Times Higher Education
Impact Rankings

SDG 13

Climate Action

SDG 13.2.1 Low carbon energy tracking

The amount of low-carbon energy used by NCUE in 2022 is **583,750 kWh** = **2101.5 GJ**, and all the low-carbon energy used was from solar energy.

SDG 13.2.2 Low-carbon energy use

Total energy used

At NCUE's Jinde Campus, the total electricity consumption for 2022 was 8,561,240 kWh, while at the Baoshan Campus, the total electricity consumption for 2022 was 3,840,380 kWh. The total electricity consumption for the entire University in 2022 was **12,401,620 kWh**, equivalent to **44,464.83 GJ**.

Total energy used from low-carbon sources

1. In 2017, Jinde Campus installed a photovoltaic solar power system that generated 467 kwp osf power. As of July 2023, the cumulative total electricity generated has exceeded 3,480,000 kWh (>12,541 GJ), with an average annual power generation of **583,750 kWh (2,101.5 GJ)**, accounting for 4.70% of the total power consumption of the University in 2022.

2. It is expected that in academic year 2021-2022, the annual solar power generation of Jinde Campus will increase to 3,197,968 kWh (11,512 GJ), and that of Baoshan Campus will increase to 714,375 kWh (2,572 GJ), which will account for more than 30% of the University's total power consumption for the academic year.

3. For academic year 2023-2024, there are plans to further increase the annual solar power generation capacities to 3,828,483 kWh (13,782 GJ) and 1,305,799 kWh (4,700 GJ), respectively, on Jinde and Baoshan Campuses.

4. It is estimated that by 2024, the University's total solar power generation will reach 5,134,282 kWh (18,483 GJ), which would represent 40% of the total power consumption in 2022. Table 1 summarizes the University's use of low carbon energy from 2021 to 2024.

Table 1. NCUE 2021-2024 Total Usage of Low-Carbon Energy

Campus	Year	Newly Added Capacity (kWp)	Accumulated Capacity (kWp)	Expected Power Generation (kWh)	% of Total Power Consumption in 2022
Jinde	Before 2020	467	467	583,750	6.7%
	2021-2022	2,091.375	2,558.375	3,197,968	37.35%
	2023-2024	510.04	3,068.415	3,835,518	44.80%
Baoshan	Before 2020	0	0	0	0%
	2021-2022	571.5	571.5	714,375	19.63%
	2023-2024	473.14	1,044.64	1,305,799	35.88%
Total	Before 2020	467	467	583,750	4.73%
	2021-2022	2,657.25	3,124.25	3,905,308	31.62%
	2023-2024	983.18	4,107.43	5,134,282	41.57%

5. The University is striving for carbon neutrality. Prior to 2020, during peak hours, solar energy generated on Jinde campus was 467 kW, and low-carbon energy accounted for approximately 15.57% of total power consumption (3,000 kW), whereas Baoshan campus consumed 1,000 kW, which was not from low-carbon sources.

6. It is expected that in academic year 2021-2022, total solar energy generated on Jinde Campus will increase to 2,552.75 kW during peak hours, whereas power consumption will reduce to 2,600 kW, which will push low-carbon energy sources to 98.18% of the total energy consumed. On Baoshan Campus, solar power generation is expected to increase to 571.5 kW during peak hours, whereas power consumption is expected to reduce to 900 kW, increasing low-carbon energy sources to 63.5% of the total power consumed.

7. The target for the academic year 2023-2024 is to increase solar power generation to 3,062.79 kW during peak hours and reduce power consumption to 2,400 kW on Jinde Campus, with low-carbon energy exceeding 100% of the total energy consumed. Similarly, for Baoshan Campus, it is expected that solar power generation will increase to 1,044.64 kW during peak hours and power consumption will reduce to 800 kW, with low-carbon energy exceeding 100% of the total energy consumed. The excess power generated will be supplied to neighboring power grids to increase the use of low-carbon energy in the region. Table 2 summarizes the solar power generation capacity to be added between the academic years 2021-2022 and 2023-2024.

Table 2. NCUE 2021-2024 total planned capacity of new solar photovoltaic power installations

Campus	Year	Solar Energy Generated during Peak Hours (kW)	Power Consumption during Peak Hours (kW)	Proportion of Solar Power to Power Consumption
Jinde	Before 2020	467	3,000	15.57%
	2021-2022	2,558.375	2,600	98.18%
	2023-2024	3,068.415	2,400	>100%
Baoshan	Before 2020	0	1,000	0%
	2021-2022	571.5	900	63.5%
	2023-2024	1,044.64	800	>100%

(1)The following table presents the detailed distribution of Solar photovoltaic power generation facility newly installed in academic year 2021-2022 (by building), as shown in Table 3.

Table 3. NCUE 2021-2024 total planned capacity of new Solar photovoltaic power installations

Campus	Building	Estimated capacity (kWp)	(Total)	Estimated power generation (kwh/year)	(Total)
Jinde Campus	Qiaosi Building	69	2,091.375 kWp	94,687	2,607,183 kWh
	Baisha Building	191.625		239,531	
	Zhishan Building	48		60,000	
	Mingde Building	85.125		80,156	
	Educational Building	92.25		115,312	
	No. 8 Dormitory	189		236,250	
	No. 7 Dormitory	181.5		226,875	
	No. 6 Dormitory	88.5		110,625	
	Hubin Building	123		153,750	
	Library	133.5		183,281	
	Comprehensive Center	103.875		129,843	
	Student Canteen	146.625		183,281	
	Shengyang Building	99.375		124,218	
	Xuesi Building	36		45,000	
	Wang Jinping Activity Center	160.65		192,187	
	Wang Jinping Swimming Pool	239.4		302,812	
	Old Activity Center	103.5		129,375	
Baoshan Campus	No. 9 Dormitory	99.75	571.5 kWp	125,625	714,375 kWh
	First Educational Building	69.75		126,563	
	Engineering College Building	139.5		174,375	
	Jingshi Building	114.375		142,969	
	Lixing Building	148.125		185,156	

(2)The solar power consumption percentages during peak hours at the Jinde Campus and the Baoshan Campus of NCUE in 2020 and 2024 are shown in Figures 1-6.

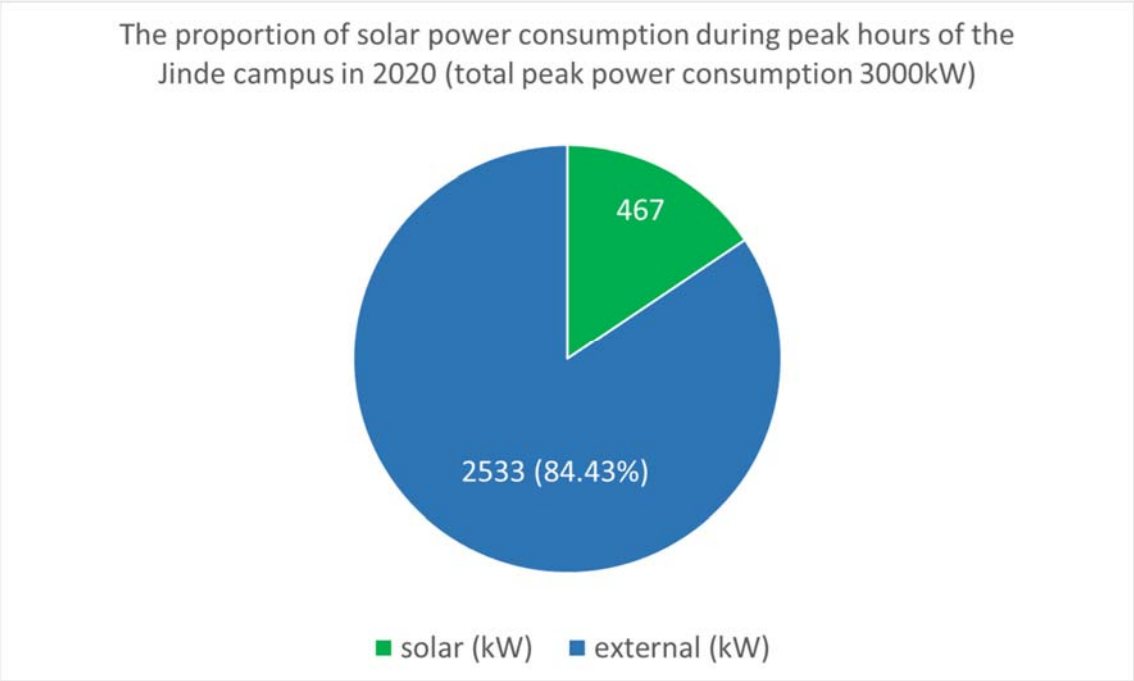

Figure 1. The proportion of solar power consumption during peak hours of the Jinde campus in 2020

