Energy Research Institute @ NTU (“ERI@N”) - Overview

Energy Smart, Research Innovation.

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Overview

- NTU/ ERI@N Organisation Structure
- ERI@N groups and research activities
- Flagship projects: EcoCampus and REIDS
- Laboratories and facilities
- Partnerships and collaborations
**NTU Structure**

### Colleges (Departments)

- **Engineering**
  - Chem / Biomedical, Civil / Env, Computer Sc, Electrical / Electronic, Mech & Aero, Materials Science

- **Nanyang Business School**

- **Science**
  - Biological Sc, Physics / Chem, Maths, Asian School of Environment

- **Medicine**
  - with Imperial College London

- **Humanities, Arts, & Social Sc**

- **National Institute of Education**
  - Primary / Secondary Teachers’ training

### Research Institutes

- **Energy (ERI@N)**
- **Water (NEWRI)**
- **Media (IMI)**
- **Healthcare (NIHTM)**
- **Consumer Insight (ACI)**
- ...

### Objectives of Research Institutes:

- Multi-disciplinary
- Pan-University
- Industry relevant
**ERI@N Structure**

- **ERI@N**
  - Energy Smart, Research Innovation.
  - Flagships: EcoCampus & REIDS
  - Materials, Sim. & Modeling, Electrical Power/Control, Reliability
  - Colleges of Sciences, Engineering, Humanities, Arts, & Business

- **Industry Partnerships & Spin-off**
  - TRL 4-7

- **Technology Groups**
  - Translational RD&D
  - TRL 3-6
  - 190 Researchers

- **Basic Research Technology Pipeline**
  - 130 PhD/MS Students
Sustainable Building Technologies & Comfort

FOCUS

- Building, energy - modeling & simulation
- Building management information system
- Energy efficient ACMV and smart lighting
- Building envelopes, facades

PROJECTS & ACTIVITIES

- Scientific design / planning - high-performance buildings
- Radiant cooling, dehumidification
- Demand based control, plant optimization
- Thermal, visual comfort

COLLABORATE

- Advanced building energy modeling and simulation
- New materials for envelopes and facades
- User behavior analytics
- Wireless sensor network and IOT
Energy Storage and Fuel Cells

FOCUS
- Materials for high performance, low cost and improved durability
- Scale up and Prototyping
- System Integration, Battery and Power Management
- Safety (Built in / Monitoring / Modelling)

PROJECTS & ACTIVITIES
- Li-ion, Na-ion, Vanadium redox flow batteries
- Supercapacitors
- Fuel cell systems and electrolysers
- Nanomaterials for energy storage and conversion
- Hydrogen generation, storage and purification

COLLABORATE
- Design, prototypes development, component sizing & matching, techno-economic studies
- Materials and system scale up
- Grid balancing, storage and integration
- Renewable energies-to-fuel
Wind & Marine, Grid Integration

FOCUS

- **Wind & Tidal turbines**: simulation & design, advanced materials, monitoring, field deployment
- **Grid Integration**: Weak grids, protections, offshore DC power collectors, MVDC/HVDC transmission

PROJECTS & ACTIVITIES

- Wind turbines: aerodynamics, on/offshore & urban turbines, typhoon resistant
- Marine turbines: low flow, modular, hydrodynamics, risk assessment
- Nano/Microgrids – integration of PV, wind/marine turbines, fuel cells

COLLABORATE

- Resource mapping, environmental risk assessment, on/offshore deployment
- Renewables integration, hybrid AC/DC grids, bi-directional converters, transmission
**Solar Energy**

**FOCUS**
- Thin films, CIGS family, perovskite solar cells
- Device Architecture, Fabrication & Characterization
- Solar Fuels - photocatalysis, CO$_2$ to hydrocarbons

**PROJECTS & ACTIVITIES**
- Perovskite materials for solar cells LEDs and lasers
- Integration of energy harvesting & energy storage
- New materials, catalysis, photo-electrochemical cells

**COLLABORATE**
- Next generation materials and devices
- Scale up, demonstration and deployment
- Fischer-Tropsch pilot plant: catalysts, processes
- Grid integration of solar cells
FOCUS

- Communication and connectivity
- Power Electronics
- Hybrid AC-DC grids
- Multi Energy systems & grid integration

