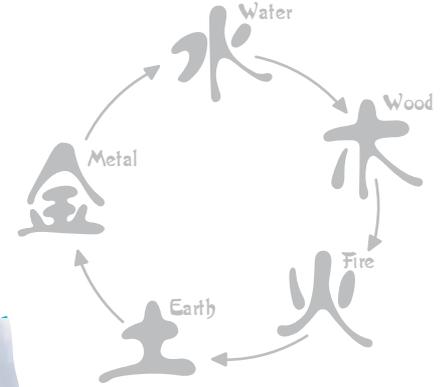


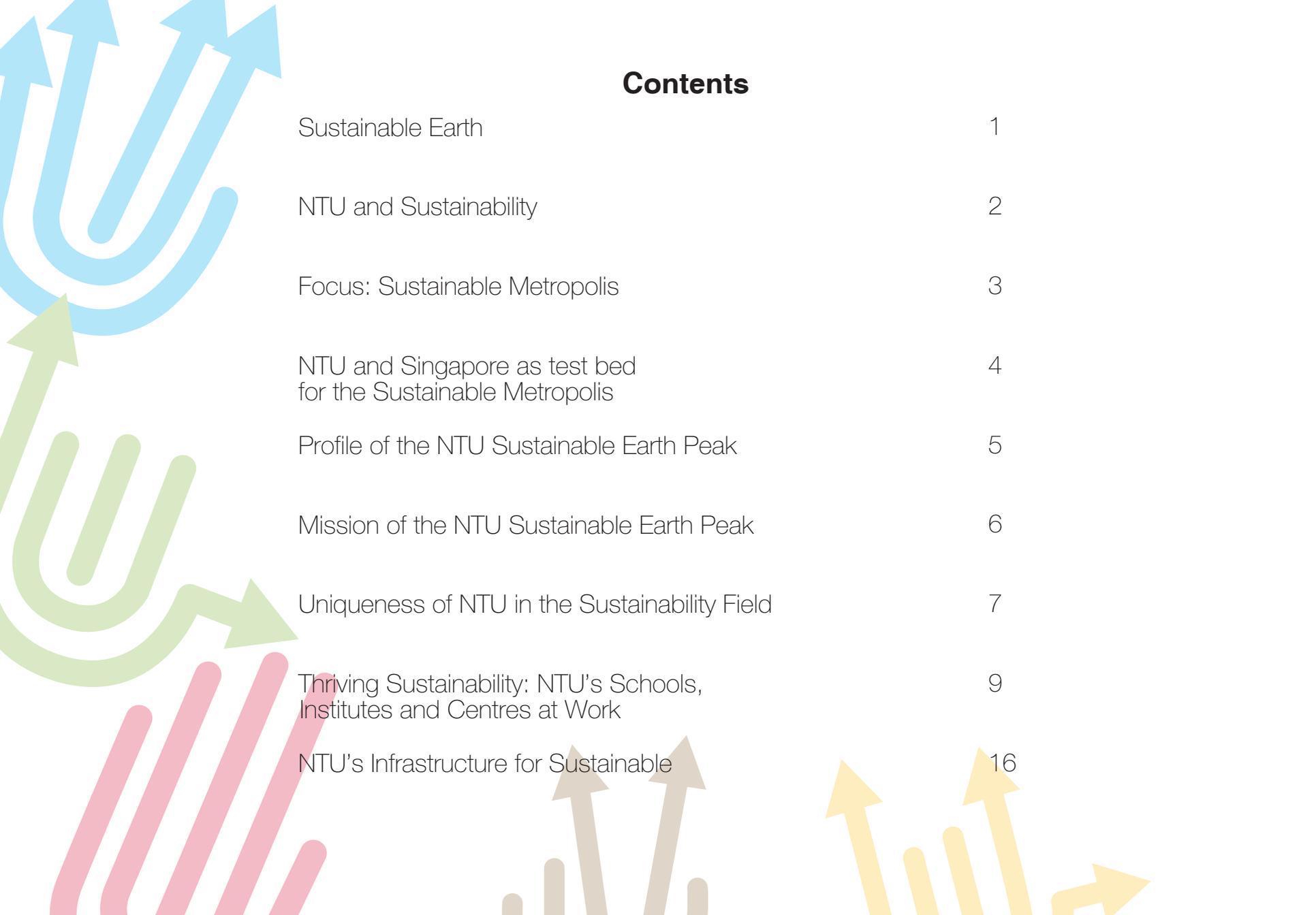


NANYANG
TECHNOLOGICAL
UNIVERSITY

NTU Peak of Excellence Sustainable Earth

with the focus Sustainable Metropolis





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Sustainable Earth with the focus Sustainable Metropolis

