

SMART ENERGY



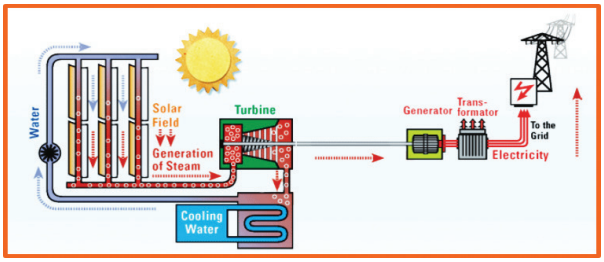
ENABLING RESEARCH AND INNOVATION

Nanomaterial Coating and Coating Technique for Parabolic Trough Solar Concentrator

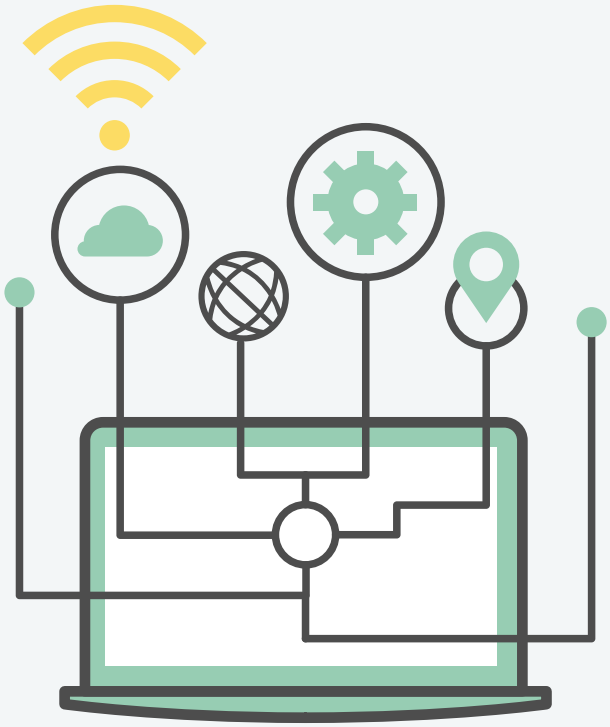
Enhancing solar thermal energy efficiency, utilizing local expertise, creating 157-million-baht impact

A parabolic trough solar concentrator is a type of solar thermal collector used for generating electricity. Its efficiency was found to be compromised by the poor quality of absorber tube coating. The traditional coating is not durable, peels easily and does not adhere well to stainless steel surface of the absorber tube under vacuum and high temperature conditions. This problem adversely affects the absorption and transmission capability, and subsequently the efficiency of the entire solar power system.

Researchers from NANOTEC-NSTDA developed nanomaterial coating and coating technique for parabolic trough solar concentrator to overcome the shortcomings and improve the efficiency of the device. This technology has been utilized by a private company to improve its solar farm.



SMART INDUSTRY



ENABLING
RESEARCH AND INNOVATION

NETPIE

Supporting the growth of IoT industry, creating over 233-million-baht investment and saving over 14 million baht

NETPIE is a cloud-based platform-as-a-service that interconnects (Internet of Things) devices together in the most seamless and transparent manner. It has a very unique design philosophy and approach to IoT development. In contrast to the view of other platforms where things are just components to be manipulated in order to serve in a predesigned function of an application, NETPIE uses thing-centric or bottom-up approach. With NETPIE, developers do not need to worry about the issue of setting device identity and access control in the beginning, as in other platforms that are application-centric. Ownership and access rights are defined dynamically at a later time (e.g., after the device is sold to consumers). The interaction among devices is designed to be as loose-couple as possible. This is almost analogous to a social network of things where things can communicate in pairs or in groups. Group members can be added or removed dynamically. More importantly, all security features (encryption, authentication, authorization, access control) of NETPIE support low-end microcontrollers while other platforms require quite a high-end microcontroller boards.

By moving the complexity of connecting IoT devices from application developers or device manufacturers to the cloud, NETPIE helps shorten development time and reduce the burden of server administration. NETPIE is therefore a shortcut solution for industry to enhance efficiency in IoT innovation. NETPIE is currently being used in a number of large organizations, including Nidec Shibaura Electronics (Thailand) Company Limited that sets its sights on becoming an automated facility in supporting Industry 4.0.

ENZease

A duo-activity enzyme for one-step biodesizing and bioscouring process of cotton fabric, 100% replacement of chemicals

Textile is considered one of the industries with large chemical inputs. These chemicals are harmful to workers' health and create pollution to the environment. Chemicals are used in virtually every process in textile production, in particular the desizing and scouring processes that use very acidic and alkaline chemicals such as hydrogen peroxide and caustic soda. In addition, desizing and scouring are performed in two separate steps because they require different operating conditions and therefore result in high energy, time and water consumption.

Researchers from BIOTEC and MTEC have collaborated with Thanapaisal textile factory to develop ENZease, a duo-activity enzyme for one-step biodesizing and bioscouring process of cotton fabric. Produced by a fermentation process of agricultural wastes using selected microorganisms from Thailand Bioresource Research Center, ENZease is a "smart enzyme", consisting of amylase and pectinase activities which are active at the same pH and temperature ranges, e.g. pH 5.5 and 50 degree celcius. These pH and temperature conditions also preserve the strength of the fabric. The one-step desizing and scouring process with ENZease takes only 1 hour, saving time, energy and costs significantly, not to mention the environment.

The technology has been licensed to Asia Star Trade Company Limited, a company specializing in industrial-scale enzyme production, for the production and commercialization of ENZease, with expected production capacity of 10 tons/month. The use of this innovative enzyme has also been promoted among small Mauhom production enterprises in Phrae province. Mauhom is a traditional fabric in northern Thailand produced with a specialized dyeing technique using fermented Hom leaves to render dark blue color.

SUPPORTING TECHNOLOGIES TO THE FARMING COMMUNITIES

Agricultural Technology and Innovation Management Institute (AGRITEC)

AGRITEC was established pursuant to the resolution of the NSTDA Governing Board on 23 December 2015 with the following goals:

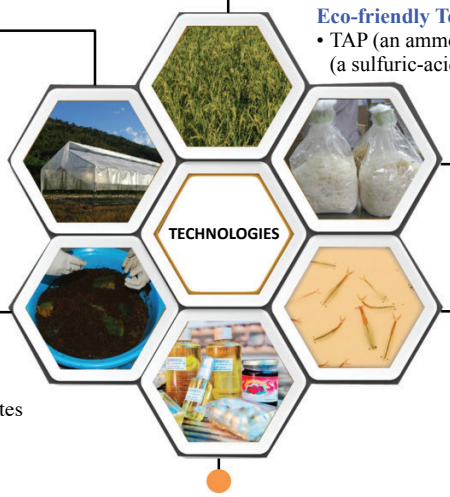
- Accelerate the transfer and adoption of technologies to farmers
- Support the life-long learning processes for farmers and communities which shall lead to the creation of knowledge and innovations.
- Enhance manpower development across the value chain.
- Connect farmers to processing factories.

36 Technologies Available for Transfer

Production Technologies (crop varieties / seed production / farm management / productivity)
- Rice / cassava / rubber tree / mungbean / chili / tomato
- Alternative crops such as 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)

Equipment and Machineries
- Rice milling machine for community usage
- Meteorological station
- TAMIS registration system
- Greenhouse with photoselective plastic cover
- Drying machine/facility for agricultural products



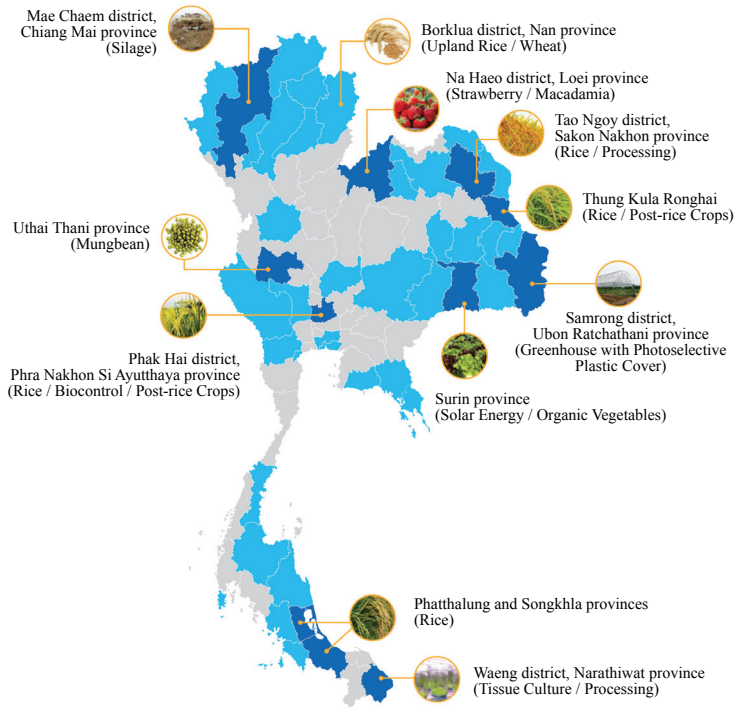
Biocontrol
- Beauveria for controlling aphids
- NPV for controlling armyworm
- Streptomyces for controlling fungi and bacteria infecting melons

Technologies for Soil and Water Management
- Unturned composting
- Vermicomposting
- Compost from agricultural wastes
- Irrigation systems

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
- Microorganisms to control foul odor in farms

Processing Technologies
- Processing of Agricultural Produce
- Good Manufacturing Practice

Areas of Technology Transfer in 2017



- 220 communities in 45 provinces took part in the technology transfer activities.
- 36 technologies are available for transfer.
- 6,032 farmers participated in the technology transfer activities.
- 547 extension officers / farmer leaders / business operators / marketing professionals were trained.