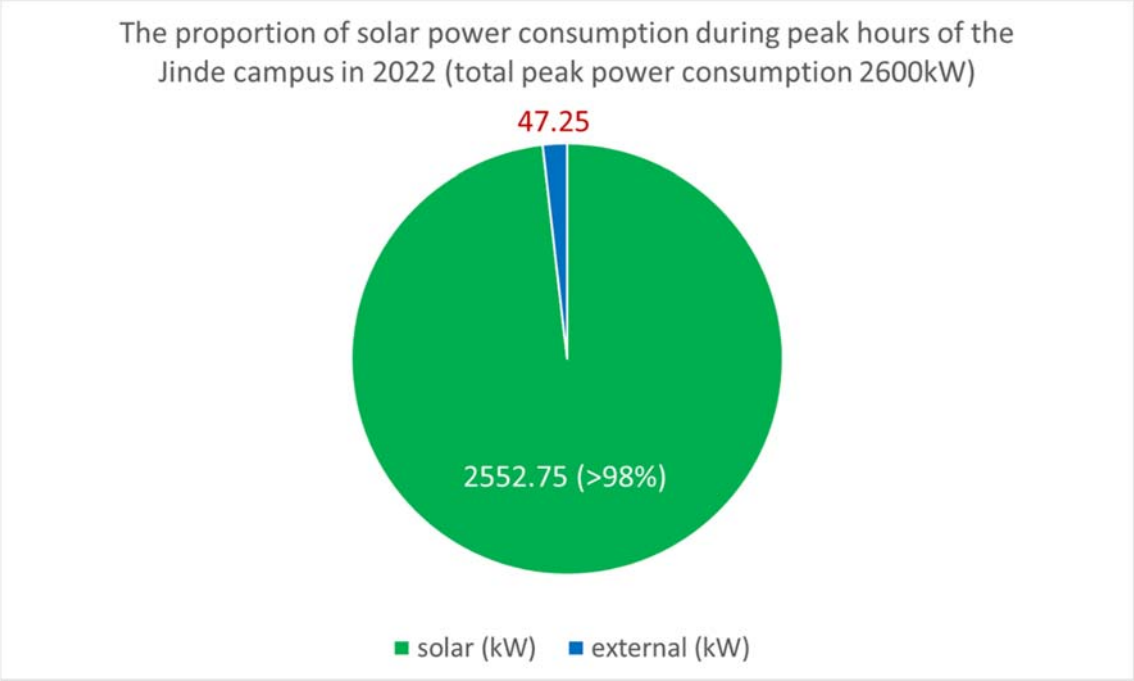

Figure 2. The proportion of solar power consumption during peak hours of the Jinde campus in 2022

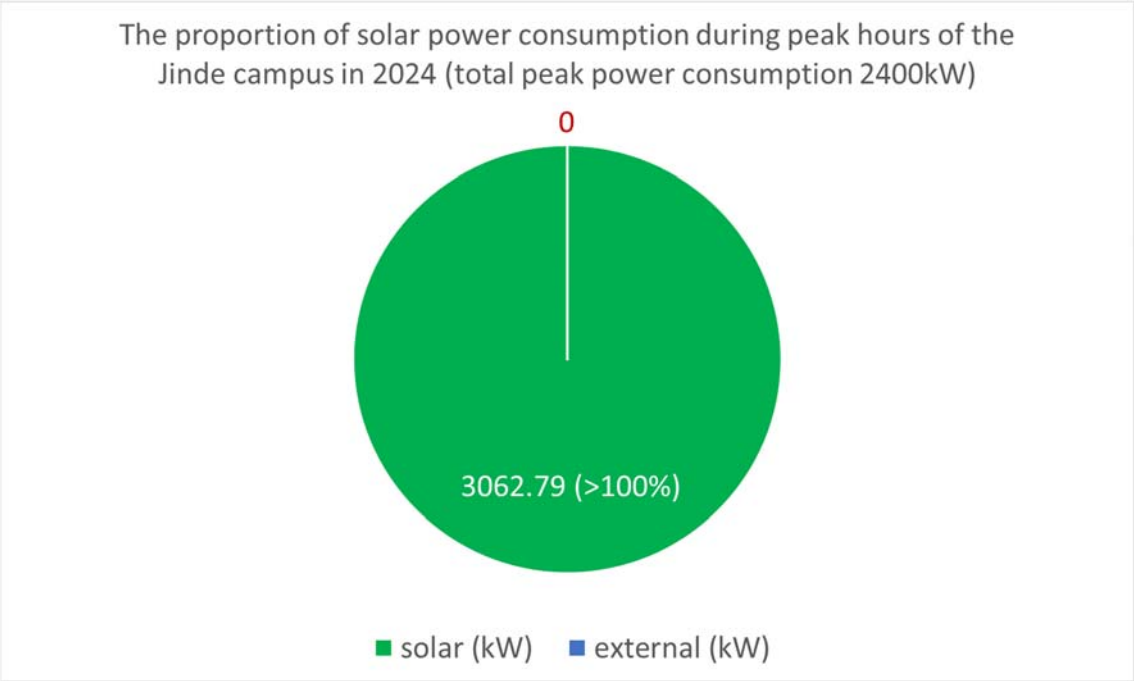

Figure 3. The proportion of solar power consumption during peak hours of the Jinde campus in 2024

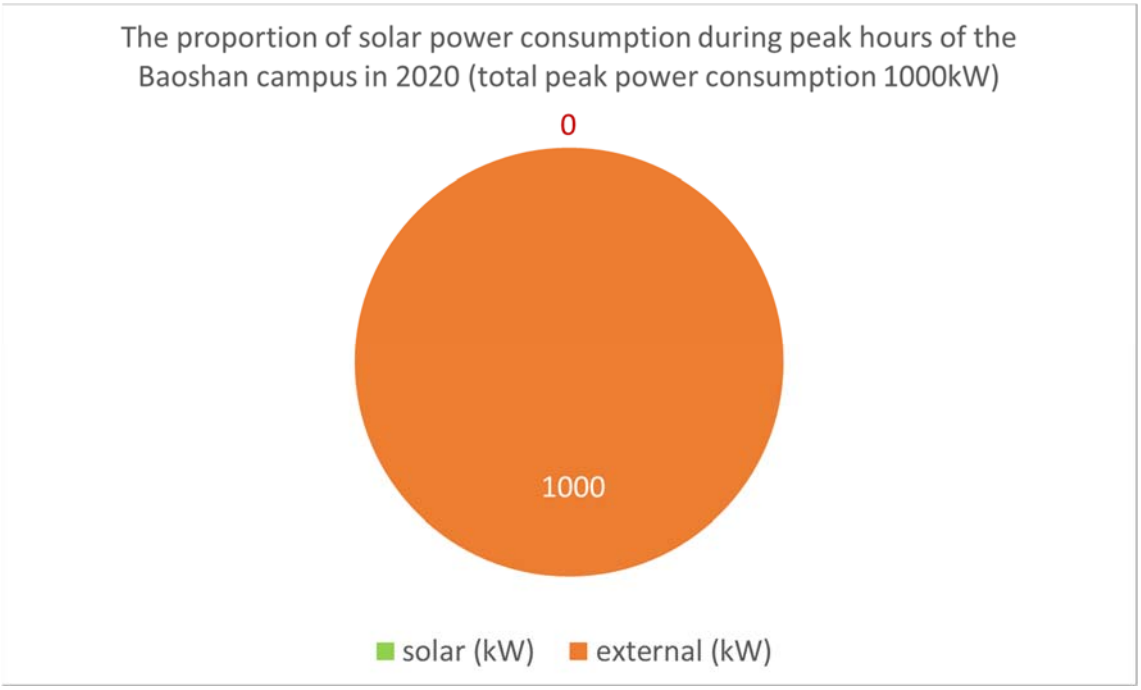

Figure 4. The proportion of solar power consumption during peak hours of the Baoshan campus in 2020