PROJECTS & ACTIVITIES

- Harmonization of multi-energy networks and market interactions
- Microgrid energy management systems
- Optimum power flow & control
- High power wireless charging system
- Internet of things (IoT)

COLLABORATE

- Hardware-in-the-loop / real time digital simulation studies
- High efficiency modular converter development
- Smart field microgrid integration
- Big data energy analytics
Autonomous Vehicles & Electro-mobility

FOCUS
- Transport electrification, Grid integration
- Autonomous, Connected transport
- Electric power, Control systems
- Energy storage management, integration

PROJECTS & ACTIVITIES
- EV technology & implementation roadmap
- Flash/Opportunity charging
- First/Last mile for public transport & logistics
- High power/energy density packs
- Self aligning charging mechanism

COLLABORATE
- Platforms for wireless power transfer
- Hybrid energy modular packs for EV and grids
- Grid connectivity simulations
- Power train tests & validation
Maritime Clean Energy

FOCUS

- Emission Management
- Smart Power Management for Hybrid & Full Electric System
- Green Technologies for Ports
- Ship & Port Energy Management

PROJECTS & ACTIVITIES

- Scrubber, catalytic reduction technologies
- Waste energy recovery
- Electrification, shore-power, distributed generation / storage
- Anti-fouling technologies

COLLABORATE

- Exhaust gas cleaning system
- Hybrid & electric propulsion
- Shipboard energy storage & management
- Alternative, clean energy / fuel
- Total cost of ownership analysis
Flagship Project
EcoCampus

High Impact Energy Efficiency and Sustainability
Accentuating Innovation and Green Growth

1. ENERGY INFORMATION MANAGEMENT SYSTEM:
   - Data Acquisition
   - Communication Network
   - Data Management
   - Data Analytics
   - Data Visualization

2. BUILDING ENVELOPES & FACADE SYSTEMS:
   - reduced thermal conductivity of construction material

3. ADVANCED ACMV SYSTEMS:
   - Demand Based Controls
   - Cooling Plant Optimization
   - Data Centre Optimization
   - Radiant Cooling Technologies

4. ADVANCED LIGHTING TECHNOLOGIES

5. ALTERNATIVE LOW CARBON TRANSPORT:
   - wireless battery charging
   - electric bus fleet
   - super capacitor for charging EV Bus

6. WASTE & WATER REDUCTION, REUSE & RECYCLING:
   - solid organic and liquid waste treatment plant

7. DISTRIBUTED ENERGY GENERATION & SMART GRID:
   *VFB-EES shows the greatest potential for large scale storage application

8. RENEWABLE ENERGY:
   - 5MWp PV installation
   - solar thermal PVT

9. BUSINESS MODELS & INCENTIVISING ADOPTION, USER BEHAVIOUR:
   - interactive solutions to drive energy, water, waste reductions

*Including projects under discussion*
Flagship Project

* Renewable Energy Integration Demonstrator – Singapore (REIDS)

RD&D at a large-scale - proper integration of a broad range of renewable energy production - onshore and offshore, energy storage and rational energy end-use technologies
**LABORATORIES**
3,900 sqm sited @ NTU, JTC

**Research Techno Plaza - NTU**
- **Batteries / Solar Cell** - Printing, Deposition, Mats / Elec Characterization, electrochem testing (LiB, Supercap, CIGS, DSSC, OPV)
- **Smart Energy Systems** - Micro-grid simulator, Fuel cell grid interface system, Roof-top solar PV system and wind turbine, Flywheel energy storage and Battery energy storage
- **Fuel Cells** – Materials Processing, Catalysis, Electrochemical / Materials Characterization, Feedstock conditioning
- **High Performance Computing Lab** - (dx360 M2 x 2400 cores, 2GB / core, 24TFlops)

**Clean Tech One - JTC**
- **Air Conditioning** - Solar Thermal / Liquid Dessicant Air Conditioning (Regenerator, Evaporative cooler, Liquid Desiccant energy storage & recovery), Radiant Cooling test lab
- **Energy Systems** - Drive Train lab (motor genset, converter, 100 kW), Wind / Water tunnel testing, Tribology
- **Prototyping Labs** - Fuel Cells (1-5 kW PEMFC stacks)/Batteries (1-5 Ah laminated sheet batteries; 1-5 kW flow batteries), control / management systems, Wet Chemistry (materials scale up), Dry Labs (Smart Sensors / Energy harvesting)
University, RD&D Partnerships