Under the five-year strategic blueprint (NTU 2015), NTU will develop Five Peaks of Excellence: among these, Sustainable Earth is the “peak of peaks”. With more than S\$830 million in research and project funding in sustainability, NTU is already a global leader in this area. Singapore expects the clean-tech sector alone to contribute S\$3.4 billion to gross domestic product by 2015 and provide 18,000 jobs. Therefore, NTU's sustainability peak represents an important effort in developing and leveraging the university's diverse strengths, particularly its main task in educating students and Singapore's teachers, its longstanding expertise in engineering and business, and its growing multidisciplinary capacity in areas such as healthcare, science, economics, and the humanities. Besides supporting many new areas that will drive Singapore's economy, NTU's Sustainable Earth thrust will shape and support leaders who will help to address some of the major challenges facing Singapore and the entire world.

“peak of peaks”



NTU and Sustainability

The concept of sustainability is rooted in our wish to allow current and future generations of humans the opportunity to build lives of health and dignity. Sustainability is a global issue which requires specific regional and local solutions. The problems we face are complex and serious—and we cannot address them in the same way we created them. But we *can* address them.

NTU started developing expertise in sustainable development and urbanisation in the 1990s, in response to Singapore's need for new and reclaimable sources of water. Under its current Sustainable Earth Peak of Excellence, NTU is taking a comprehensive and holistic approach to the inter-related and increasingly convergent issues of water, alternative energy sources, clean technologies, urban planning, catastrophes and disaster preparedness, and geological concerns.

At the successful Sustainable Earth Peak Retreat on 15-16 September 2011 and the Sustainable Earth Office's (SEO) Energy Efficient Building Workshop on 5 October 2011, NTU's faculty, divisions, and specialised centres began developing an action plan and determining key priorities in sustainability research and practice. Through these events and subsequent discussions generated on campus, an organising theme of *Sustainable Metropolis* was selected by the university community. In addition, there was broad agreement that sustainability projects and practices must include all departments and divisions in an open, interdisciplinary manner.

Mega-Issues of Sustainability

The mega-issues are the same for the developed North as they are for the developing South. However, their intensities, impacts, short-, long-term effects, and specific risks may differ drastically, depending on the geographical regions, specificities of nations, and neighboring countries. The mega-issues represent the key basic needs for each human.

- They are:
1. Water
 2. Food
 3. Shelter
 4. Health
 5. Personal and social security, including resilience against disasters
 6. Energy supply and management
 7. Sound land-use and its management



In the coming years, NTU will concentrate and organise many of its efforts around themes of sustainable metropolis. With this focus on the future of sustainable cities, NTU is tackling one of the world's key environmental and economic sustainability issues of increasing urbanisation. Urban centres will continue to be the economic drivers of our future, and a majority of the world's population will soon live in large cities. Therefore, the outcomes of NTU's efforts are pivotal to Singapore and will allow it to set global sustainability standards for the future.

Focus: Sustainable Metropolis

The effects of the mega-issues, like water and food, energy supply, land use, health, and security, have their main impacts in cities and metropolitan areas. Within the framework of global change, these effects have been particularly acute in the world cities, those ultra dynamic metropolises that function as global leaders in a world increasingly dominated by city-states. As such, it is the sustainability and viability of cities that will largely determine the well-being of their own inhabitants, the surrounding regions, and the nations in which they are located.

Sensitive Drivers for Sustainable Solutions

Successful implementations of sustainable solution are based on three pillars:

1. Innovative technological solutions and/or societal concepts
2. Economic framework, including financial markets and societal incentives
3. Governance, regulations and institutions, including property rights and legal enforceability

If one of these pillars is missing, the solutions will have no chance to induce a change. There are many technological solutions that never made it because of unfavourable economic factors or a lack of political will for implementing the right regulations or setting up an adequate institutional framework. The same is true for financial market instruments. Without a societal concept and a legal framework, their implementation will not take place. Likewise, farsighted political intentions have also been stuck because of a lack of adequate technological solutions.