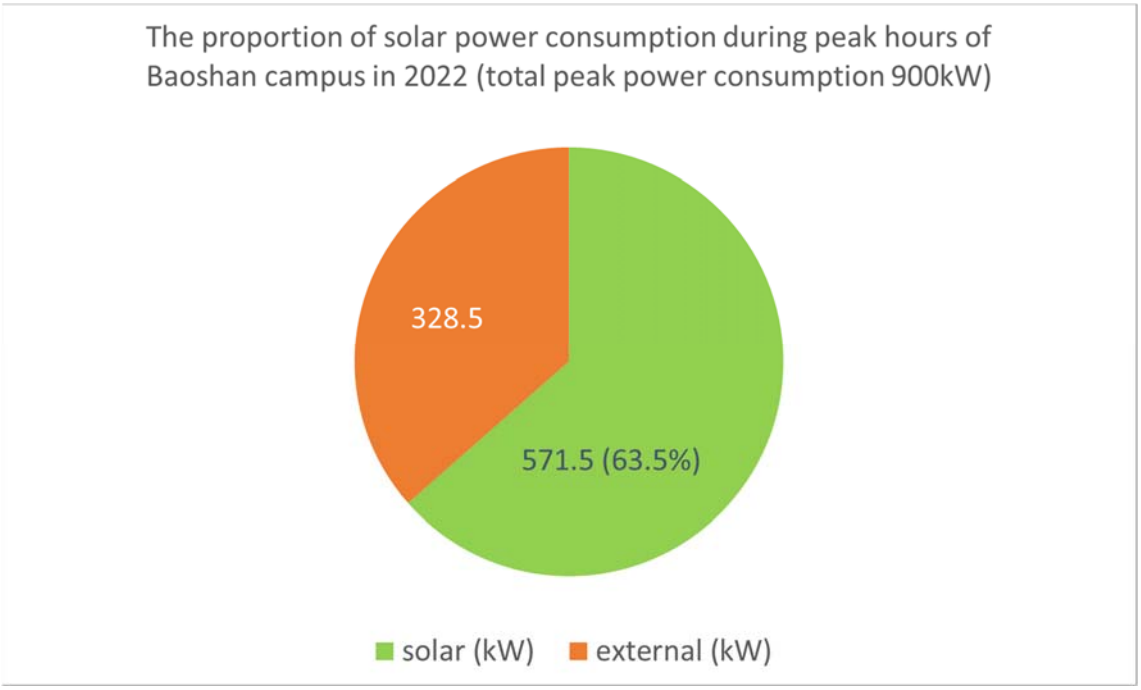

Figure 5. The proportion of solar power consumption during peak hours of the Baoshan campus in 2022

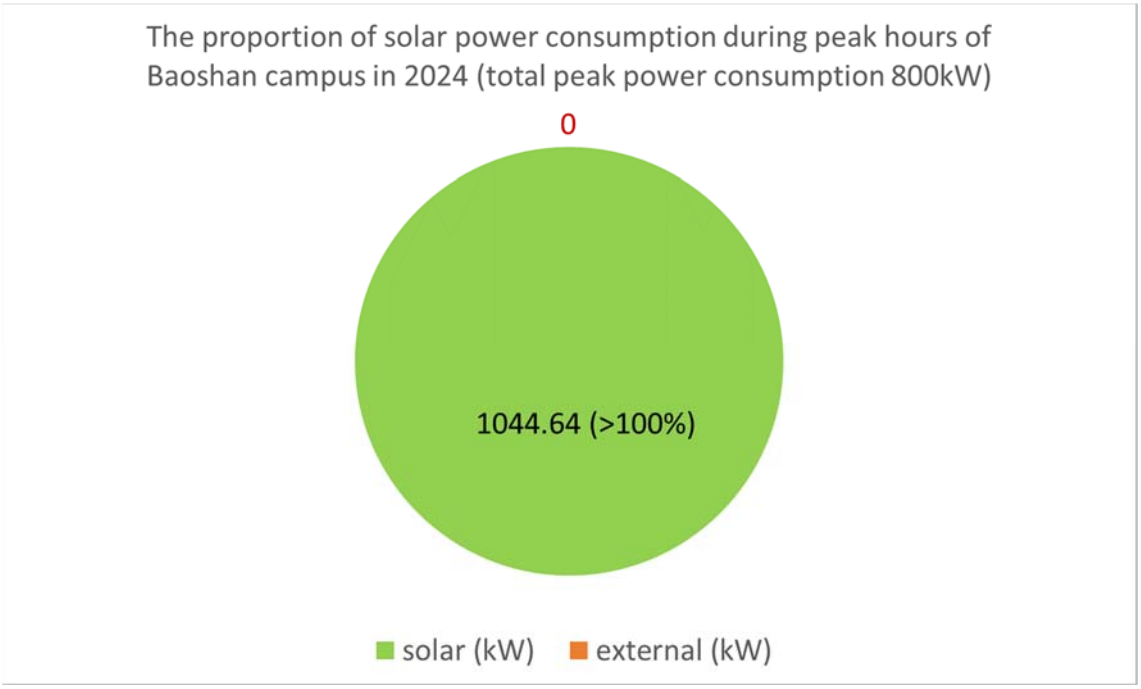

Figure 6. The proportion of solar power consumption during peak hours of the Baoshan campus in 2024

(3)The following table presents the detailed distribution of new solar power generation facilities to be installed during academic year 2023-2024 (for each building) as shown in Table 4. The growth trends of solar installation capacity and electricity generation at the Jinde Campus and the Baoshan Campus are shown in Figures 7-8.

Table 4. Details of the planned new solar power installation distribution at NCUE for 2023-2024

Campus	Building	Expected Capacity (kWp)	Total	Expected Power Generation (kWh/year)	Total
Jinde	No. 3 Dormitory	259.94	510.04 kWp	324,925	637,550 kWh
	No. 5 Dormitory	69.7		87,125	
	Parking lot at the East Gate	102.5		128,125	
	Left and right sides of the Torch Tower	77.9		97,375	
Baoshan	Behind No. 9 Dormitory	138.99	473.14 kWp	173,737	591,424 kWh
	Parking lot of No. 9 Dormitory, next to Baoshan Road	123.41		154,262	
	Parking lot of the First Educational Building, next to Baoshan Road	113.98		142,475	
	Parking lot of the Second Educational Building	96.76		120,950	

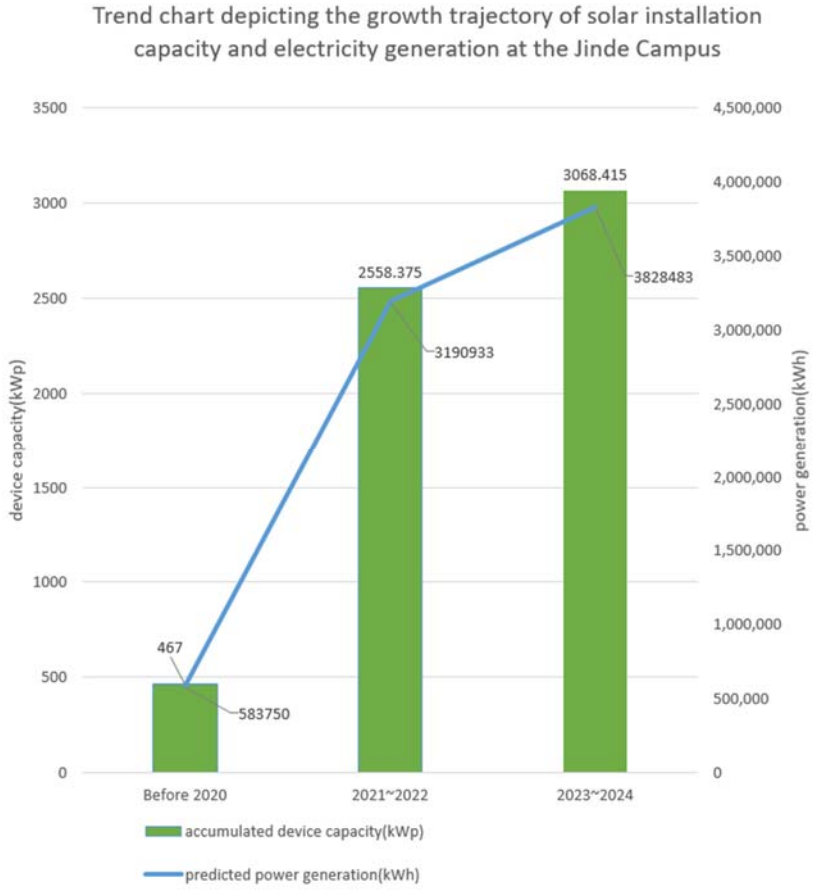

Figure 7. Trend chart depicting the growth trajectory of solar installation capacity and electricity generation at the Jinde Campus