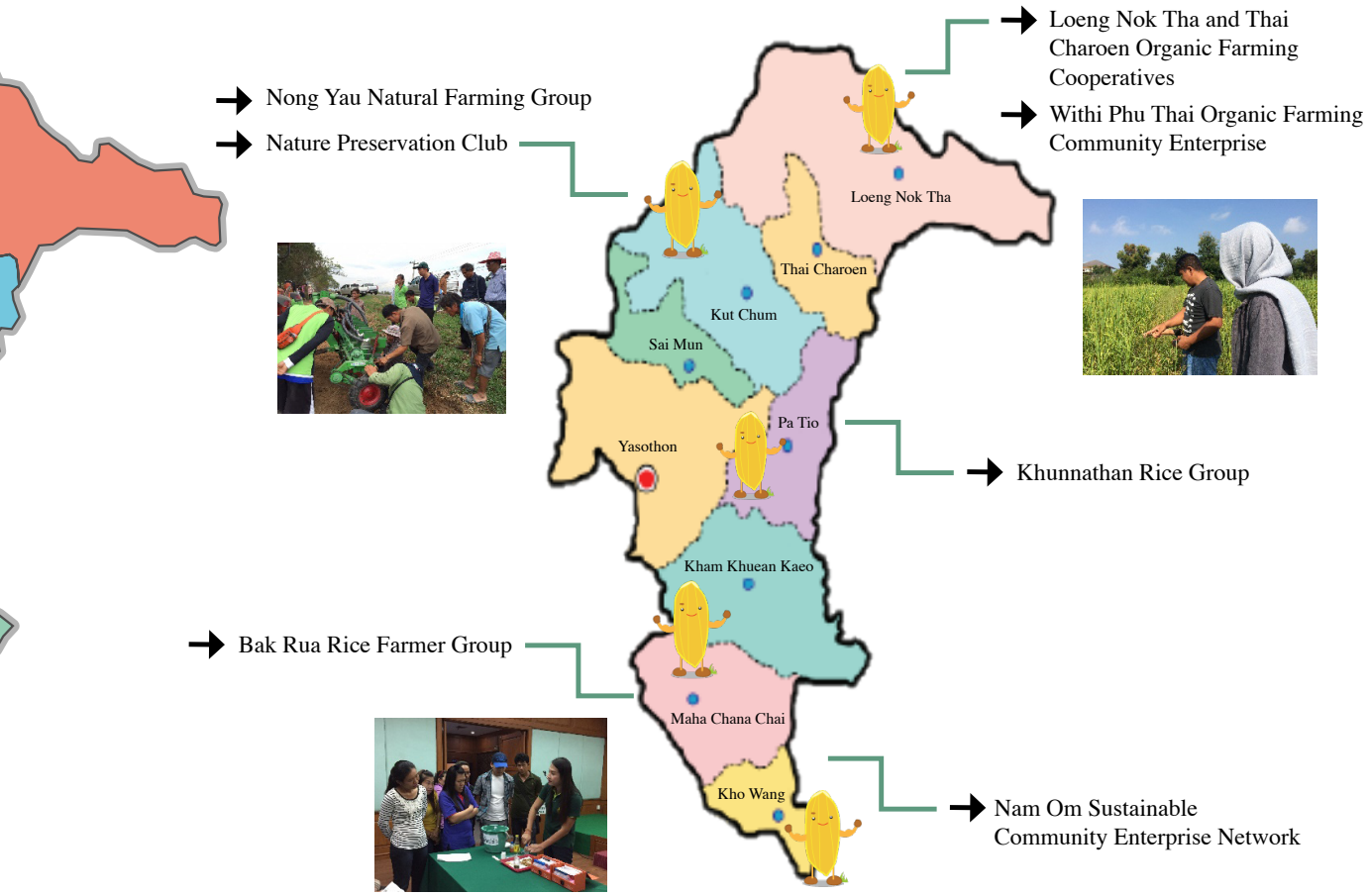
Key technologies that have been transferred

- Greenhouse technology and photoselective plastic film
- Production of stingless bee queens
- Production of quality rice seeds and farm management to increase rice productivity
- Cultivation of mungbean
- Production of quality Beauveria inoculum and the production of ready-to-use Beauveria
- Water and soil management (unturned composting, vermicomposting production from organic wastes, and soil analysis and nutrient management)

Upgrading Organic Rice Production in Yasothon Province

Supporting 4,000 farmers, creating an impact of 104 million baht

Yosothon province is an important production base of organic rice in Thailand. NSTDA provided know-how and innovation on the production of organic rice to 4,000 farmers from 7 farmer groups in 5 districts of Yasothon, aiming to upgrade Thai organic rice to the world-class level. The process was done through technology transfer and knowledge sharing on the following topics: production of quality rice seeds at the community level to achieve high productivity and low production cost; integrated organic rice business; market intelligence and management of rice mill. NSTDA also promoted the development of mechanisms to drive community enterprise, leading to the new model of network management to achieve high quality and meet standards for export.



Greenhouse with Photoselective Plastic Cover

Providing proper types of light, improving crop yields, increasing monthly income by 16,000 baht

Climate change clearly has an effect on agriculture. Growing crops in a greenhouse can minimize the risk on crop yields. NSTDA has developed greenhouse-covering plastic film that can control the light types entering the greenhouse, as well as greenhouse design with efficient ventilation to reduce heat accumulated inside. Double roof design structure improves ventilation efficiency; whereas specially-formulated plastic film can diffuse light more effectively and absorb or reflect specific wavelengths of light in order to enhance plant growth. This innovative greenhouse enables farmers to grow crops all year round and is suitable for growing salad greens, snack-slim tomato, American garlic, Japanese green onion, celery, scallion, Chinese kale, lettuce and baby carrot.

A total of 80 greenhouses have been built based on this technology in 17 provinces, namely Nakhon Phanom, Sisaket, Yasothon, Sakon Nakhon, Nakhon Ratchasima, Loei, Roi Et, Kalasin, Surin, Nong Bua Lam Phu, Ubon Ratchathani, Phayao, Nakhon Nayok, Prachinburi, Chai Nat, Udon Thani and Bangkok. One greenhouse is estimated to generate a monthly income of 16,000 baht. A study has indicated that this innovation has generated an economic impact of 8 million baht/year in Ban Nong Mang village in Ubon Ratchathani province, and 15 million baht/year to the village's network.

FOSTERING TECHNOLOGY-BASED BUSINESS

Mechanisms to Support Research and Development in the Private Sector

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

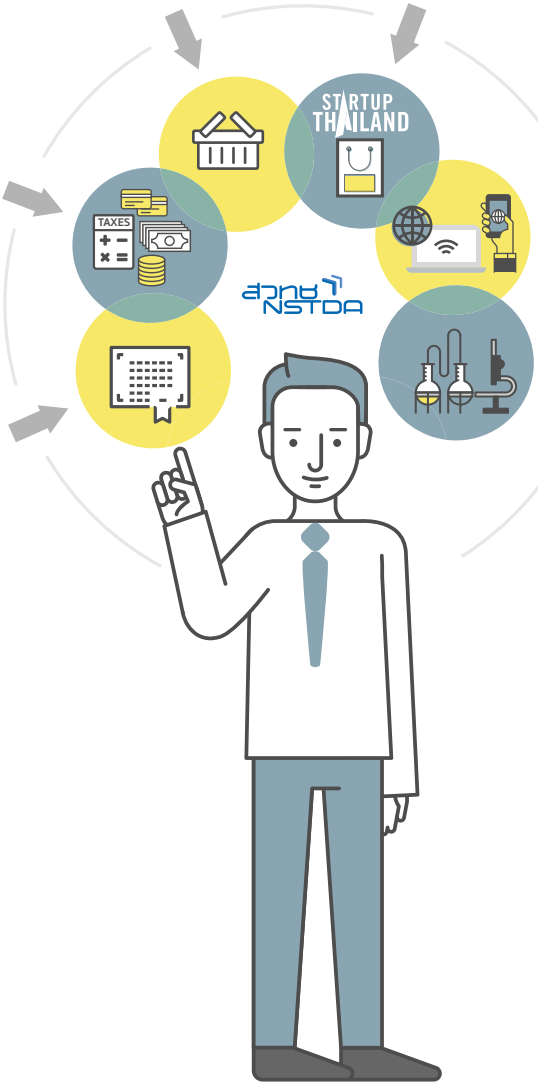
More than 306 applications for technology license received

Startup Voucher

82 business operators granted financial support of 60 million baht in total, 80 million baht revenue earned by grant recipients