For example, a sustainable supply of water, food, and energy for city dwellers is crucial for the functioning of productive agglomeration in successful cities supported by prosperous metropolitan areas. The infrastructures to supply the inhabitants with the basic needs have to be in place, as well as the infrastructures for mobility both within and between cities. To make a city liveable, everyday life must be reasonably secure and safe.

All of these urban planning and development issues, however, are highly dynamic. Take housing as an example, which plays a crucial role in both a city's viability and its likely trajectory of development and growth. Housing is one important example of an urban mega-issue that sits at the intersection between social welfare, economic development, and urban quality of life. Extending this example further, green space with intact ecosystems in cities and their surroundings is also a key to the life quality of metropolitans. In summary, how cities are designed and how urban infrastructures are renewed and maintained will remain vital for the future sustainable use of the planet's resources and for the support of most of the world's human inhabitants.

Taking all this into account, it will be a formidable challenge and a great opportunity for NTU to take the lead in helping to shape a sustainable future for humanity through its initiatives under the Sustainable Metropolis.

NTU and Singapore as test bed for the Sustainable Metropolis

The Inter-Ministerial Committee on Sustainable Development (IMCSD) was set up in February 2008 to formulate a clear national framework and strategy for Singapore's sustainable development in the context of the emerging domestic and global challenges. Sustainable development for Singapore was defined as growing the city-state in a way that is resource-efficient, prevents pollution of the environment, and preserves greenery, waterways and the natural heritage. NTU, along with its local and international project partners, possesses all the academic and intellectual ingredients to help Singapore achieve its sustainability goals.



However, the NTU Sustainable Earth Peak is poised to go beyond these current goals and challenges, to pave the way with entirely new and innovative approaches and solutions. NTU's faculty, students, and partners from the academic, public, and private sectors, will develop showcase projects on the campus, spanning sustainable buildings, new engineering designs, mobility solutions, monitoring and creating databases of sustainability metrics, improvements in resource-management planning, new policy approaches, and sustainable financing. At the same time, town centres, districts, and the entire state of Singapore with its dense international economic and political links are almost ideal areas in which to develop these concepts, blueprints, and technologies for sustainable solutions. In other words, NTU, CleanTech Park, and Singapore are already becoming a living, sustainability laboratory.

NTU is well-positioned to work within this environment to innovate sustainability solutions that are increasingly needed in Southeast Asia and the rest of the world. Along the way, there will be tremendous opportunities for the university and the nation in that all of these efforts are also linked to excellent economic opportunities, and will contribute towards making Singapore the leading nation for providing sustainability-related products, technologies, information, policy solutions, and management structures.

Profile of the NTU Sustainable Earth Peak

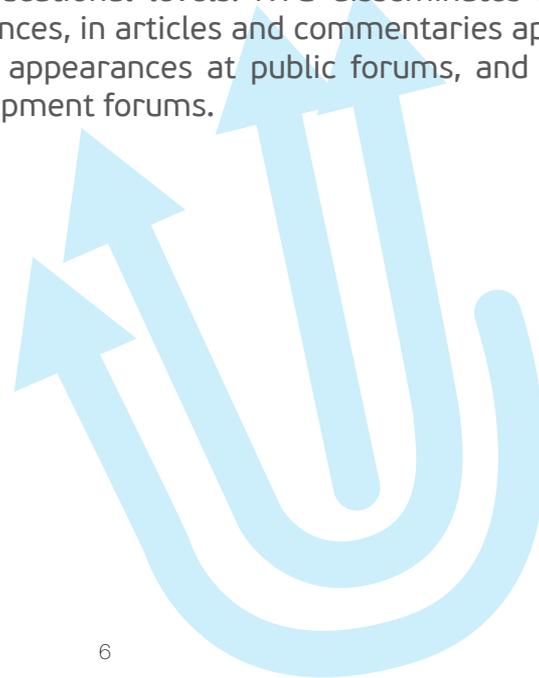
NTU's Sustainable Earth Peak will be defined by its ability to identify, assess, and innovate solutions to: (1) key threats to the basic needs and mega-issues required for sustainable human life; and (2) the drivers of survival and prosperity most sensitive to these threats. The key elements are water and food, energy supply and management, land use and its management, human health, resilience against catastrophes, and the security of both resources and individuals. And as such, the need for a truly multidisciplinary approach becomes evident, as these challenges involve, equally, questions of technology and engineering, governance and institutions, property rights and incentives, and social investments in education and infrastructure.



