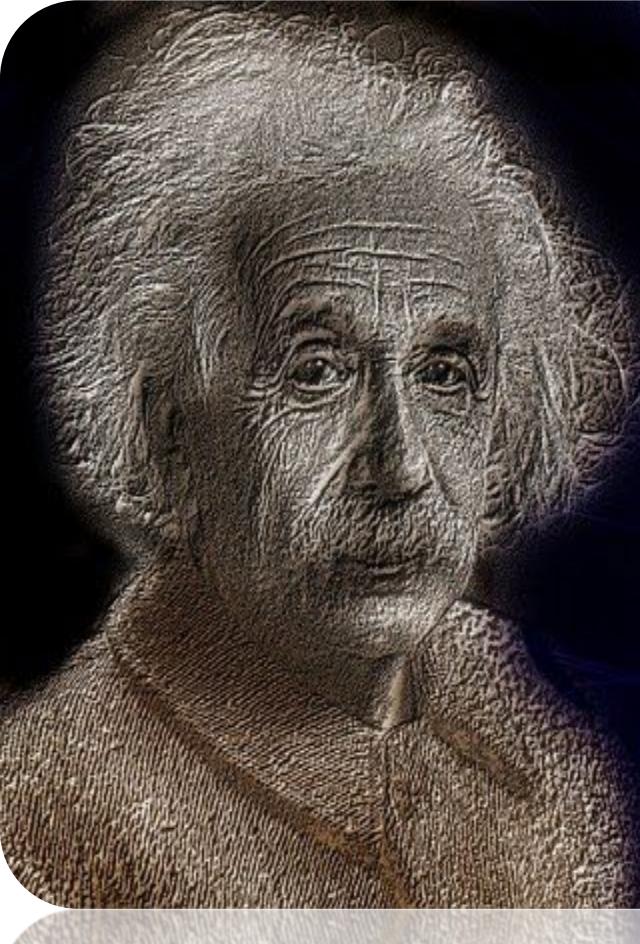


EMA Energy Innovation 2022

George LOH

Senior Director, Strategic Collaboration & Partnership

15 July 2022



Necessity is the mother
of all invention.

~Albert Einstein~

NUS Research Community



Senior Management

Strategic hires | Establish platforms | Support researchers



Research Directors, Deans and Vice-Deans

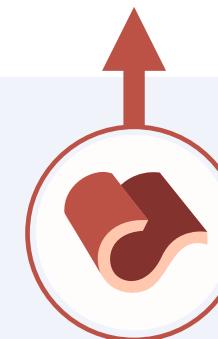
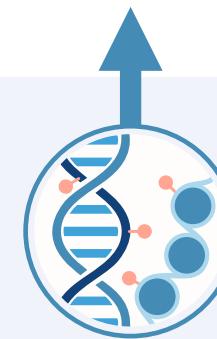
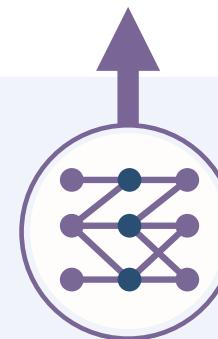
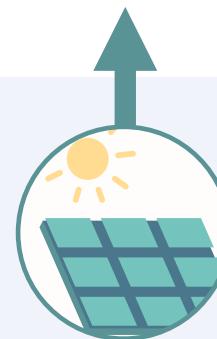


A '**living lab**' for the generation of new knowledge & the development and test-bedding of innovative solutions