300% Tax Exemption for R&D Expenses

385 projects certified with the total value of 1,299 million baht



ITAP

1,551 SMEs supported

Innovation List

136 inventions passing assessment, 105 inventions listed

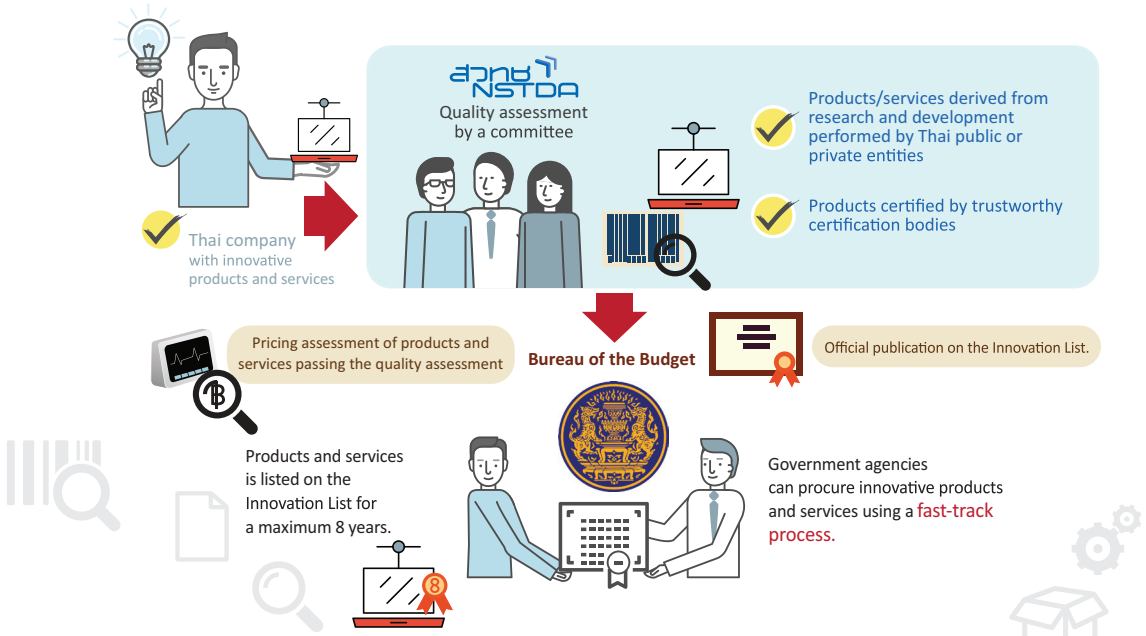
Testing Services

Over 43,000 tests performed

Innovation List

Supporting local innovations, products and services through government procurement program

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 were 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 30 October 2017, 326 applications were received; 136 innovations passing the evaluations and 105 innovations were published on the Innovation List. A total of 487 million baht procurement were made by government agencies from the Innovation List (a survey conducted between January 2016 - May 2017).



Performance (as of 30 October 2017)

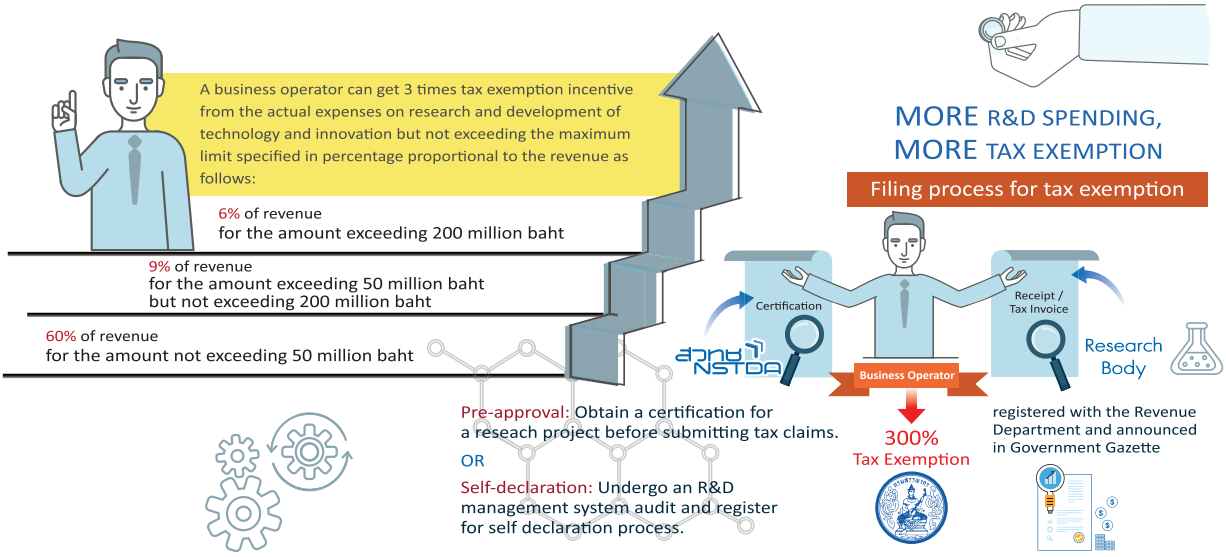
Year	Number of applications*	Number of innovations passing the assessment	Number of innovations published on the Innovation List
2016	168	72	34
2017	158	64	71
Total	326	136	105

* 42 applications were ineligible and withdrawn.

300% Tax Exemption for R&D Expenses

Enticing the private sector to invest in research, enhancing national competitiveness

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 2017, 467 companies have submitted tax claims under this program, with a total of 4,072 projects submitted and 3,545 project certified. Records show that companies submitting claims have a tendency to return the following years with more projects. In 2017, NSTDA introduced RDIMS, a system that allows a company with a previous certified project and a registered account with NSTDA to 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, one company, Siam Cement Group (SCG), has successfully been certified under this new system.



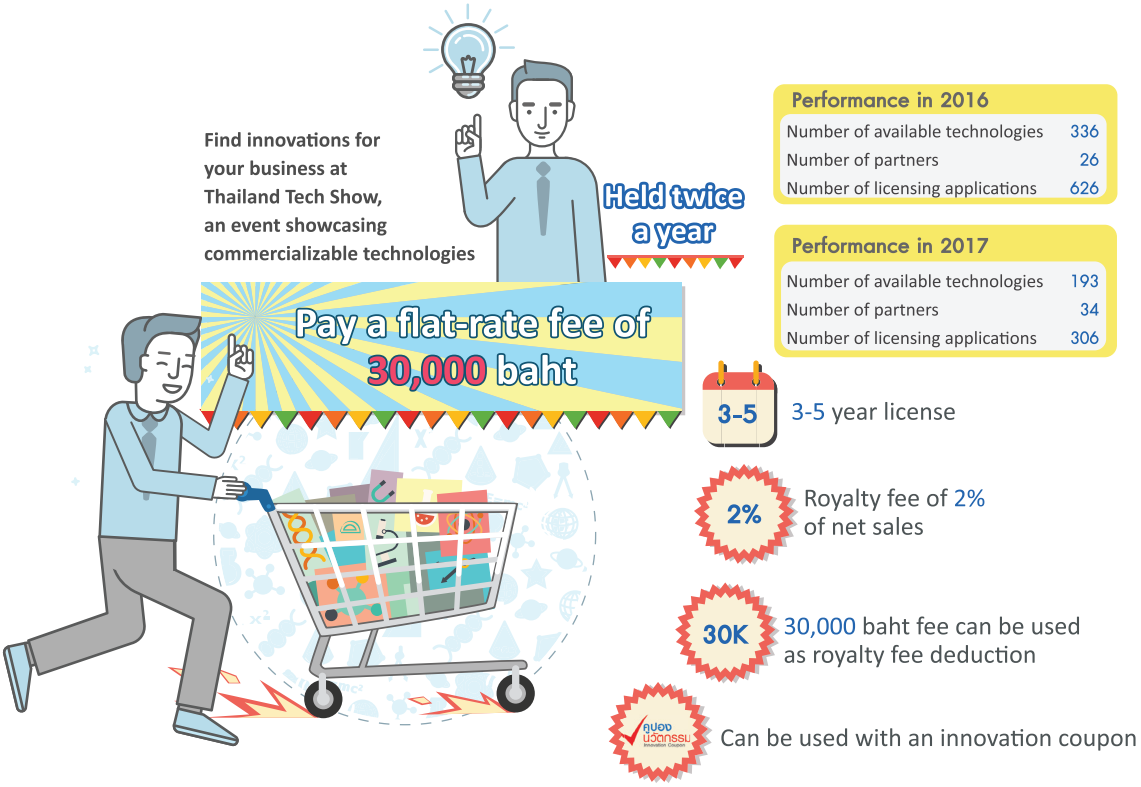
Performance from FY 2002 - 2017 (as of 30 September 2017)

Fiscal Year	Pre-approval					Self-declaration	
	No. of projects applied for certifications	Project value (million baht)	No. of projects received certifications	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	2,572	8,337	281	-	-
2015-2017	1,228	5,297	973	4,511	186	1	1