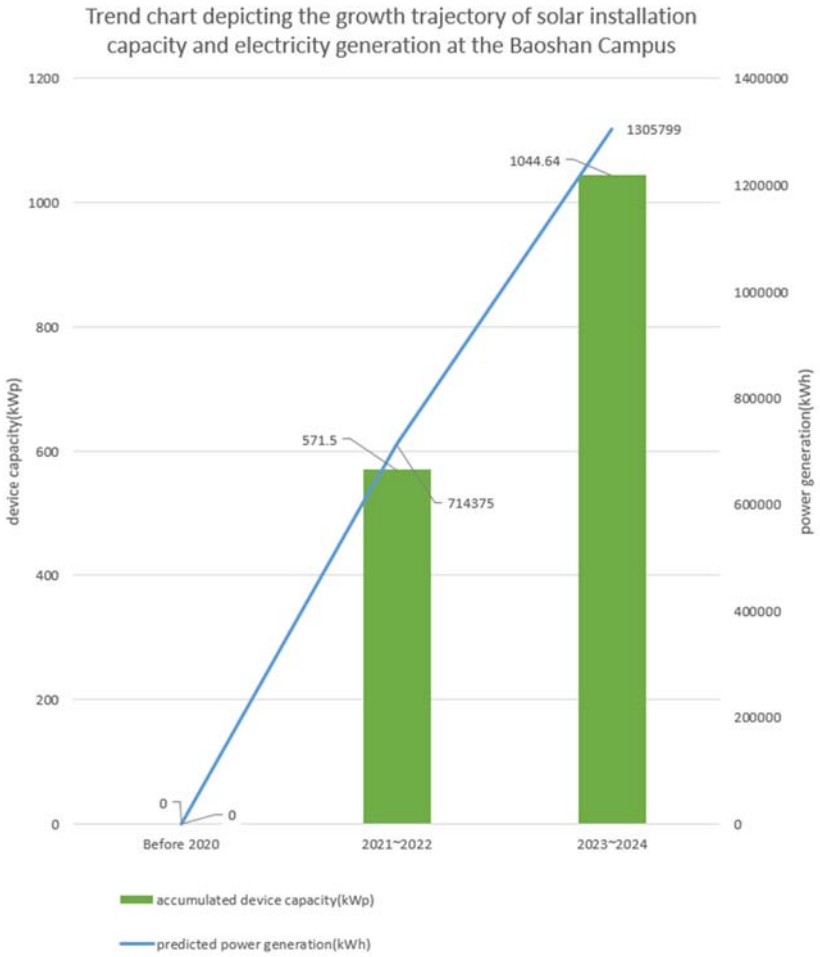

Figure 8. Trend chart depicting the growth trajectory of solar installation capacity and electricity generation at the Baoshan Campus

SDG 13.3.1 Local education programmes on climate

1. In 2022, NCUE initiated a project as part of the "In-Depth Cultivation of Fangyuan, Working Hand in Hand with Dacheng: Industrial and Environmental Sustainability Plan of the Two Townships of Changhua County" in 2020-2022 project, which focused on providing local education programs or activities related to climate change risks, impacts, mitigation, adaptation, reducing effects, and early warning. Related events and activities are shown in Table 1.

Table 1. Table of activity, date and number of participants in 2020-2022 events and activities

Activities	Date	Number of participants
My Low-Carbon Lifestyle	April 13 & 16, 2022	239
Environmental Educator Certification Workshop - Dacheng Junior High School Class	August 2022	13

2. Ministry of Education, "In-Depth Cultivation of Fangyuan, Working Hand in Hand with Dacheng: Industrial and Environmental Sustainability Plan of the Two Townships of Changhua County" project: April 13 and 16, 2022, My Low-Carbon Lifestyle, with 239 participants, photos of the event are shown in Figure 1. References: https://www.facebook.com/media/set/?set=a.1203605307043242&type=3.

Figure 1. My Low-Carbon Lifestyle

2. The Ministry of Education's "In-Depth Cultivation of Fangyuan, Working Hand in Hand with Dacheng: Industrial and Environmental Sustainability Plan of the Two Townships of Changhua County" project organized an environmental educator certification workshop - Dacheng Junior High School class in August 2022, with 13 participants. Photos of the activity are shown in Figure 2. References: https://www.facebook.com/media/set/?set=a.636923044887728&type=3.

Figure 2. In-Depth Cultivation of Fangyuan, Working Hand in Hand with Dacheng

SDG 13.3.2 Climate Action Plan, shared

1. Our faculty members implemented Ministry of Science and Technology projects to provide advice and assistance to local and regional governments on the future planning of agricultural production systems, disaster prevention, and water resource allocation, as shown in Table 1.

Table 1. Serial No., Principal Investigator, Project Title

No.	Project leader	Project name
1	Professor Lin Chung-Chi	Impacts of Climate Change on Lowland Ecology and Lowland Ant Problems Due to Community Changes: Discussion and Solutions (Annex 13.3.4A - Report of Outcomes)
2	Professor Tu Jien-Yi	Spatial distribution of rainfall hotspots influenced by different weather systems in Taiwan (Annex 13.3.4B - Report of Outcomes)

Details of the project are provided below:

(1)The Ministry of Science and Technology's project was led by NCUE Professor Lin Chung-Chi. The project title is: "Impacts of Climate Change on Lowland Ecology and Lowland Ant Problems Due to Community Changes: Discussion and Solutions". Issues targeted by the project: given natural disasters due to climate change and development stress, lowland areas in Taiwan are ecologically fragile, with issues of landscape fragmentation, ecological barriers, and habitat loss. In recent years, the emerging problem of ant infestation has appeared in the lowland towns of central and southern Taiwan. Ants flood into houses like streams and flying ants invade houses like black fog. Such abnormal ecological phenomena are a warning of the gradual loss of health in Taiwan's ecological system. The project covered multiple areas, delving into the causes behind the ant infestation affecting lowland residents and identifying the issues of landscape fragmentation, ecological loss, and development stress. Within the framework of slope ecosystem services, the research team investigated key biologic facies in the habitats, analysed landscape changes, established relevant indicators, and analysed environmental vulnerability and ecological potential. Given the mechanism of the impact of ant problems on village industries and tourism, a lowland agricultural production system with ecosystem service potential and human welfare benefits was proposed under the context of climate change.

(2)The team also examined the relationship between invasive species and habitat spatial changes caused by climate changes. The action guidelines for biological disaster adaptation under climate change could inform the local government's decision-making process. (Figure 1)

Figure 1. Ant infestation in shallow mountains is attributed to climate change and human factors

Climate change and warming caused the overgrowth of honey insects (Planococcus citri), worsening ant problems in lowland areas (Figure 2: Technomyrmex albipes and Planococcus citri).

Figure 2. Technomyrmex albipes and Planococcus citri

The phenomena of natural landscape fragmentation, ecological loss, and habitat destruction caused by debris avalanches in Taiwan's lowland areas due to extreme rainfall (Figure 3: collapsed slope in lowland areas).