Mission of the NTU Sustainable Earth Peak

NTU and the university's Sustainable Earth initiative are well-situated to develop recommendations for best practices in policy development, regulatory practices, the assessment of economic fundamental needs, and all in the context of involving society's major stakeholders. NTU is able to do this by drawing on the depth and breadth of its many academic and intellectual resources to develop technologically, financially, and institutionally sound solutions. In fact, NTU always strives for thought leadership and has been equally successful at theory building, conceptualisation, and developing applied and practical sustainability solutions.

NTU regularly partners with other institutions and organisations, from academia, government, and the private sector, in efforts to innovate technological solutions and improve knowledge-based policy development processes. NTU is actively involved in education, and in developing new sustainability curricula at all educational levels. NTU disseminates its work through publication in leading journals, at conferences, in articles and commentaries appearing in widely-read newspapers, through high-impact appearances at public forums, and through many executive education and professional development forums.



Uniqueness of NTU in the Sustainability Field

NTU already has, in its various departments and divisions, an exceptional and uncommon amount of talent and expertise in two of the most important areas necessary to do outstanding work in the sustainability field, namely: (1) solution-oriented science and engineering; and (2) socio-economics and business.

For example, NTU is a world leader in clean-tech research. Its centres of excellence, namely EOS (Earth Observatory Singapore) and SCELSE (Singapore Centre on Environmental Life Sciences Engineering), are two national flagships of environmental research in Singapore that greatly support all of the university's sustainability efforts. Along the same lines, NTU is building up a Medical School, which will deal with many of the needs of a modern society in developed and developing countries. The social sciences and humanities, together with a highly successful business school, are developing new concepts and frameworks for future sustainable societies. This combination of science, medical science, engineering, business, social science, and humanities is already rather exceptional, and only rarely found worldwide.

Singapore also provides a unique example of the transboundary necessities of truly sustainable strategies. As a densely populated city state, Singapore depends heavily upon its neighbours for key resources, is vulnerable to environmental decline in surrounding areas and is inextricably tied to the political, economic and security dynamics that define the Southeast Asian region. In the context of sustainability, this means that Singapore cannot operate in a vacuum, but must rather work collaboratively to assess areas of ecological stress in the region, improve sustainable practices along its supply, import and export chains, and promote environmentally responsible practices in neighbouring countries. The S. Rajaratnam School of International Studies (RSIS) brings particular expertise to bear on these issues, and is well-placed to add to NTU's goal of driving sustainability in Singapore.



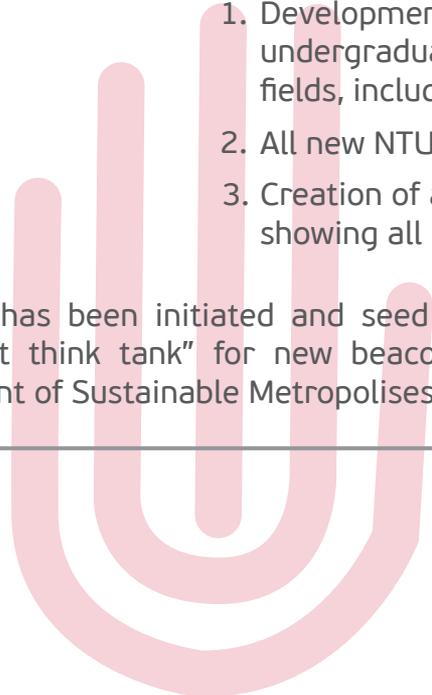
The additional presence of NIE (National Institute of Education) at NTU gives the university a truly unique position in the world for sustainability research and practice. NIE's mission and purpose is to educate all public school teachers in Singapore. This allows NTU the opportunity to develop a sustainability curriculum that begins at early ages, and that lays a solid foundation for the nation's more advanced educational and degree programmes. As a result, NTU will be at the forefront of educating a broadly-based and highly-informed population with all the necessary tools, knowledge, and desire to become world sustainability leaders.