Thailand Tech Show

Driving research to market with a flat-rate fee of 30,000 baht per IP

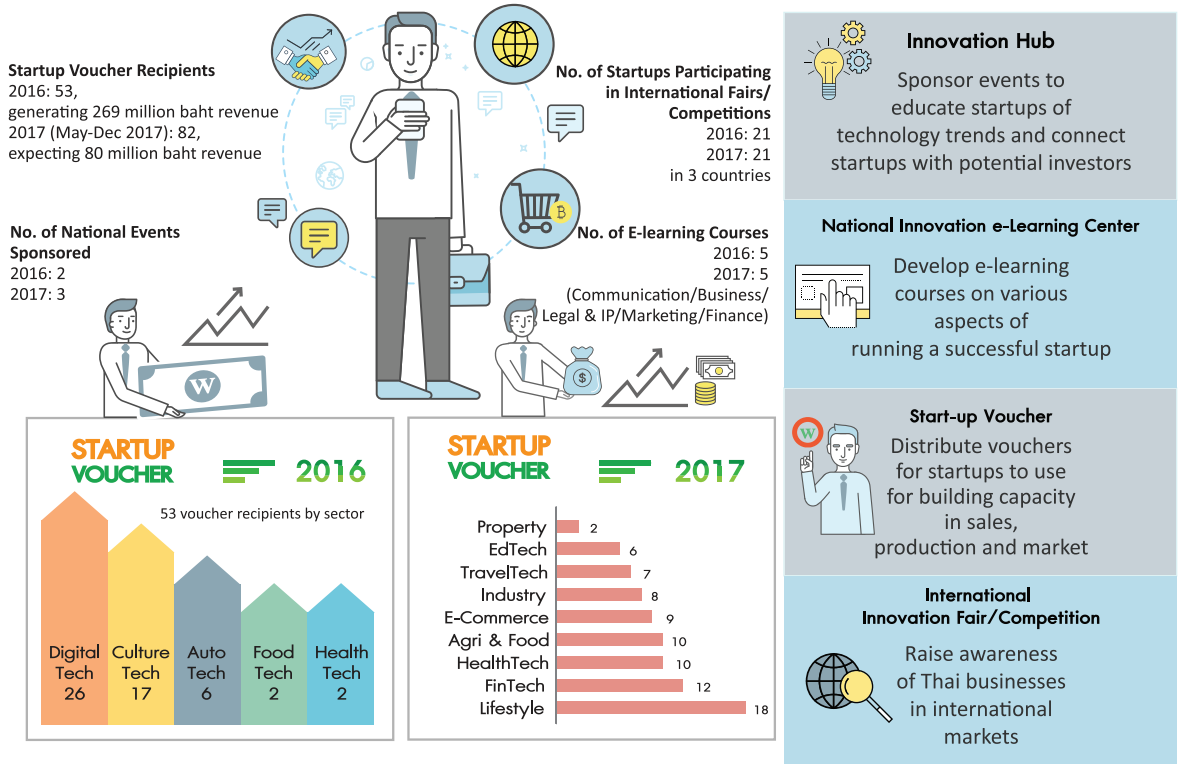
NSTDA, in collaboration with universities, continues to implement "Thailand Tech Show" into the second year. Thailand Tech Show provides SMEs with easy access to intellectual properties owned by public research and academic institutes by offering a license to an IP to interested SMEs at a flat-rate fee 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 facilitate the exploitation of local inventions. Thailand Tech Show 2017 INNO-FUSION: Power Up Business with STI was organized on 20 - 24 September 2017 at Bangkok International Trade & Exhibition Centre (BITEC), showcasing over 200 inventions to prospective entrepreneurs with engaging activities such as business pitching, seminar and consultation services. The event attracted over 13,000 business operators and entrepreneurs. 306 licensing applications were received in 2017.



Startup Voucher

Building markets, increasing revenue, accelerating the growth of startups

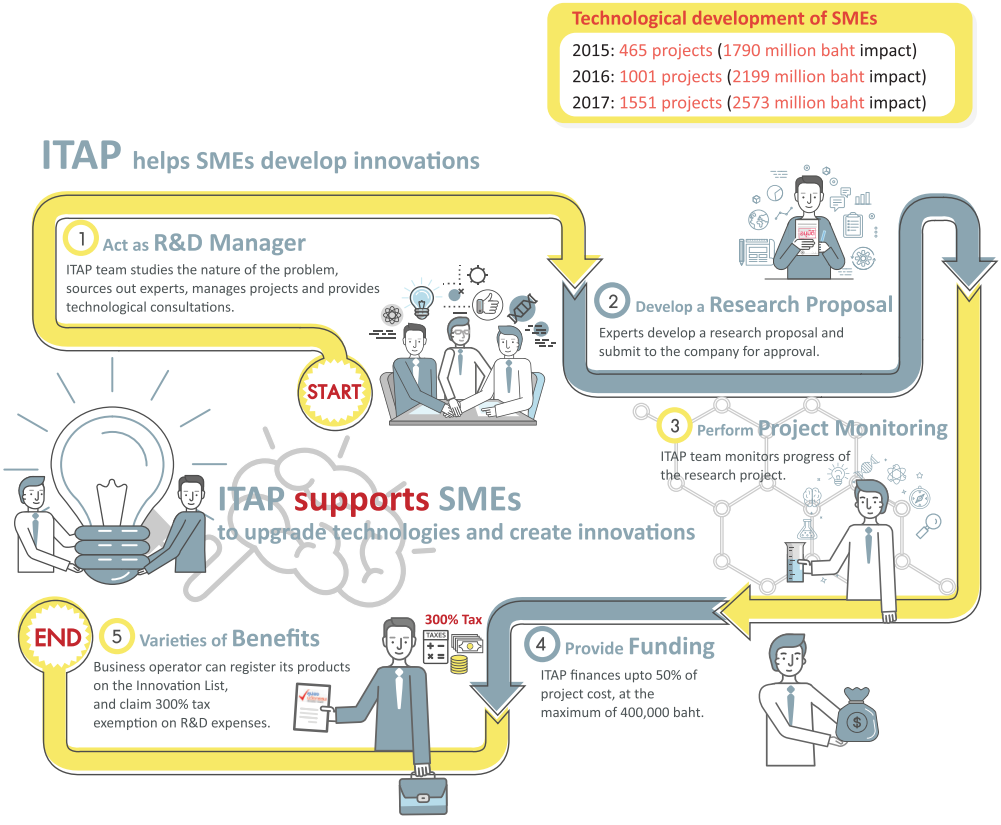
Startup Voucher is a scheme designed to assist startups to find and expand their markets. This is achieved through the development of e-learning courses, the organization of national events in collaboration with the National Innovation Agency (NIA), and supporting the participation of Thai startups in 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. 82 projects have been financed with a total budget of 60 million baht. These grant recipients have credited the scheme for enabling them to develop new products and expand their markets both domestically and internationally. 80-million-baht revenue have reportedly been earned by startups participating in the program.



Innovation Technology Assistance Program (ITAP)

Enhancing technological capability of Thai SMEs

Innovation Technology Assistance Program or ITAP is a main mechanism to provide technological assistance to industries by sending an expert team to work cooperatively with companies to conduct research and develop projects — acting like an R&D department for the companies — that will provide solutions to the problems faced by the companies. ITAP finances up to 50% of a project budget, at the maximum of 400,000 baht. With increasing support from the Government, ITAP has grown steadily in the past couple of years, sponsoring 465 projects in 2015, 1001 projects in 2016 and 1,551 projects in 2017. These projects have generated an impact of 2,573 million baht. By collaborating with universities and agencies under the Ministry of Science and Technology such as Thailand Institute of Scientific and Technological Research and the National Institute of Metrology, ITAP expects to fund as many as 3,000 projects per year. In 2016, the University of the Thai Chamber of Commerce estimated that every 1 baht spent by the private sector under this scheme has generated an economic impact of 7.64 baht, or 7 folds, within 1 year.



NSTDA Testing Services

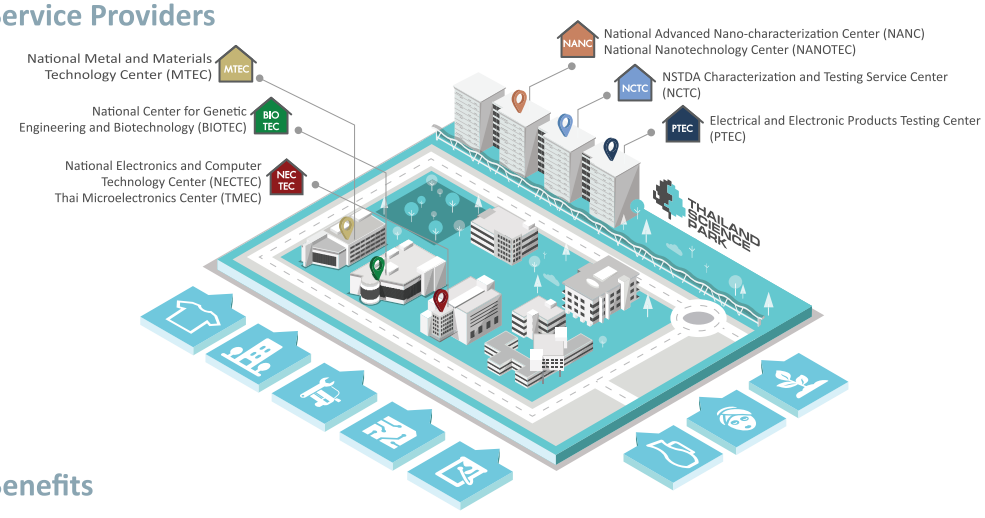
Offering product testing services according to international standards, performed by competent technicians, using advanced and reliable equipment

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. NSTDA testing labs and centers performed over 43,000 tests and services for clients, valued at 115 million baht. 47 tests on our service list are ISO 17025 certified as of 2017, and 34 more tests will be added to support growing demand from industries.

Testing services for 8 industries

- Textiles and Clothings
- Ceramics and Building Materials
- Automotives
- Electronics
- Paints, Coatings and Chemicals
- Plastics and Metals
- Cosmetics, Health Products, Medical Devices
- Food and Agriculture

Service Providers



Benefits

- Reducing the cost of seeking testing services from overseas
- Supporting advanced research
- Enhancing products' safety and quality
- Strengthening capacity of Thai industries

ENHANCING HUMAN RESOURCE DEVELOPMENT IN SCIENCE AND TECHNOLOGY

Recognizing the importance of competent and skilled manpower in driving forward science and technology in Thailand, NSTDA implements a human resource development program to address various segments of the society, from school children to S&T professionals. The key strategy employed is the integration of R&D activities to an academic program through the use of NSTDA researchers and infrastructure such as Thailand Science Park and Sirindhorn Science Home to groom young scientific professionals as well as educate youngsters and the public at large. Various forms of activities are organized to enhance manpower development including youth camps, contests and scientific conferences, all aiming at creating an understanding and awareness of the value of science and technology.