Joint PhD Programs

- International Center for Energy Research, Renewables / Grid Interactions; Electromobility (75 staff, 45 joint PhD students)
- Energy Materials (Battery, Solar Cells), Systems (5 staff, 10 joint PhD students)
- Nanomaterials, Energy (12 staff, 10 joint PhD students)

Strategic Partnerships

- Petro Chem Process Efficiency (10 staff, 14 PhD students)
- Sustainable Buildings. Solar (15 staff, 25 PhD students)
- Solar, Solar Fuels (5 staff, 10 PhD students)
- Sustainable Bldgs, Renewables, Integration
- Renewables, Energy Systems
Industry, Strategic Partnerships

Joint Labs in NTU (current, past)

- **Rolls-Royce**
  - Elec Power, CE, Mfg (75 staff, 40 students)
- **BMW**
  - Future Mobility (8 staff, 13 students)
- **Johnson Matthey**
  - Materials - Energy, Env (12 staff, students)
- **Vestas**
  - Elec Drives, Composites, Tribology (6 staff, students)
- **BOSCH**
  - PV, Storage, *Power Electr*
- **IBM**
  - Energy Analytics, Optimiz.
- **Gamesa**
  - Turbines - Coatings / Matls

Partnerships with S’pore RD&D Groups

- **JTC**
  - Smart Buildings
- **Lloyd’s Register**
  - *Marine Renewables, Power Systems*
- **DNV·GL**
  - Grids, Renewables
- **DLR E**
  - Energy Efficiency, Renewables

New Partnerships

- **Diamond Energy**
- **Engie**
- **SONY**
- **ClassNK**
- **muRata**
- **Schneider Electric**
- **ABB**
Rolls-Royce@NTU Corporate Lab

- Corporate lab supported by funding from NRF, RR, NTU: 75 Research Staff, 40 PhD students

- Research Focus
  - Electrical Power & Control Systems
  - Manufacturing Process Technology & Computational Engineering

Rolls-Royce, NTU launch lab in $75m research tie-up

By KASH CHEONG

Rolls-Royce and Nanyang Technological University yesterday launched a new lab to boost cutting-edge research in the aerospace and maritime industries. Named the Rolls-Royce@NTU Corporate Lab, the $75 million tie-up is a joint five-year investment between the British company, NTU and the National Research Foundation (NRF).

Rolls-Royce declined to reveal how much it is putting in, but said this was its largest investment in a university research facility in Asia. “The cutting-edge R&D at the lab will strengthen the leadership position of Singapore’s aerospace industry,” said Minister of State for Finance and Transport Josephine Teo at yesterday’s launch. This 600 sq m lab is the first under a new CorporateLab@University scheme, announced by NRF yesterday to enhance collaboration between universities and industry. NRF expects to set up more of these labs by 2016.

Housed in NTU, the lab will focus on three research areas – electrical power and control, manufacturing and repair, and computational. Rolls-Royce and NTU start 32 research projects next five years, effective the number of projects ready share. Researchers at building more efficient engines, and state-of-the-art data...
NTU & BMW Collaboration | Future Mobility Research Lab

- **Advanced Battery Materials** – advanced battery concepts beyond lithium batteries, reliability
- **Human Machine Interface** – computational intelligence approaches to in-car behavior, real-time brain state recognition
- **Advanced Mobility Concepts** – routing / mapping / parking constraint prediction algorithms, flexible car usage technology
- **Smart Materials** – shape memory materials, tactile response materials, sensor materials
- **Electromobility** - Charging infrastructure, tropical megacity driving usage analysis
Summary

✓ Excellence in Energy Research:
   Advanced research aimed at improving efficiency of current systems while maximizing synergistic effects of alternative energy sources

✓ Synergy & Innovation:
   Foster a multidisciplinary environment, promote relevant energy solutions and policies

✓ Collaboration & Use-inspired Research:
   Knowledge creation, manpower training, and technology transfer

“...development of sustainable energy solutions will not only help to improve Singapore’s own urban environment but also position us favorably to capture the new economic opportunities that are emerging”

Thank You
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