First Campus-Wide Initiatives

In a workshop with representatives of all NTU faculties, three landmark sustainability projects were launched:

1. Development of first-year sustainability courses for all undergraduates with largely common elements for all study fields, including NIE
2. All new NTU buildings are sustainability icons
3. Creation of an accessible interactive Virtual Reality Campus showing all relevant sustainability metrics in real time

A process has been initiated and seed money set aside for creating a campus-wide "permanent think tank" for new beacons in sustainability, primarily focused on the development of Sustainable Metropolises.



Thriving Sustainability: NTU's Schools, Institutes and Centres at Work



Nanyang Environment and Water Research Institute (NEWRI)

Launched in March 2008, NEWRI represents NTU's efforts over the last two decades of being a committed and active participant in Singapore's Environmental and Water Technology (EWT) R&D landscape. Operating with 8 co-ordinated units and some 400 researchers, NEWRI provides a coherent platform for multi- and trans-disciplinary interactions and a contiguous value chain involving research, translation, development and application. This approach better ensures development of innovative and practical environmental solutions relevant to industry and community.



Singapore Centre on Environmental Life Sciences Engineering (SCELSE)

The Singapore Centre on Environmental Life Sciences Engineering (SCELSE) is focused on translating the understanding of microbial biology and ecology into life sciences based technologies for sustainable urban and natural environments.

Exploring, harnessing and controlling microbial biofilms require the use of molecular life science tools in novel environmental engineering technologies and the grooming of new generations of experts to provide sustainable solutions for environmental quality. Engineering of microbial biofilms for efficient bioremediation of pollutants, reuse of water and preventing pathogenic biofilms are but a few of the SCELSE targets.



Earth Observatory of Singapore (EOS)

In 2010, EOS built the foundations of a major branch of its organisation, the Sustainability Directorate, headed by the former business executive from Monitor Group, Andreas Schaffer. The mandate of the group is to integrate climate science into decision making and thus make EOS relevant to senior decision makers in business and policy. For example, the Sustainability Directorate is planning to host a new initiative of Corporate Leaders on Climate Change in Southeast Asia. In addition, the group is conducting economics and policy research to address issues relevant to stakeholders.





S. Rajaratnam School of International Studies (RSIS)

The S. Rajaratnam School of International Studies (RSIS) is an academic institution and policy-oriented think tank within NTU that is dedicated to analysing the multifaceted characteristics of contemporary international affairs. The RSIS Centre for Non-Traditional Security Studies pursues this objective by, among other things, exploring the importance of environmental trends and policies to the progress of countries and communities throughout the Asia Pacific region. The Centre regularly carries out detailed field work projects to this end, consults regularly with government and non-governmental stakeholders and has extensive publication and outreach agendas.



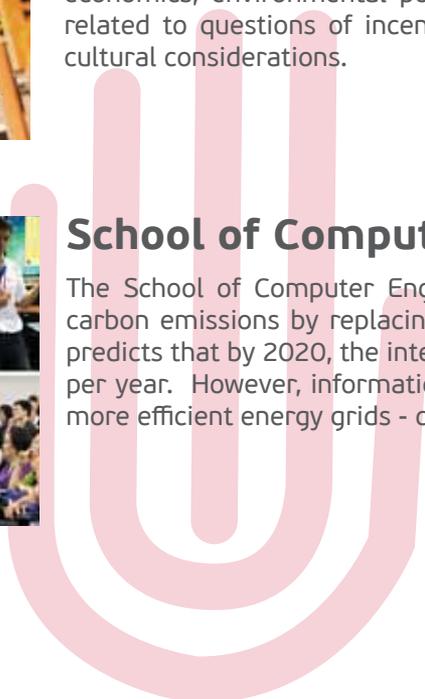
School of Humanities and Social Sciences (HSS)

The School of Humanities and Social Sciences (HSS) at NTU is actively involved in a wide variety of multi-disciplinary environmental and sustainability research projects. Our School is committed to playing an important part in NTU's Sustainable Earth Peak initiative, in areas such as energy economics, environmental policy, and complexity studies, and including expertise and analysis related to questions of incentives, governance, and a whole host of behavioral, linguistic, and cultural considerations.