Building critical mass of S&T graduate students and researchers. NSTDA provides a total of 730 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) and STEM Workforce, the last two programs designed for promoting both manpower development and research in industry. In addition, laboratories of NSTDA research centers also welcome university students and recent graduates to work on active research projects. In the past year, 97 students have joined NSTDA workforce in various positions, namely 39 collaborative research students, 16 research assistants, 17 co-investigators and 25 post doctoral fellows.

Development of children. NSTDA promotes science learning and stimulates interest in science and technology among young minds through youth camps such as First-Step-towards-Science-Career Camp, E-CAMP (electronics camp for kids), Path-to-Researcher Camp, and Math and Science Camp. A total of 8,422 children have participated in these camps.

Manpower development in science and technology. 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 2017, over 10,000 people participated in NSTDA training courses which included topics such as biosafety at laboratory and industrial levels, application of robotic technology in manufacturing and service sectors, monitoring and maintenance of photovoltaic systems, and management of an electric vehicle charging station.

The 3rd Path-to-Researcher Camp

Inspiring children to pursue careers in science

NSTDA organized the 3rd Path-to-Researcher Camp on 10 - 14 October 2016, inviting 40 grade-7 students who won the 2015 Genius, a program implemented by the Institute for the Promotion of Teaching Science and Technology (IPST) to participate. Held at Sirindhorn Science Home from 10 - 14 October 2016, the 5-day camp was designed to stimulate science curiosity, engage students to learn science through STEM education, and practice scientific thinking. The Path-to-Researcher Camp aims to inspire gifted students to explore a research career and continue to take part in science camp activities. Participants in the Camp was also introduced and encouraged to join other exciting programs such as NSTDA Junior Science Talent Project (JSTP).

Bangkok Mini Maker Faire 2017

Strengthening the maker culture, building the foundation for Thailand 4.0

Following the success of the first Bangkok Mini Maker Faire in September 2015, NSTDA in collaboration with Chevron Thailand Exploration and Production organized the 2nd Bangkok Mini Maker Faire, the largest gathering of markers in Thailand, on 21 - 22 January 2017 at The Street Ratchada in Bangkok. Maker Faire aims to inspire and foster a "maker" culture, a key foundation to drive Thailand 4.0 strategy. Makers from Thailand and overseas showcased their inventions across more than 60 booths. There were a number of activities designed to engage the young generation and spark their interest in maker culture such as workshops on 3D printer, textile art and drone assembly; a robot contest; and a light-and-sound parade. The winners of the Enjoy Science: Young Makers Contest, which was part of the Chevron Enjoy Science project, were announced during the Maker Faire. The theme for the Young Makers Contest was Innovation for the Elderly and the Disabled. Each winner was awarded a scholarship and a trip to join Maker Faires in the UK and Japan, valued at 1.5 million baht in total. The Young Makers Contest was sponsored by the National Science Museum and the Office of Vocational Education Commission.

IDC RoBoCon 2017

Developing skills in robotics and automation

MTEC-NSTDA in collaboration with the Faculty of Engineering, Chulalongkorn University, sponsored and mentored winners of RDC 2017, a national robot design contest, to compete in an international design contest, IDC RoBoCon 2017, hosted by Zhejiang University in China on 6 - 19 August 2017. Held under the theme "Silk Road", the IDC RoBoCon 2017 attracted participation of 55 students from 15 universities in 8 countries, including Japan, Singapore, China, Korea, Egypt, Mexico, the US and Thailand. Twelve teams, each consisting of 4 - 5 members from different countries, were formed on site. Teams were asked to design two small robots for transporting cargoes and collecting treasure troves. The final round competition was held at Hangzhou Low Carbon Science & Technology Museum. Three Thai students were part of the winning teams. Ms. Thitima Sukajit from Pibulsongkram Rajabhat University was part of the first runner-up team (Skyblue Team). Mr. Suthiwat Yarnchalothorn from Chulalongkorn University was in the second runner-up team (Blue Team) and Mr. Wiwat Silarak from Mahidol University in the third runner-up team (White Team). IDC RoBoCon 2018 will be hosted by Tokyo Institute of Technology, Japan.

TAIST-Tokyo Tech

Scholarship program producing world-class researchers and engineers

TAIST-Tokyo Tech is an international scholarship program, operating under the collaboration between NSTDA, Tokyo Institute of Technology (Tokyo Tech) and four leading Thai universities — King Mongkut's Institute of Technology Ladkrabang (KMITL), King Mongkut's University of Technology Thonburi (KMUTT), Sirindhorn International Institute of Technology (SIIT), and Kasetsart University (KU). TAIST-Tokyo Tech currently offers three master's degree programs: Automotive Engineering, Information and Communication Technology with Embedded Systems, and Sustainable Energy and Resources Engineering. The courses are taught by faculty members of Tokyo Tech and take place at the Thailand Science Park. Students accepted to the programs receive full scholarships for the 2-year duration, as well as opportunities to work in NSTDA research labs or leading companies. Since inception, 521 students have enrolled and 280 have graduated. 52% of the graduates work in Thai and multi-national companies, 19% working as engineers in the public sector, 23% studying in PhD program and 6% working as researchers at NSTDA.

Cozy Mark IV Thailand

Raising skills in aircraft maintenance, underpinning aviation industry

NSTDA handed over the Cozy Mark IV aircraft to Rajamangala University of Technology Krungthep. Cozy Mark IV is a 4-seat composite aircraft equipped with a 360-HP engine that can support a maximum of 2,050 pounds in weight. The presentation ceremony was held on 8 May 2017 at Sirindhorn Science Home. The aircraft will be used in the aircraft-maintenance crew training curriculum offered at Rajamangala University of Technology Krungthep to allow students to practice on the maintenance and repair of small aircraft, before moving up a larger model. Cozy Mark IV is the first aircraft built by Thai students under the 'Engineering Design and Development of Cozy Mark IV Thailand Project,' aiming to develop the engineering skills of secondary-school students. The project was supervised by Dr. Sawat Tantiphanwadi, a specialist in aviation engineering. Taking 7 years to complete, the project had 3,105 students from all over the country taking part in the endeavor. Each student had a role in developing the body structure, installing the engine and completing its electrical and electronic systems.

NSTDA Annual Conference 2017: NAC2017

On 29 March 2017, HRH Princess Maha Chakri Sirindhorn graciously presided over the Opening Ceremony of the NSTDA Annual Conference 2017: NAC2017. NAC2017 was organized from 29 March - 1 April 2017 at Thailand Science Park, Pathumthani, under the theme "New era of NSTDA catering to target customers with the guidance of sufficiency economy philosophy". The event showcased achievements of basic and applied research performed by NSTDA. NAC2017 lineup consisted of 52 tracks of scientific conferences, seminars and workshops. On display in the exhibition zone were over 100 inventions developed by NSTDA and its partners that can support the manufacturing and service sectors or serve the communities and public at large. An open house activity introduced visitors from the private sector to 24 laboratories and 10 tenants at the Thailand Science Park; whereas the S&T job fair saw the participation of 81 companies. NAC2017 attracted a good number of visitors — 4,296 participants to the scientific seminars/worshops, 3,501 visitors to the exhibition, 432 attendees to the open house activity, and 1,100 visitors to the job fair — an increase from the previous year.

ESTABLISHING SCIENCE AND TECHNOLOGY INFRASTRUCTURE

NSTDA is committed to develop S&T infrastructure to promote research and development in Thailand. Rental space 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 lease space with fully-integrated services to support technology businesses and companies looking to expand their R&D activities.

In 2017, Thailand Science Park was the home for 86 leading local and multi-national companies, accounting for 39,481 sq. m. rental space. In addition, Software Park Thailand is hosting 54 companies occupying its 7,289.86 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 our successful tenants include:

"Basing our company at Thailand Science Park allows us to have access to all kinds of support and services available at NSTDA such as ITAP, Research Gap Fund, Startup Voucher and low-interest loan. It helps expand our investment tremendously."

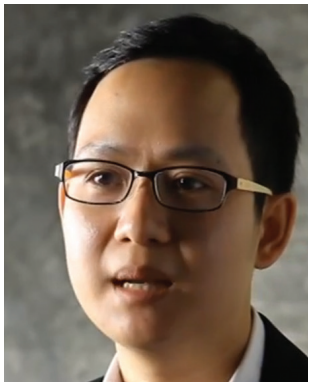
Dr. Sharnon Tulabadi
President & Chief Engineer
Gravitech (Thailand)

Gravitech (Thailand) Company Limited established Research and Development Electronic Creative Hub with aims to incubate electronic startups as well as to serve as their base for the design and development of electronic circuits. The facility is staffed with skilled personnel and equipped with proper machineries for the prototype production of smart electronic parts for innovators and electronic companies. The new facility can reduce the time of prototype production from 1 year down to a few months.

Gravitech joined Thailand Science Park in 2016 and has been expanding its space in response to the continuous growth of the company. At present, it occupies 274 sq. m. space in Innovation Cluster 1 building, and is in the process of adding 120 sq.m. for Robotic Maker Space dedicated to R&D in robotic technology.

Since joining Thailand Science Park, the company's annual revenue has grown 2.6 times in 2016 and 3.3 times in 2017. Half of its revenue derived from participating in marketing activities organized by NSTDA such as exhibition, training, open house and Bangkok Mini Maker Faire.

"Participation in NSTDA activities such as NSTDA Annual Conference, NSTDA Investor's Day and Thailand Tech Show and Business Matching led us to 5-6 new clients per month on average. Furthermore, 3-5 new clients were added each time we gave a talk at conferences and seminars."



Dr. Sittichai Daengprasert
Co-founder and Chief Innovation Officer
CDIP (Thailand)

CDIP (Thailand) Company Limited is an integrated research and development company specializing in food products, food supplements, cosmetics and herbal products. The company offers a full range of services which includes formulation, production, label design, product registration and distribution, as well as product characterization and testing.