Figure 3. collapsed slope in lowland areas

(3)Prof. Jien-Yi Tu/National Science and Technology Council (NSTC) Project/Spatial distribution of rainfall hotspots in Taiwan under the influence of different weather systems (Figure 4). Project description: This research analyzes the impacts of different weather patterns on rainfall in Taiwan and finds that there is a significant interaction between large-scale circulation, weather systems, and topography. Different circulation patterns and moisture transport, in conjunction with topographical effects, result in variations in the distribution of rainfall hotspots. Moreover, the sources of moisture also vary widely. Some weather systems are primarily associated with near-surface moisture transport (e.g., afternoon convection), while others are more dominant below 850 hPa (e.g., the northeast monsoon), some concentrate in the 850-700 hPa layer (e.g., stationary fronts), or even higher in the 700-500 hPa layer (e.g., the eastward movement of the South China Rainband). These differences in characteristics also remind us that future analyses of different weather systems should pay special attention to the location of the main moisture transport layer. The research findings allow us to gain a deeper understanding of the relationship between rainfall hotspots and circulation, providing substantial assistance and contributions to future government disaster preparedness planning.

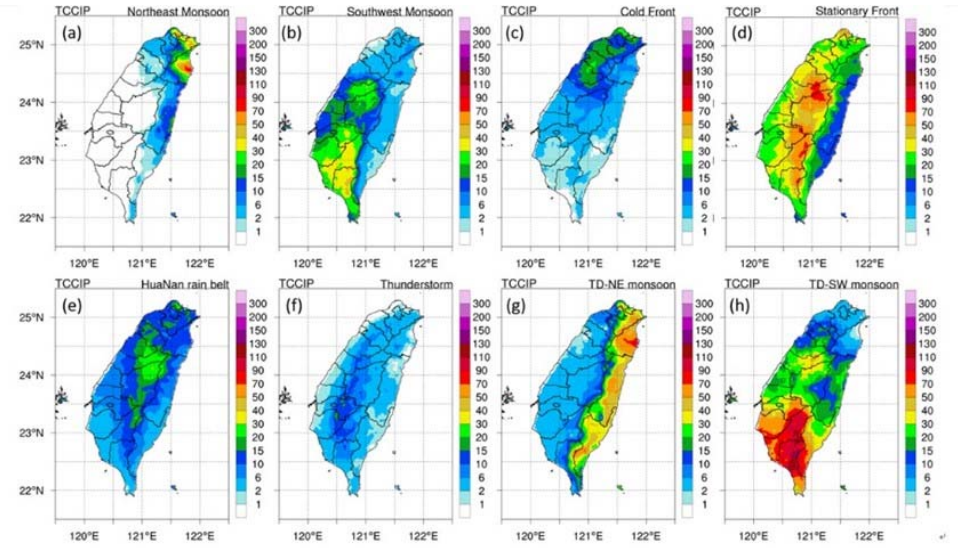

圖1 不同天氣系統影響下的降雨量空間分布。(a)東北季風、(b)西南季風、(c)冷鋒、(d)準滯留鋒、(e)華南雨帶東移、(f)午後對流、(g)颱風與東北季風共伴、(h)颱風與西南季風共伴。

Figure 4. Spatial distribution of rainfall under the influence of different weather systems

2. There are seven environmental education programmes at NCUE in collaboration with NGOs. Each is described in detail, below.

No.	Programme
1	Fangyuan Reengineering USR Seed Programme and Sprouting Programme for Engaging Fangyuan and Dacheng: Industrial and Environmental Sustainability for Changhua's Twin Towns

2	Taoyuan International Airport Corporation Programme/entrusted to plan, design, and implement control measures against fire ants
3	The Ministry of Science and Technology's project/Impacts of Climate Change on Lowland Ecology and Lowland Ant Problems Due to Community Changes: Discussion and Solutions
4	The Ministry of Science and Technology's project/Reshaping Global Control Efforts for Invasive Species: Positioning Taiwan as the Hub of Control, Prediction, and Education of Asiatic Red Fire Ants
5	The Ministry of Science and Technology's project/Development of Microbiological Control Technologies for Harmful Ants in Farmland
6	The project of the Animal and Plant Health Inspection Agency, Ministry of Agriculture/Development of Core Technologies and Construction of a Safety Assessment Model for Industrial Chain Agricultural Spraying based on Unmanned Aerial Vehicles (UAV): Field Experiment of UAVs Used against Invasive Red Fire Ants and System Management of UAV Pesticide Spraying
7	Programme for Kenting National Park/Investigation on the Invasion and Control Strategy of Yellow Termites in Kenting National Park

(1)Fangyuan Reengineering USR Seed Programme and Sprouting Programme for Engaging Fangyuan and Dacheng: Industrial and Environmental Sustainability for Changhua's Twin Towns in 2020-2022: included in the research project: cooperation with the Changhua Aquaculture Association to explore adaptive measures to climate change.

(2)Taoyuan International Airport Corporation Programme/entrusted to plan, design, and implement control measures against fire ants. (Figure 5)

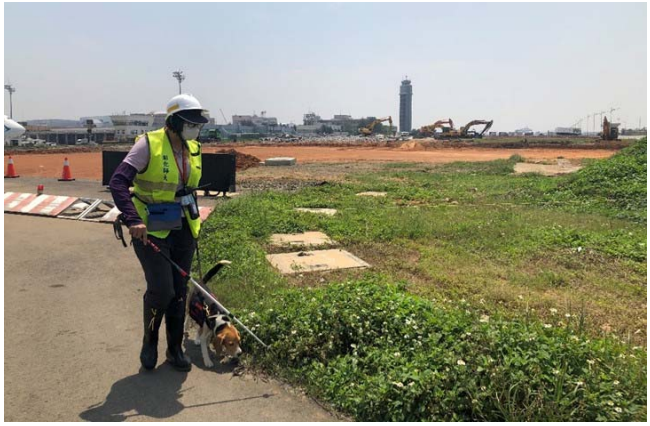

Figure 5. The NCUE-Taoyuan International Airport fire ant control team searches for imported red fire ants at Taoyuan Airport with the assistance of a fire ant detection dog

(3)The Ministry of Science and Technology's project/Impact of Climate Change on Lowland Ecology and Lowland Ant Problems Due to Community Changes: Discussion and Solutions. (Figure 6)

Figure 6. The project delved into the causes behind the ant infestation affecting lowland Zhongxing New Village residents in central and southern Taiwan and identified the issues of landscape fragmentation, ecological loss, and development stress. Within the framework of slope ecosystem services (supply, adapt, culture, and support), the research team investigated key biologic facies in the habitats affected by ant damage, and analysed environmental vulnerability and ecological potential. A lowland agricultural production system with ecosystem service potential and human welfare benefits was proposed under the context of climate change

(4)The Ministry of Science and Technology's Project/Reshaping Global Control Efforts for Invasive Species: Positioning Taiwan as the Hub of Control, Prediction, and Education of the Asiatic Red Fire Ants. (Figure 7)

Figure 7. Data model analysis and establishment of an innovative platform for invasive

red fire ants. The project made significant contributions to the ongoing scientific debate on the causes of global invasive imported red fire ants as well as control measures for the fire ants, the impact on agriculture and economy, and the scientific development of Taiwan

(5)The Ministry of Science and Technology's project/Development of Microbiological Control Technologies for Harmful Ants in Farmland. (Figure 8)

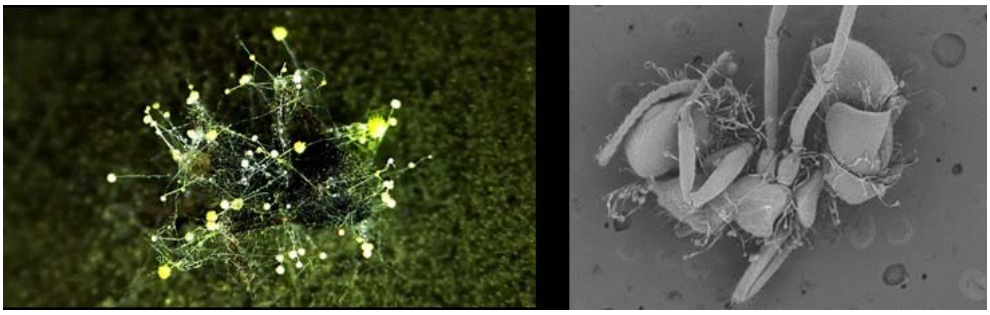

Figure 8. Development and application of microbial control for the growing problem of harmful ants in the agricultural environment. Especially in the development of sustainable agriculture and organic agriculture, this research focuses on the design, development, and application of microbial agents on crops to control harmful ants as well as the valuable development of its practical value and commercial potential