School of Computer Engineering

The School of Computer Engineering applies computer and information technology to reduce carbon emissions by replacing carbon-intensive activities with virtual tools. The Climate Group predicts that by 2020, the internet's footprint will have tripled to 1.43bn tonnes of carbon emitted per year. However, information technology - such as smart logistics, energy-aware buildings and more efficient energy grids - could reduce emissions by 15% overall.





School of Electrical and Electronic Engineering

The School of Electrical and Electronic Engineering's main research thrust in sustainability is in improving the technologies and standards of intelligent electrical power distribution for eventual deployment throughout Singapore. This includes advanced smart energy meters, building power management systems and home automation networks which are being test-bedded in the NTU Yunnan Campus. Besides reducing energy losses, the intelligent power distribution allows easy connectivity to renewable energy sources and energy storage systems.



National Institute of Education (NIE)

The National Institute of Education (NIE) is the national teacher training institute in Singapore. The Singapore education system has been referred to as being one of the most successful educational systems in the world. This is, in part, due to the sound educational policies and research in the shaping of curriculum and management practices for schools.



The Energy Research Institute at NTU (ERI@N)

The Energy Research Institute at NTU (ERI@N) is an umbrella research institute that works on clean energy (wind, solar, fuel cells, electromobility, and energy storage) and energy efficiency (green buildings, and green ships/ports).

ERI@N has a number of applied and fundamental research projects in the above areas that actively seek industry participation in collaboration with top researchers at NTU and around the world.





Centre for Excellence in Learning and Teaching (CELT)

CELT supports the University's Sustainable Earth initiatives as part of the Five Peaks of Excellent by assuring and advancing the quality of educational development, instructional and media support services, and to serve the common good by sharing and deploying appropriate technologies on blended education and learning models to significantly enhance student learning and professional teaching.



Nanyang Business School (NBS)

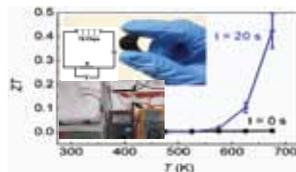
The Nanyang Business School has a multi-pronged strategy to incorporate sustainability into all its activities. Specialised courses on sustainability such as Sustainable Business Operations, Corporate Social Responsibility, Green Trading & Emissions Trading, Sustainable Enterprises etc. have been introduced at undergraduate, MBA as well as EMBA levels. The School has also introduced a specialised EMBA track on energy management.



School of Materials Science & Engineering

Shown here is a water splitting experiment by iron oxide-coated conducting substrate (e.g. FTO=Fluoride-doped-tin oxide) illuminated by a solar simulator / platinum mesh/reference electrode (far end, blocked, not clear)

Also shown are thermoelectric materials capable to convert waste heat back to electricity. We used plasma treated carbon nanotubes (20 second) to make thermoelectric (TE) chips. These TE chips are highly flexible, chemically stable and cheaper than conventional TE modulus. With a temperature gradient of ~ 75 K, it can generate a power of ~ 0.2 W.





School of Mechanical & Aerospace Engineering

The School of Mechanical and Aerospace Engineering embarks on initiatives that promote sustainability technologies such as the establishment of SIMTech-NTU joint research labs for remanufacturing and the development of solar cars. The SIMTech-NTU joint research labs aim to come up with innovative manufacturing and industrial processes that are sustainable, efficient and cost-effective – factors which are crucial to the industry of today, which includes remanufacturing.



School of Chemical and Biomedical Engineering

Architectural engineering of nanocomposites for sustainable energy harvesting: Dr Timothy Tan's research group takes on the challenge of tailoring nanostructures and functions of hybrid nanomaterials for high performance solar energy harvesting applications.



Nanyang Centre of Public Administration (NCPA)

The Lien Challenge was launched in 2008 with S\$3 million funding from Lien Foundation as part of NTU's Master of Science in Managerial Economics and Master of Public Administration. The Challenge offers a practice-based learning platform for the high-level Chinese officials who attended the class, to translate innovative ideas into real-life solutions, and apply what they have learnt beyond NTU and Singapore.