CDIP established an R&D center at Thailand Science Park in 2009 at the inception of the company. Their business has grown steadily and the company now occupies 300 sq.m. space at the park.

Since inception, CDIP has delivered over 100 products and testing/IP services to its clients. These inventions result in over 1 billion baht worth of product sales.

"NSTDA helps our company gain access to international research institutes and funding agencies, enabling us to acquire necessary funds and technologies to grow our business. Most importantly, we were able to expand our domestic and international markets with NSTDA's assistance."

Dr. Karsidete Teeranitayatarn, DVM.
Chief Innovation Officer and Co-founder
Green Innovative Biotechnology (GIB)

Green Innovative Biotechnology Company Limited engages in research and development of products for agricultural application, with an emphasis on using natural products in place of chemical pesticides and antibiotics. The company participated in NSTDA incubation program in 2015 - 2016 and established its research and development center in Innovation Cluster 2 building at Thailand Science Park in 2016, occupying 171 sq.m. space.

Over the years, the company has actively taken part in NSTDA activities such as exhibition in scientific and trade fairs and networking activities. This participation allowed the company to gain access to international funding and alliances such as the Newton Fund and research collaboration with international institutes like Fraunhofer from Germany, for instance.

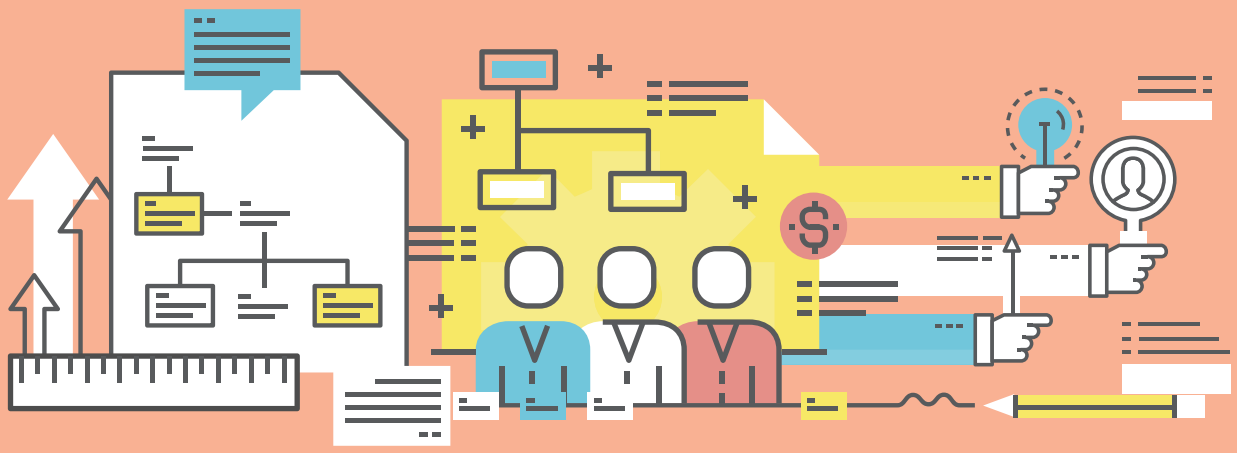
Their presence at Thailand Science Park also introduces the company to various NSTDA departments, such as ITAP, BIOTEC, NANOTEC, Food Innopolis, and they are able to reap the benefit. These benefits come in numerous forms, including research collaboration, experts, research funding and manpower development. The company has been able to register 7 new products, enormously contributing to the company's growth in 2017 which saw 95% of its revenue derived from networking with NSTDA and its partners.

"Haydale is proud to be a part of Thailand Science Park initiative; to bring our technology here to Thailand and generate jobs and prosperity. We look forward to many successful years together..."

Mr. Raymon Gibbs
Chief Executive Officer
Haydale Technologies (Thailand) Co., Ltd.

Haydale Technologies (Thailand) Company Limited, formerly known as Innophene Company Limited, was founded in 2011 and based at Thailand Science Park. The company licensed the technology to synthesize graphene-based conductive ink using an electrochemical technique from NECTEC. The technology enables the production of high purity graphene at low cost that can be used in printed electronics. The company was the first in the world to launch a transparent graphene conductive ink, under the brand name "PHENE Plus".

Recognizing the competence of Thai research team in graphene technology and NSTDA, Haydale Graphene Industries PLC. (HGI), a company listed on the London Stock Exchange, acquired Innophene and changed the name to Haydale Technologies (Thailand). As NSTDA is able to provide the right eco-system for innovation at Thailand Science Park, Haydale Group designated Haydale Technologies (Thailand) as its first and only Asian Graphene Research Center to conduct translational research to serve industries in the Asian region. Their research focuses on functionalized graphene, nano-composite and graphene-based conductive ink for printed electronics. The company is committed to collaborate with NSTDA research team to build an innovative economy to support Thailand 4.0 initiative.



BUILDING INTERNATIONAL COLLABORATION

NSTDA places significant importance on establishing linkages, alliances and collaboration 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 transfer technologies in order to prepare and build up long-term S&T capacity for Thailand. In 2017, a number of international activities have been undertaken with the following examples.

Memoranda of Understanding and Agreements

Collaboration with Germany on Cassava Research and Development

NSTDA along with Thai partners and the German Forschungszentrum Jülich have signed a contract for "The Collaborative Bioeconomy International Project" on 27 February 2017 at Bangkok International Trade & Exhibition Centre (BITEC). The project aims to improve the productivity of cassava through the study of plant phenotypes, genotypes and physiology relating to storage root development, and subsequently, new cassava varieties. The 3-year project, lasting from 2017 to 2019, receives 32-million-baht funding from the German government and a matching 30-million-baht fund from NSTDA.

Collaboration with Laos on Agricultural Science

NSTDA and the National Agricultural and Forestry Institute (NAFRI) from Laos signed a memorandum of understanding (MOU) for mutual cooperation in the field of agricultural science on 29 March 2017 at Thailand Science Park. The 5-year MOU provides a framework for collaboration on research, capacity building and technology transfer, with the focus on germplasm collection and phenotype-genotype evaluation of rice, corn and

other economically important crops. This collaboration will play a key role in building up capacity of manpower and research in biotechnology for the ASEAN region which will contribute to an improvement in quality of life and sustainable agriculture.

Collaboration with Korea on Capacity Building of Thai SMEs

The Innovation and Technology Assistance Program (ITAP) of NSTDA and Korea Advanced Institute of Science and Technology (KAIST) have entered into collaboration to strengthen capacity of Thai SMEs. The ceremony signifying the collaboration was held on 30 March 2017 at Thailand Science Park as part of NSTDA Annual Conference 2017. Under this collaboration, five areas of smart technology — Smart Farm, Smart Health, Smart Home, Smart Factory and Smart Service — will be introduced to SMEs in Thailand. A survey to identify technological needs of Thai SMEs will be conducted by experts from ITAP and KAIST, after which a suitable technology and work plan will be proposed for each individual company by KAIST experts. An uptake of smart technology in SME sector will enhance competitiveness of Thai industry and effectively support Thailand 4.0 policy.

Collaboration with Japan on Medical Technology

NSTDA and representatives from the Medical Device Cluster of the Federation of Thai Industries and the Bureau of Supporting Industries Development signed an MOU with Fukushima Medical Device Industry Promotion Association (FMDIPA) on 5 June 2017 in Tokyo, Japan. The MOU aims to promote research, innovation and product development of medical device SMEs in Thailand and Fukushima Prefecture to expand their markets in Thailand, ASEAN and Japan. The objective will be achieved through activities including joint research, development of lab technicians and business matching. Companies from Fukushima will be introduced and enticed to invest in the Eastern Economic Corridor of Innovation (EECi) project.

Scientific Conferences and Seminars

Joint Symposium for International Industry-Academia Collaboration

NSTDA and Tokyo Institute of Technology (Tokyo Tech) hosted the Joint Symposium for International Industry-Academia Collaboration at Thailand Science Park Convention Center on 8 March 2017 with active participation of executives and researchers from NSTDA and Tokyo Tech. NSTDA and Tokyo Tech established a graduate program in Thailand in 2007 under the concept of Thailand Advanced Institute of Science and Technology (TAIST) aiming to develop high-level researchers and engineers. This symposium provided an opportunity for researchers in TAIST network to present their exciting work to industry and to further promote research collaboration between Tokyo Tech, Thai academic/research institutes and companies in Thailand. The disciplines addressed in this symposium included mechanical engineering and robotics, sustainable environment, information and communication technology, and material science. The event attracted over 60 participants.