(6)Project of the Animal and Plant Health Inspection Agency, Ministry of Agriculture/Development of Core Technologies and Construction of Safety Assessment Model for Industrial Chain Agricultural Spraying based on Unmanned Aerial Vehicles (UAV): Field Experiment of UAVs Used against Invasive Red Fire Ants and System Management of UAV Pesticide Spraying). (Figures 9-10)

Figure 9. Assist in establishing a standard practice for pesticide application against invasive imported red fire ants on large areas or special terrains using agricultural drones

Figure 10. Assist in establishing a standard practice for pesticide application against invasive imported red fire ants on large areas or special terrains using agricultural drones

(7)Programme for Kenting National Park/Investigation on the Invasion and Control Strategy of Yellow Termites in Kenting National Park. Assisted Kenting National Park to investigate the invasion status of Anoplolepis gracilipes, one of the most harmful invasive species in the

world, in the land crab distribution concentration areas. This study is the first time that Anoplolepis gracilipes has been found to threaten land crab populations in East Asia. In addition to ant damage, land crabs also face threats from road killing, habitat destruction, and human harvesting. (Figure 11)

Figure 11. Anoplolepis gracilipes attack young crabs

SDG 13.3.3 Co-operative planning for climate change disasters

Taiwan is located at the boundary of the “Eurasian Plate” and the “Philippine Sea Plate”; therefore, earthquakes are very frequent. According to seismic data from the Seismic Information Centre (Central Weather Bureau) from 1991 to 2015, about 3,000 earthquakes occured in Taiwan every month on average, and 102 major earthquake disasters occurred from 1901 to 2016.

The director of the Seismic Information Center stated in March 2022 that it is highly likely that the “active seismic period” has begun in the Pacific Ring of Fire, which includes Taiwan.

Although an accurate earthquake prediction technology is not available yet, increasing seismic observation data are rather helpful in improving the efficiency of disaster relief and reducing the loss of life and property during earthquakes. In cooperation with the Central Weather Bureau, NCUE has installed strong motion observation apparatuses on the two campuses and in the Family Quarters as well as the Bai Sha weather station.

1. Below are some more details about the seismic observation apparatuses. (Figures 1-3)

Figure 1. Strong motion observation station in Jinde Campus. The observation station houses the strong motion observation apparatus. The time, location, and size of an earthquake can be calculated when many stations are connected to form a seismograph network

Figure 2. Crustal deformation observation station in Baoshan Campus. The station continuously receives signals emitted from the global satellite positioning system and, with the signals received simultaneously by other stations, it can accurately calculate its location relative to other stations. Long-term observation data can reflect significant surface displacement due to major earthquakes. In addition, data on small crustal deformation during earthquakes are very helpful in understanding crustal movement and earthquake potential

Figure 3. Underground seismograph observation station in the Family Quarters. The seismograph installed at a depth of 300 metres in the well can significantly reduce interference from surface noise and obtain high quality ground motion signals, improving the accuracy of seismic locating and the ability to monitor small-scale, regional earthquakes

2. The Central Weather Bureau works with academic institutions in Taiwan by installing weather facilities for teaching purposes. They can be used as practice areas by students. The automatic meteorological observation station run by NCUE's Department of Geography is one such facility.

It is also the only such station in central Taiwan under the partnership. This automatic meteorological station was built in the attic of the Geography Department Building. It was commissioned in November 1997 and will have run for 25 years in 2022(Figure 4). The meteorological instruments and peripheral devices are used for real-time observation, and meteorological data are synchronised with the South District Weather Centre of the Central Weather Bureau. Real-time data are useful for disaster prevention units. The features of the observation station are shown in the photo below. In addition, a sufficiently long observation time also means that the station could help researchers better understand regional climate characteristics and changes and allow them to conduct relevant studies.

Figure 4. NCUE’s Bai Sha weather station

SDG 13.3.4 Inform and support government

1. Our faculty members implemented Ministry of Science and Technology projects to provide advice and assistance to local and regional governments on the future planning of agricultural production systems, disaster prevention, and water resource allocation, as shown in Table 1.

Table 1. Serial No., Principal Investigator, Project Title

No.	Project leader	Project name
1	Professor Lin Chung-Chi	Impacts of Climate Change on Lowland Ecology and Lowland Ant Problems Due to Community Changes: Discussion and Solutions (Annex 13.3.4A - Report of Outcomes)
2	Professor Tu Jien-Yi	Spatial distribution of rainfall hotspots influenced by different weather systems in Taiwan (Annex 13.3.4B - Report of Outcomes)

Details of the project are provided below:

(1)The Ministry of Science and Technology's project was led by NCUE Professor Lin Chung-Chi. The project title is: "Impacts of Climate Change on Lowland Ecology and Lowland Ant Problems Due to Community Changes: Discussion and Solutions". Issues targeted by the project: given natural disasters due to climate change and development stress, lowland areas in Taiwan are ecologically fragile, with issues of landscape fragmentation, ecological barriers, and habitat loss. In recent years, the emerging problem of ant infestation has appeared in the lowland towns of central and southern Taiwan. Ants flood into houses like streams and flying ants invade houses like black fog. Such abnormal ecological phenomena are a warning of the gradual loss of health in Taiwan's ecological system. The project covered multiple areas, delving into the causes behind the ant infestation affecting lowland residents and identifying the issues of landscape fragmentation, ecological loss, and development stress. Within the framework of slope ecosystem services, the research team investigated key biologic facies in the habitats, analysed landscape changes, established relevant indicators, and analysed environmental vulnerability and ecological potential. Given the mechanism of the impact of ant problems on village industries and tourism, a lowland agricultural production system with ecosystem service potential and human welfare benefits was proposed under the context of climate change (Figure 1).

Figure 1. Ant infestation in shallow mountains is attributed to climate change and human factors

(3)Prof. Jien-Yi Tu/National Science and Technology Council (NSTC) Project/Spatial distribution of rainfall hotspots in Taiwan under the influence of different weather systems. Project description: This research analyzes the impacts of different weather patterns on rainfall in Taiwan and finds that there is a significant interaction between large-scale circulation, weather systems, and topography. Different circulation patterns and moisture transport, in conjunction with topographical effects, result in variations in the distribution of rainfall hotspots. Moreover, the sources of moisture also vary widely. Some weather systems are primarily associated with near-surface moisture transport (e.g., afternoon convection), while others are more dominant below 850 hPa (e.g., the northeast monsoon), some concentrate in the 850-700 hPa layer (e.g., stationary fronts), or even higher in the 700-500 hPa layer (e.g., the eastward movement of the South China Rainband). These differences in characteristics also remind us that future analyses of different weather systems should pay special attention to the location of the main moisture transport layer. The research findings allow us to gain a deeper understanding of the relationship between rainfall hotspots and circulation, providing substantial assistance and contributions to future government disaster preparedness planning. (Figure 2)

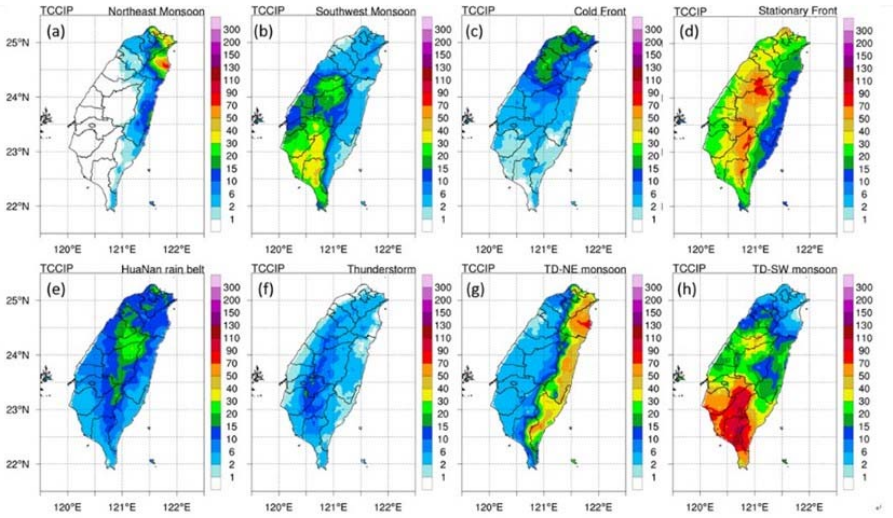

圖1 不同天氣系統影響下的降雨量空間分布。(a)東北季風、(b)西南季風、(c)冷鋒、(d)準滯留鋒、(e)華南雨帶東移、(f)午後對流、(g)颱風與東北季風共伴、(h)颱風與西南季風共伴。

Figure 2. Spatial distribution of rainfall under the influence of different weather systems

2. Taiwan is located at the boundary of the “Eurasian Plate” and the “Philippine Sea Plate”, so earthquakes are very frequent. According to the seismic data of the Seismic Information Centre, Central Weather Bureau, from 1991 to 2015, about 3,000 earthquakes occurred in Taiwan every month on average, and 102 major earthquake disasters occurred from 1901 to 2016. Although an accurate earthquake prediction technology is not available yet, increasing seismic observation data are rather helpful in improving the efficiency of disaster relief and reducing the loss of life and property during earthquakes. In cooperation with the Central Weather Bureau, NCUE has installed strong motion observation apparatuses in the two campuses and in family quarters as well as the Bai Sha Weather station.