The TUM-CREATE Centre for Electromobility

The TUM-CREATE Centre for Electromobility is jointly sponsored by the Technical University of Munich (TUM), NTU, and the National Research Foundation's Campus for Research Excellence & Technological Enterprise (CREATE) programme. The TUM-CREATE Centre for Electromobility will capitalise on TUM and NTU's complementary strengths in research and development as well as their long-standing strong academic collaborations to meet the demand for a new paradigm in urban e-mobility fusing safety and energy efficiency.



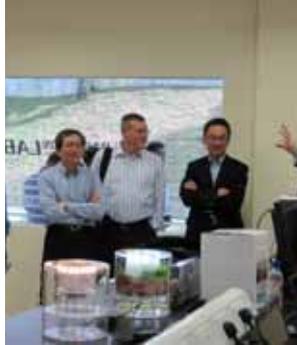
Nanyang Technopreneurship Centre (NTC)

Green Entrepreneurship Symposium and Exhibition

The Centre hosted this meaningful event on 10 August 2011, being part of the University's Entrepreneurship & Innovation Week 2011. The event attracted more than 250 participants.

The topic "The Rise of Green Entrepreneurship" was discussed at the Symposium and the leaders of green businesses, such as Mr. Derek Ong from Olive Ventures and Mr. David Chng of CHWMEG, shared their experiences being in a niche industry and their contribution in having a sustainable earth.





Nanyang Innovation and Enterprise Office (NIEO)

The Nanyang Innovation and Enterprise Office (NIEO) supports NTU's Innovators to commercialise intellectual property created as a result of their research efforts into market-ready products and services.

NIEO aims to develop an innovation and entrepreneurial ecosystem that encourages innovation, foster and cultivate entrepreneurship, and facilitate the commercialisation of research through supporting the RIEC's national research, innovation and enterprise strategies.



Institute of Environmental Science and Engineering Pte Ltd (iESE)

Nanyang Innovation and Enterprise Office (NIEO) serves as an accelerator and incubator for start-ups and spin-offs for many companies providing sustainable solutions. Among them are KVI Pte Ltd developing new battery storage and Third Wave Power Pte Ltd producing portable solar powered battery packs. Its portfolio also includes iESE Pte Ltd which is active in developing solutions for water treatment and recycling, as well as energy from waste and biomass.



Centre for IT Services (CITS)

Centre for IT Services (CITS) has embarked on the 3P-less initiative, i.e. Print less, Paper less, Pay less. We promote staff mobility and productivity by adopting notebook over desktop as the mainstream computing equipment. We encourage online collaboration document repository usage and adoption of managed print service to reduce hardcopy output.



NTU's Infrastructure for Sustainability



NTU Campus

NTU is home to more than 33,000 undergraduate and postgraduate students, as well as thousands of academic faculty and university administrators, on the largest university campus grounds in Singapore. Our lush 200-hectare Yunnan Garden campus holds student accommodations, classrooms, academic and administrative offices, canteens, cafes, and many other facilities including stores for shopping, books, groceries, and computers. The Yunnan campus is well served by the SBS Transit Ltd and Internal Bus Shuttle service.



Cleantech Park and Cleantech One

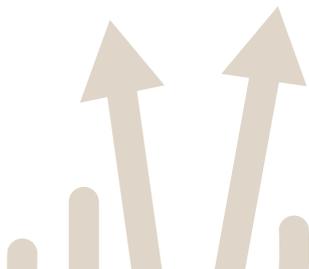
Cleantech Park is located adjacent to NTU, and the university is one of the first tenants for the park's first building project, Cleantech One. JTC launched Cleantech Park to be Singapore's first large-scale and integrated cleantech development to allow firms to test-bed cleantech technologies and products, especially those designed for tropical climates, before they go to market. Cleantech One incorporates cutting-edge sustainability and energy efficiency systems including solar energy systems, rainwater harvesting, sky gardens and other sustainable construction techniques. The successful sustainability solutions developed at Cleantech Park and Cleantech One will then be available for use, replication, commercialisation, and economic growth in Singapore and throughout Southeast Asia.



Office of Development & Facilities Management (ODFM)

Office of Development & Facilities Management (ODPM) oversees all new development, operation and maintenance of the University's facilities and grounds. Our vision is to create a green & sustainable environment, conducive for life-long learning, creativity and entrepreneurship. Our School of Art, Design and Media was awarded Green Mark Platinum, the highest Green Building Award, by Building & Construction Authority of Singapore in 2011.







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