Seminar on Updated Seed Technology

AGRITEC and NSTDA Food and Agriculture Cluster and Program Management, in collaboration with the Royal Thai Embassy in the Hague and Chiang Mai University, hosted a Seminar on Updated Seed Technology on 3 July 2017 in Chiang Mai province. Five Dutch experts were invited to share information on advanced technologies in seed production, best practice on seed technologies in the Netherlands, and regulations and seed quality control in the Netherlands. Distinguished speakers were drawn from Wageningen University & Research, a world-class university in agriculture, science and food technology; as well as the Netherlands Inspection Service for Horticulture; and Access to Seeds Foundation. The seminar is the first step for technology transfer, research collaboration

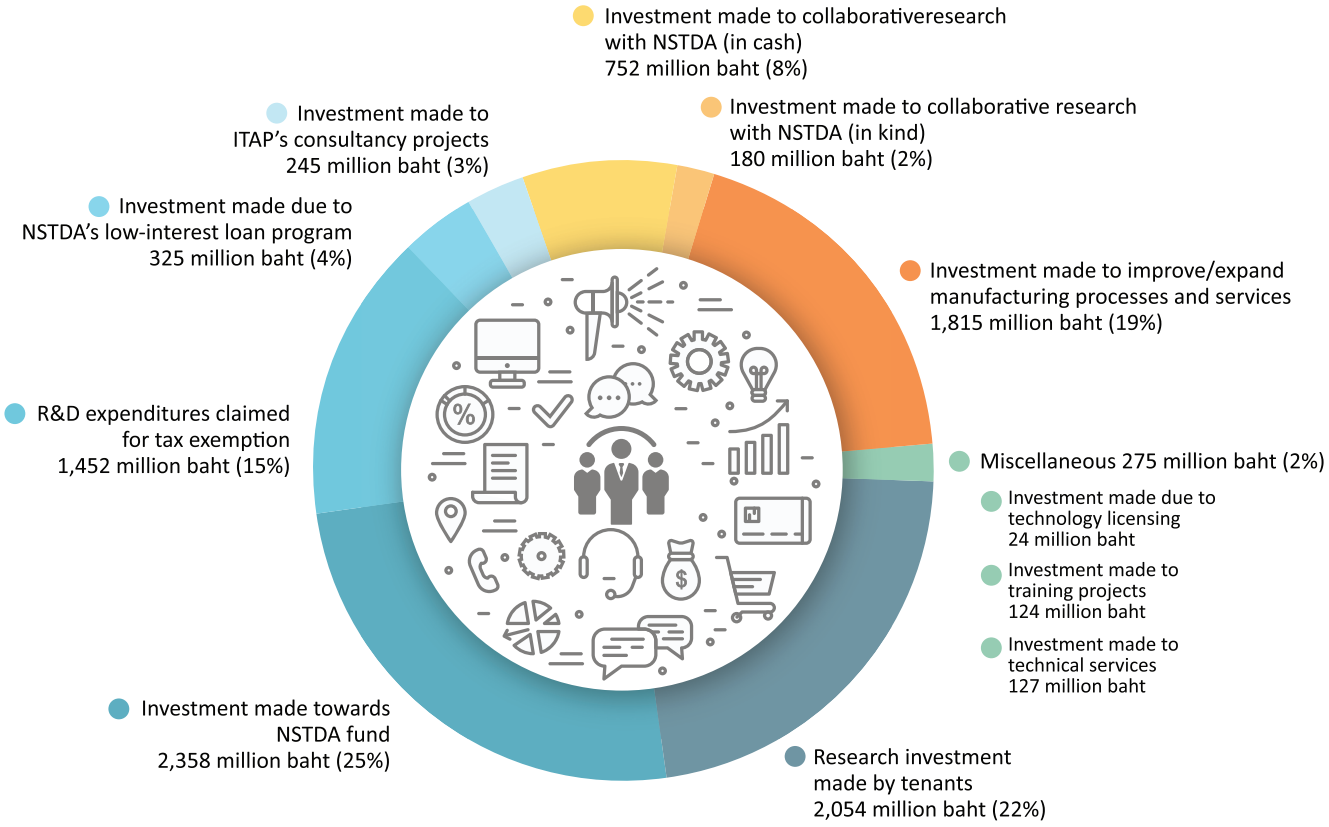
and trade promotion between Thailand and the Netherlands. 179 participants attended the seminar, including 46 officials from 8 government agencies, 88 representatives from 28 companies, 41 researchers and lecturers from 9 universities and 4 from general public.

Joint Research Meeting on Nanomaterial for Renewable Energy and Nanobiotechnology

NSTDA and The Australian Government Department of Education and Training organized Thailand-Australia Joint Research Meeting on Nanomaterial for Renewable Energy and Nanobiotechnology on 1 - 2 May 2017 in Bangkok, Thailand. The event was held to commemorate the 65th Anniversary of Thailand – Australia diplomatic relations and to bring together leading Thai and Australian researchers to exchange research information and identify opportunities for research collaboration in the fields of nanomaterials for renewable energy and nanobiotechnology. The meeting also introduced participants to funding opportunities and fostered bilateral collaboration and networking. A total of 91 speakers and participants, drawing from the University of Technology Sydney, the University of Queensland, Flinders University, Mahidol University, Chiang Mai University and NSTDA, took part in the event.

SOCIO-ECONOMIC IMPACT

NSTDA strives to enhance the nation's competitiveness on the global scale based on strength in science and technology backed by research and development. This is reflected in our mission that positions the Agency to be a key partner supporting every sector — manufacturing, service and agriculture — in applying science and technology to improve efficiency. The performance is therefore measured in the form of S&T investment made by our partner organizations. In 2017, this **S&T investment totaled 9,456 million baht** with details as follows:



1. After acquiring technologies from NSTDA, organizations made an investment to improve or expand their manufacturing processes and services, procure machineries and equipment, and increase their employment, totaling 1,815 million baht (orange section on the pie chart).
2. R&D investment made by the private sector through participation in NSTDA schemes designed to support enterprises (blue sections on the pie chart), e.g. donations to NSTDA fund, R&D investment made by tenants in Thailand Science Park and Software Park Thailand, R&D expenditure claimed for tax exemption, investment made on projects seeking low-interest loan and investment made to ITAP's consultancy projects, totaling 6,434 million baht.

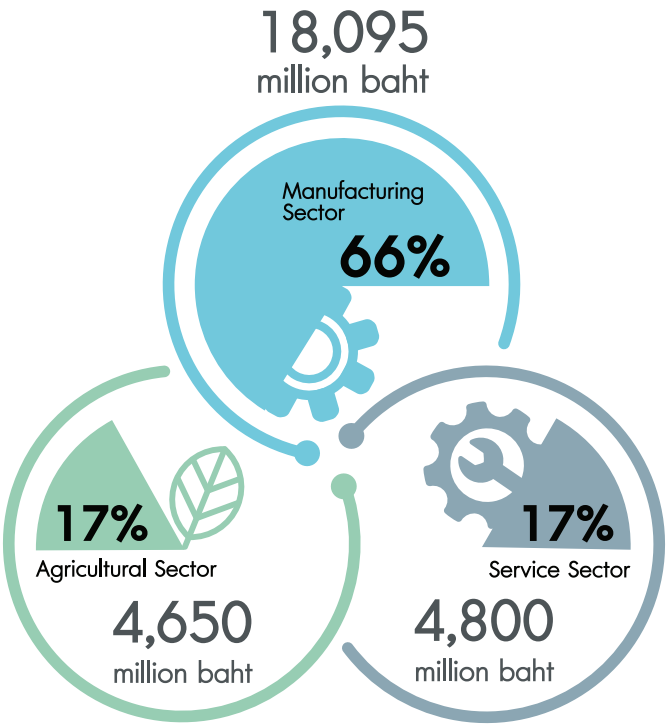
3. Investment made to collaborative research with NSTDA by both public and private sectors (yellow sections on the pie chart) was 932 million baht, comprising 752-million-baht in-cash investment and 180-million-baht in-kind investment (facilities, equipment and R&D personnel).
4. Investment made to other S&T services offered by NSTDA (green sections on the pie chart) including analytical /technical services, training and technology licensing, totaling 275 million baht.

NSTDA is committed to conduct research and development to create S&T innovation to benefit the nation. In 2017, data gathered from beneficiaries of NSTDA's projects/programs showed **an economic outcome of 27,545 million baht.** Beneficiaries of this economic outcome are categorized into the manufacturing sector, service sector and agricultural sector. Economic benefit to the manufacturing sector was 18,005 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. A prime example is **an electronic nose.** An electronic nose has been developed by NANOTEC research team to overcome limitations posed by human sensory organs. It is a device designed to mimic the human olfactory system and has application in odor quality assessment in a wide range of industry, including manufacturing and environment. A medical glove manufacturer was interested in this equipment as it enables the selection of medical gloves according to the scent preference of each individual country. Since acquiring a license to use this technology, the company has been able to gain confidence from its clients, maintain its customer base and garner its reputation. Due to the recent production capacity expansion of the company, the use of an electronic nose was required 24 hours/day and the company therefore decided to acquire a license to an additional electronic nose machine. In 2017, the use of electronic nose generated an economic outcome of 1,750 million baht to the company.

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 4,930 million baht. A highlight of this category is **Thailand's Telecommunication Relay Services,** established under the partnership of NECTEC, Office of the National Broadcasting and Telecommunications Commission (NBTC) and the Universal Foundation for Persons with Disabilities with an aim to promote and assist those with hearing or speech impairment, including the elderly, in accessing telecommunication services in order to communicate with others in society. The services enable this group of people to have access to news and information as well as promoting

independence. Because these services support a social objective, a Social Return on Investment (SROI) methodology was used to assess the economic impact of this project which gave an estimation of 643 million baht impact in 2017.

Some of NSTDA's projects have resulted in a productivity improvement in the agricultural sector and the economic impact of these projects was approximately 4,650 million baht. One example is the development of **hot pepper variety with male sterility** for seed production. The variety was developed by Dr. Bubpa Chaitiang of Ubon Ratchathani University, with research funding from NSTDA. The variety is resistant to anthracnose disease, and provides consistent seed productivity. Male sterility helps produce hybrid seed efficiently, as it eliminates the step of emasculation and also yields higher purity seeds. The technology was transferred to Real Seeds Agro Company Limited and Lucky Seeds Agro Limited Partnership. Both enterprises contract farmers to produce seeds. This pepper variety was new to these contract seed growers, and therefore this innovation has created jobs and additional income to the farmers. In 2017, this group of farmers earned a net income of 161 million baht.