(1)Below are some more details about the seismic observation apparatuses. (Figures3-5)

Figure 3. Strong motion observation station in Jinde Campus The observation station houses

the strong motion observation apparatus. The time, location, and size of an earthquake can be calculated when many stations are connected to form a seismograph network

Figure 4. Crustal deformation observation station in Baoshan Campus. The station continuously receives signals emitted from the global satellite positioning system, and with the received signals at the same time by other stations, it can accurately calculate the station's location relative to other stations. Long-term observation data could reflect significant surface displacement due to major earthquakes. Also, the data on small crustal deformation occurs during earthquakes are very helpful in understanding crustal movement and earthquake potential

Figure 5. Underground seismograph observation station in family quarters. The seismograph installed at a depth of 300 meters in the well can significantly reduce the interference from surface noise and obtain high quality ground motion signals, improving the accuracy of seismic locating and the ability to monitor regional small-scale earthquakes

(2)The Central Weather Bureau works with academic institutions in Taiwan by installing weather facilities for teaching purposes. They can be used as practice areas by students. The automatic meteorological observation station run by NCUE's Department of Geography is one of such

facilities. It is also the only station in central Taiwan under the partnership. The automatic meteorological station was built on the attic of the Geography Department Building. It was commissioned in November 1997 and has run for 25 years by 2022 (Figure 6). The meteorological instruments and peripheral devices are used for real-time observation, and meteorological data are synchronised with the South District Weather Centre of the Central Weather Bureau. The real-time data are useful for disaster prevention units. The features of the observation station are shown in the photo below. In addition, sufficiently long observation time also means that the station could help people better understand the regional climate characteristics and changes and researchers conduct relevant studies.

Figure 6. NCUE's Bai Sha weather station

SDG 13.3.5 Environmental education collaborate with NGO

There are seven environmental education programmes at NCUE in collaboration with NGOs. Each is described in detail, below.

No.	Programme
1	Fangyuan Reengineering USR Seed Programme and Sprouting Programme for Engaging Fangyuan and Dacheng: Industrial and Environmental Sustainability for Changhua's Twin Towns
2	Taoyuan International Airport Corporation Programme/entrusted to plan, design, and implement control measures against fire ants
3	The Ministry of Science and Technology's project/Impacts of Climate Change on Lowland Ecology and Lowland Ant Problems Due to Community Changes: Discussion and Solutions
4	The Ministry of Science and Technology's project/Reshaping Global Control Efforts for Invasive Species: Positioning Taiwan as the Hub of Control, Prediction, and Education of Asiatic Red Fire Ants
5	The Ministry of Science and Technology's project/Development of Microbiological Control Technologies for Harmful Ants in Farmland
6	The project of the Animal and Plant Health Inspection Agency, Ministry of Agriculture/Development of Core Technologies and Construction of a Safety Assessment Model for Industrial Chain Agricultural Spraying based on Unmanned Aerial Vehicles (UAV): Field Experiment of UAVs Used against Invasive Red Fire Ants and System Management of UAV Pesticide Spraying
7	Programme for Kenting National Park/Investigation on the Invasion and Control Strategy of Yellow Termites in Kenting National Park

1. Fangyuan Reengineering USR Seed Programme and Sprouting Programme for Engaging Fangyuan and Dacheng: Industrial and Environmental Sustainability for Changhua's Twin Towns in 2020-2022: included in the research project: cooperation with the Changhua Aquaculture Association to explore adaptive measures to climate change.

2. Taoyuan International Airport Corporation Programme/entrusted to plan, design, and implement control measures against fire ants. (Figure 1)

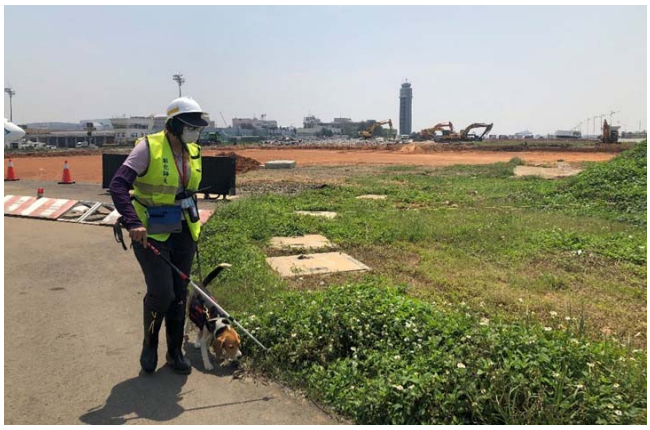

Figure 1. The NCUE-Taoyuan International Airport fire ant control team searches for imported red fire ants at Taoyuan Airport with the assistance of a fire ant detection dog

3. The Ministry of Science and Technology's project/Impact of Climate Change on Lowland Ecology and Lowland Ant Problems Due to Community Changes: Discussion and Solutions. (Figure 2)

Figure 2. The project delved into the causes behind the ant infestation affecting lowland Zhongxing New Village residents in central and southern Taiwan and identified the issues of landscape fragmentation, ecological loss, and development stress. Within the framework of slope ecosystem services (supply, adapt, culture, and support), the research team investigated key biologic facies in the habitats affected by ant damage, and analysed environmental vulnerability and ecological potential. A lowland agricultural production system with ecosystem service potential and human welfare benefits was proposed under the context of climate change

4. The Ministry of Science and Technology's Project/Reshaping Global Control Efforts for Invasive Species: Positioning Taiwan as the Hub of Control, Prediction, and Education of the Asiatic Red Fire Ants. (Figure 3)

Figure 3. Data model analysis and establishment of an innovative platform for invasive red fire ants. The project made significant contributions to the ongoing scientific debate on the causes of global invasive imported red fire ants as well as control measures for the fire ants, the impact on agriculture and economy, and the scientific development of Taiwan

5. The Ministry of Science and Technology's project/Development of Microbiological Control Technologies for Harmful Ants in Farmland. (Figure 4)

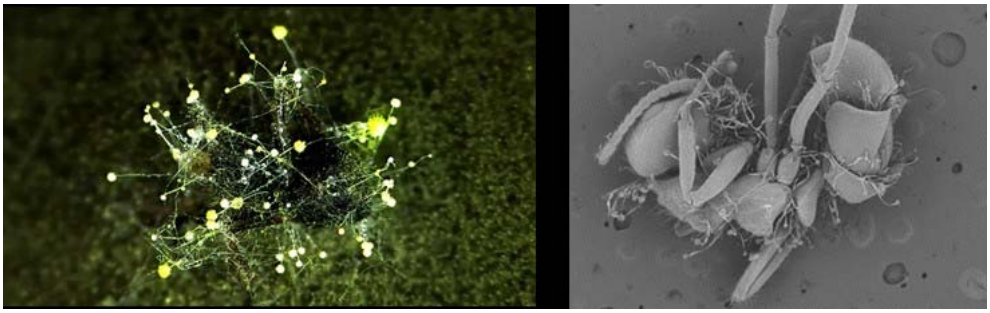

Figure 4. Development and application of microbial control for the growing problem of harmful ants in the agricultural environment. Especially in the development of sustainable agriculture and organic agriculture, this research focuses on the design, development, and application of microbial agents on crops to control harmful ants as well as the valuable development of its practical value and commercial potential

6. Project of the Animal and Plant Health Inspection Agency, Ministry of Agriculture/Development of Core Technologies and Construction of Safety Assessment Model for Industrial Chain Agricultural Spraying based on Unmanned Aerial Vehicles (UAV): Field Experiment of UAVs Used against Invasive Red Fire Ants and System Management of UAV Pesticide Spraying). (Figures 5-6)

Figure 5. Assist in establishing a standard practice for pesticide application against invasive imported red fire ants on large areas or special terrains using agricultural drones

Figure 6. Assist in establishing a standard practice for pesticide application against invasive imported red fire ants on large areas or special terrains using agricultural drones

7. Programme for Kenting National Park/Investigation on the Invasion and Control Strategy of Yellow Termites in Kenting National Park. Assisted Kenting National Park to investigate the invasion status of Anoplolepis gracilipes, one of the most harmful invasive species in the world, in the land crab distribution concentration areas. This study is the first time that Anoplolepis gracilipes has been found to threaten land crab populations in East Asia. In addition to ant damage, land crabs also face threats from road killing, habitat destruction, and human harvesting. (Figure 7)

Figure 7. Anoplolepis gracilipes attack young crabs

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SDG 13.4.1 Commitment to carbon neutral university

Our commitment to becoming a carbon neutral university is outlined as follows: **The National Changhua University of Education will adhere to the Greenhouse Gas Protocol and implement various carbon emissions regulations to achieve carbon neutrality by 2029**.

In response to this commitment, our institution has formulated the "National Changhua University of Education – Energy Conservation and Carbon Reduction Bulletin" service that aims to conserve water and energy used for lighting and air-conditioning, promote environmental awareness, and reduce carbon footprint and carbon dioxide emissions. The annual budget allocated for the replacement and maintenance of high-energy-consuming equipment will amount to at least NT$5 million. Furthermore, a minimum of 1% year-on-year increase in overall energy efficiency is anticipated. Compared to 2022, it is projected that the total annual power consumption of existing equipment will be reduced by at least 1,300,000 million kWh by 2029.

Additionally, our institution has already installed a megawatt-level power storage system and plans to accelerate the installation process of solar generators on Jinde and Baoshan campuses. An additional three sets of 100,000-watt power storage systems have also been proposed to assist in the operation of the campus microgrid. Such systems are intended to shift loads by saving excess electrical power during off-peak hours and at night for later usage during peak hours, which, in turn, alleviates the need for coal-power-driven loads during peak hours. Simultaneously, the maximum line current will be lowered, thereby reducing power transfer loss by approximately 3%, resulting in decreased carbon emissions from the power plants during transportation.

In line with global zero net greenhouse gas emission policies, assisting industry in low-carbon transformation. NCUE provided companies with greenhouse gas inventory and reduction services in 2023, with 18 projects and a project funding of NT$3,600,000. 28 faculty members participated in the carbon inventory project, accounting for 7.7% of faculty in the school. (As shown in Table 1)

Table 1. 2023 Carbon Inventory Project Statistics

No. of participating instructors	No. of projects	Project Amount (Unit: NT$)
28	18	3,600,000

Through continued education from relevant university courses, as well as our efforts to drive sustainability, we will continue to advocate energy conservation and carbon reduction measures in the future. We anticipate that our institution will become not only a sustainable campus with motivated and environmentally conscious faculty and students, but also a key facilitator of Taiwan's sustainable development programs. (Figure 1)

國立彰化師範大學
National Changhua University of Education

Carbon Neutrality Declaration –

National Changhua University of Education

National Changhua University of Education will adhere to the Greenhouse Gas Protocol and implement various carbon emission regulations in order to achieve carbon neutrality by 2029.

Our institution has formulated the "National Changhua University of Education - Energy Conservation and Carbon Reduction Bulletin" which intends to conserve electricity, water, and energy used for lighting and air conditioning. It also aims to promote environmental awareness in order to reduce the carbon footprint and carbon dioxide emissions. The annual budget allocated for the replacement and maintenance of energy-consuming equipment will amount to least NT$5 million. Furthermore, a minimum 1% yearly gain in overall energy efficiency is anticipated. Compared to 2021, it is projected that the total annual power consumption of existing equipment will be reduced by at least 1.3 million kWh by 2029.

In addition, our institution has already installed a megawatt-level power storage system and plans to accelerate the installation process of solar generators on the campuses in Jinde and Baoshan. An additional three sets of 100,000-watt-level power storage systems are proposed to assist in the operation of the campus microgrid. Such systems are intended to shift load by saving excess electrical power during off-peak hours at night for later usage during peak hours, which in turn alleviates the load on coal power units during peak hours. Simultaneously, the maximum line current will be lowered, thereby reducing power transfer loss by approximately 3%, resulting in decreased carbon emissions from power plants.

Through our continued education in relevant university courses, as well as our efforts towards sustainability, we will continue to advocate for energy conservation and carbon reduction measures in the future. We anticipate that our institution will become not only a sustainable campus with motivated, environmentally conscious faculty and students, but also a key facilitator of Taiwan's sustainable development.

President Ming-Fei Chen

Stptember 2022

Figure 1. NCUE Carbon Neutrality Declaration

SDG 13.4.2 Achieve by

1. In addition to the existing 467 kWp solar power generation system, the University expects to install an additional photovoltaic solar power system with a total capacity of 4,107.43 kWp by the end of 2024 (3,068.42.kWp for Jinde Campus and 1,044.64 kWp for Baoshan Campus), so that the total annual solar power generation reaches over 5,134,282 kWh.

2. Continuing our past power-saving achievements (saving approximately 18% of power consumption in the past 15 years), the University plans to invest more than NT$5,000,000 per year over the next 10 years into reducing the total power consumption of existing facilities, with a goal of achieving a 1% reduction in total power consumption each year (that is, more than 150,000 kWh per year). It is expected that, by 2029, the total annual power consumption of existing equipment will be reduced by at least 1,300,000 kWh, compared to 2022.

3. For Baoshan Campus, the total capacity of the solar energy system will reach 1,044.64 kWp by the end of 2024, and power consumption during peak hours will reduce to 800 kWh, thus attaining carbon neutrality during peak hours.

4. For Jinde Campus, the total capacity of the solar energy system will reach 3,068.42 kWp by the end of 2024, and power consumption during peak hours will reduce to 2,400 kWh, attaining carbon neutrality during peak hours.

5. NCUE will complete the installation of 2,087.75 kW and 601.5 kW of solar power in 2022 at the Jinde and the Baoshan Campuses respectively. Based on the average sunshine of 3.5 hours in the Changhua area of Taiwan, the total amount of electricity generated was (2,087.75+601.5)×365×3.5=3,435,517 kWh (kilowatt-hour). According to the Ministry of Economic Affairs, the carbon emission factor for electricity in 2022 was 0.495 kg CO2/kWh, therefore, carbon emissions were reduced by 3,435,517×0.495=1,700,580 kg. Peak electricity consumption during winter or summer vacation was lower than the amount of electricity generated by solar power. With a total installed capacity of 1,410 kWh, NCUE's energy storage system can completely store the excess solar power generation and transfer the energy from renewable energy to nighttime use. Therefore, NCUE can not only harness renewable energy to achieve carbon neutrality during the daytime, but also increase the degree of carbon neutrality during the nighttime by utilizing a large-scale energy storage system to increase the utilization rate of renewable energy, as shown in Table 1.

Table 1. Annual, peak solar power generation (kW), peak electricity consumption, and percentage generated through solar power

Campus	Year	Solar Energy Generated during Peak Hours (kW)	Power Consumption during Peak Hours (kW)	Proportion of Solar Power to Power Consumption
Jinde	Before 2020	467	3,000	15.57%
	2021-2022	2,558.375	2,600	98.18%
	2023-2024	3,068.415	2,400	>100%
Baoshan	Before 2020	0	1,000	0%
	2021-2022	571.5	900	63.5%
	2023-2024	1,044.64	800	>100%

6. Based on the above information, the University expects to achieve preliminary carbon neutrality by 2029.