SAFETY AND ENVIRONMENT

Enculturing Safety and Environment

NSTDA recognizes the importance of workplace safety, responsibility for our environment, and sustainable use of resources. We implement the Occupational Health and Safety Management System: OHSAS 18001 in all of our activities and workplace, and continue to make improvements, based on TIS 18001:2011 and BS OHSAS 18001:2007 standards, to mitigate, control and prevent risks caused by workplace hazards and unsafe working environments that can result in injuries, damage to assets and the environment.

"Mitigate, control and prevent risks caused by workplace hazards and unsafe working environments"

In FY 2017, NSTDA continues to create and maintain the culture of safety and environment by engaging our employees. Our employees are encouraged to monitor and report on unsafe actions taking place. Safety workshops have been organized as a platform for direction setting and communication on safety measures among all NSTDA units in order to make improvements. Various measures have been introduced. These include monitoring environmental conditions in high-risk activities. In addition, we attempt to mitigate risks in activities with medium risk or above, such as upgrading travel safety of our staff by enforcing seat belt usage in office vehicles, reviewing and revising health check-up guidelines for new and transferred employees to incorporate workplace risks, and revising document templates to align with current working environment.

Response to emergency situations is also vital to ensure safety of our employees and visitors. There exist response procedures for emergency situations such as fire, chemical spills and gas leaks. The procedure consists of incident stabilization, notification, coordination with internal and external units, and evacuation. A total of 23 drills were conducted and we also participated in drills organized by tenants of Thailand Science Park. In FY 2017, NSTDA underwent the 1st surveillance audit performed by the Management System Certification Institute (Thailand). The current certificate is valid until 25 August 2019. Our safety performance is measured by an Injury Frequency Rate (IFR), an Injury Severity Rate (ISR) and a Safe-T-Score. All three indicators met the standard levels and there were no incidents causing the shutdown of the operations.

Potential impact to the environment caused by NSTDA's operation is of paramount concern. We constantly monitor environmental quality conditions, 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 2017, 105,378 cubic meters of wastewater were generated in Thailand Science Park. We ensured that wastewater in Thailand Science Park — whether from office, laboratories or tenants — is treated effectively and the discharge quality meets the regulatory standard. Treated wastewater is reused for cleaning or watering plants in Thailand Science Park. Our 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.

"Potential impact to the environment caused by NSTDA's operation is of paramount concern. We constantly monitor environmental quality conditions"

A total of 62,360.28 kg of hazardous waste were generated from laboratories and tenants, a 33.50% increase from the previous year. Hazardous waste is segregated into incinerable hazardous waste and non-incinerable hazardous waste. Only part of the total incinerable hazardous waste is incinerated in NSTDA's incineration plant; some is sent to incinerators operating outside the premises in order to minimize the risk of our employees. Our hazardous waste management complies with ISO 9001 standard, ensuring proper incineration and proper treatment of flue gas so as not to cause air pollution. 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 2017, NSTDA received a certificate verifying that its quantity of greenhouse gas in FY 2016 (1 October 2015 - 30 September 2016) meets the requirements of TGO Guidance of the Carbon Footprint for Organizations (CFO) for the second consecutive year. The scope has been expanded to cover additional facilities, including Innovation Cluster 2 building, NANOTEC Pilot Plant and five facilities outside Thailand Science Park which are NSTDA Yothi Building, Software Park Thailand , NSTDA Northern Region in Chiang Mai province, Thai Microelectronics Center in Chachoengsao province and Shrimp Genetic Improvement Center in Surat Thani province. The total greenhouse gas emission in FY 2016 was 28,335 tonnes of CO2 eq/year. In FY 2017 (1 October 2016 - 30 September 2017), the total greenhouse gas emission was measured at 29,318 tonnes of CO2 eq/year, a 3.47% increase from the previous year.

Scope*	FY 2016		FY 2017		Remark
	Greenhouse gas emissions	Percentage	Greenhouse gas emissions	Percentage	
Scope 1	6,933	24.47	8,250	28.14	An increase in greenhouse gas emissions in FY 2017 is attributed to an increase in toilet usage due to an increase in employees and outsourced staff and the use of an R314 refrigerant.
Scope 2	20,593	72.68	20,133	68.67	A decrease in greenhouse gas emissions is due to the switch in an electricity provider to Nava Nakorn Elecricity Generating Company Limited which has a lower EF than the Electricity Generating Authority of Thailand. However, overall electricity consumption has increased in FY 2017 largely attributed to BIOTEC building, Innovation Cluster 2 and a test run of new NSTDA multi-purpose building.
Scope 3	809	2.86	935	3.19	An increase in greenhouse gas emissions in FY 2017 is caused by an increase in paper usage (more units have been added to NSTDA Central Office), amount of hazardous waste to be transported for treatment and water consumption.
Total	**28,335**	**100**	**29,318**	**100**	

Note:

* Three scopes are:

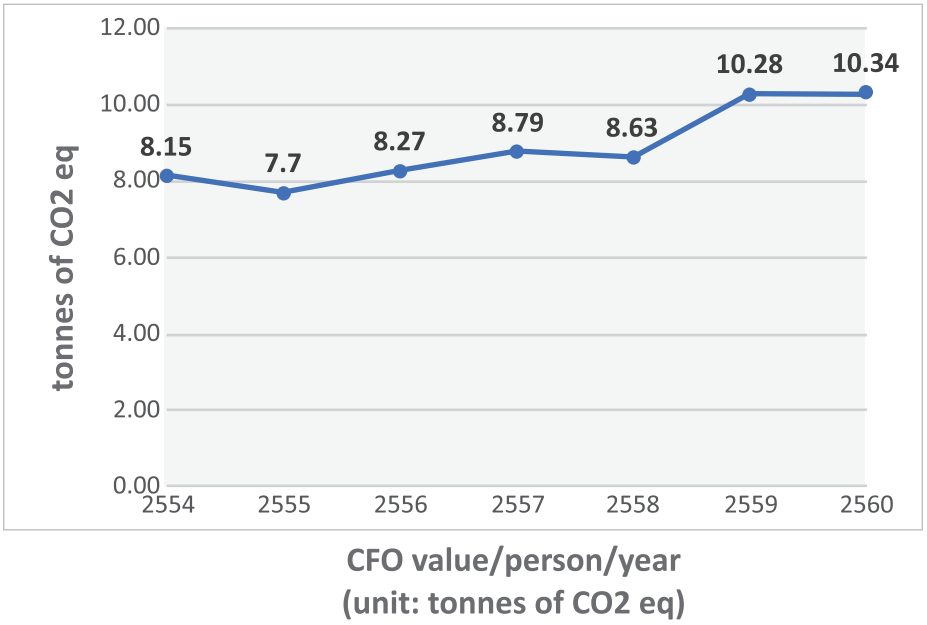
Scope 1: Greenhouse gas emissions from the consumption of fuel in general activities such as LPG consumption in laboratories and by electricity generators; diesel consumption by electricity generators, fire-fight pumps and incinerators; gasoline consumption by electricity generators, floor grinders, 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.

With the number of 2,834 employees in FY 2017, the greenhouse gas emission was 10.34 tonnes of CO2 eq/person.



RISK MANAGEMENT

NSTDA set its risk management system in accordance with the ISO 31000:2009 enterprise risk management framework. Effective in 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 2017, nine risks were identified, covering 4 aspects: Strategy (S), Operation (O), Finance (F) and Compliance (C). Out of nine risks identified, six were scored high, two were medium and one was low. Risk control plans were developed for eight risks with high and medium scores. The plan was executed and as a result the scores of seven risks were reduced and met the target, whereas the score of one risk was reduced and exceeded the target. Seven risks meeting the target were (1) REF-1 Presence of finance and resource management crisis causing output delivery not meeting expectation; (2) REO-5 Inability to maximize the benefit of resources and assets; (3) RES-2 Low utilization of research output; (4) REO-4 Inefficient ICT system; (5) RES-4 Lack of key strategic partners to drive the mission to achieve the goal; (6) REO-1 Exodus of experienced and expert R&D staff; and (7) REC-1 Damaged reputation caused by mis-management or mis-governance.

The risk that the reduction exceeding the target was RES-1 Impact generated by R&D output not meeting the expectation. As for the low-score risk, REO-3 Inability to maintain staff competency level, the risk was at an acceptable level under existing control mechanism. Therefore, the existing mechanism remained effective, however, a more robust monitoring system on performance was put in place to maintain the risk at the acceptable level.

After reviewing the afore-mentioned risk management performance in FY 2017 and examining the internal and external factors, NSTDA Risk Management Committee decided on risk management plan for FY 2018 as follows: 1) continue to work on five risks, 2) keep three risks under monitoring, and 3) transfer one risk to MPP level. Three risks under monitoring in FY 2018 are: (1) RES-2 Low utilization of research output; (2) REO-1 Exodus of experienced and expert R&D staff; and (3) REO-3 Inability to maintain staff competency level. A risk, REO-5 Inability to maximize the benefit of resources and assets, was transferred to MPP-level and modified to R1P-5 Inefficient management of R&D equipment. FY 2018 risk management plan covers the following seven risk factors:

Strategic Risks

(1) RES-1 Impact generated by R&D output not meeting the expectation
(2) RES-4 Lack of key strategic partners to drive the mission to achieve the goal
(3) RES-5 Inability to achieve the goal of EECi (Eastern Economic Corridor of Innovation) development
(4) RES-6 Inability to adapt to change

Operational Risk

(5) REO-4 Inability to provide continuous ICT system

Financial Risk

(6) REF-1 Inadequate budget to execute activities under the set mission

Compliance Risk

(7) REC-1 Damaged reputation caused by mis-management or mis-governance