4,057
Research Staff

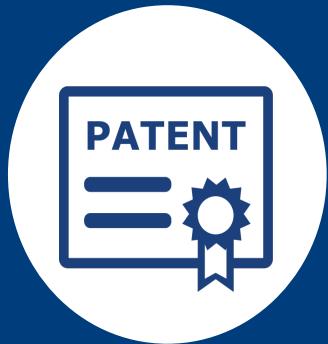
2,563
Faculty



Research Output 2020



Our researchers collaborated with
3537 institutes from
166 countries



764
Patent
applications

167
Patents
granted



439
Invention
disclosures

130
Technology
licences
executed

Smart, Safe and Sustainable (S³) Campus



NUS
University
Campus Infrastructure



Mission Statement

Develop and operate a **Smart, Safe and Sustainable (S³) campus** to energize innovation and enterprise in a learning community

Putting people and humanity first

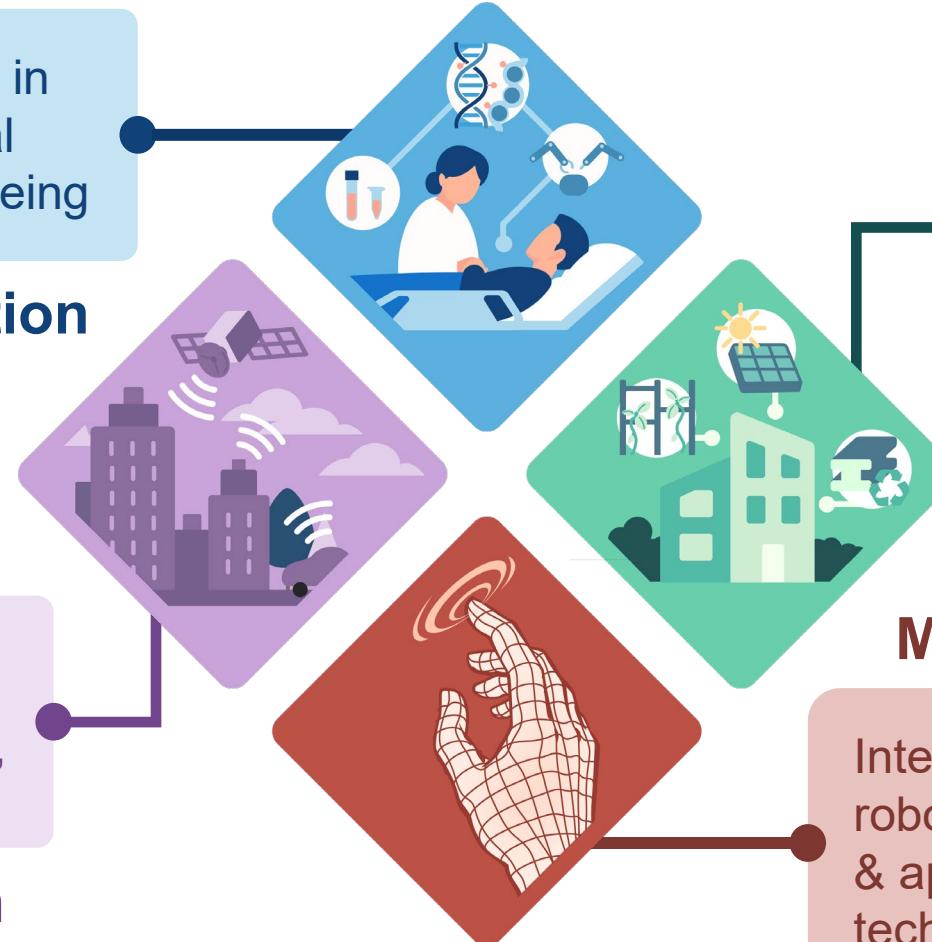
Interdisciplinary Research Areas

Test-bedding innovations in biomedical & translational medicine, wellbeing & ageing

Health Innovation

Leading the way in Singapore's pursuit to become a "Smart Nation"

Smart Nation



Sustainability and Urban Solutions

Seeking new solutions to mitigate the impacts of climate change and enable urban resilience for future generations

Materials Research

Integrating modern tools such as AI and robotics with traditional materials science & applying engineering principles towards technology development and application

Translation of Research through NUS Living Laboratory



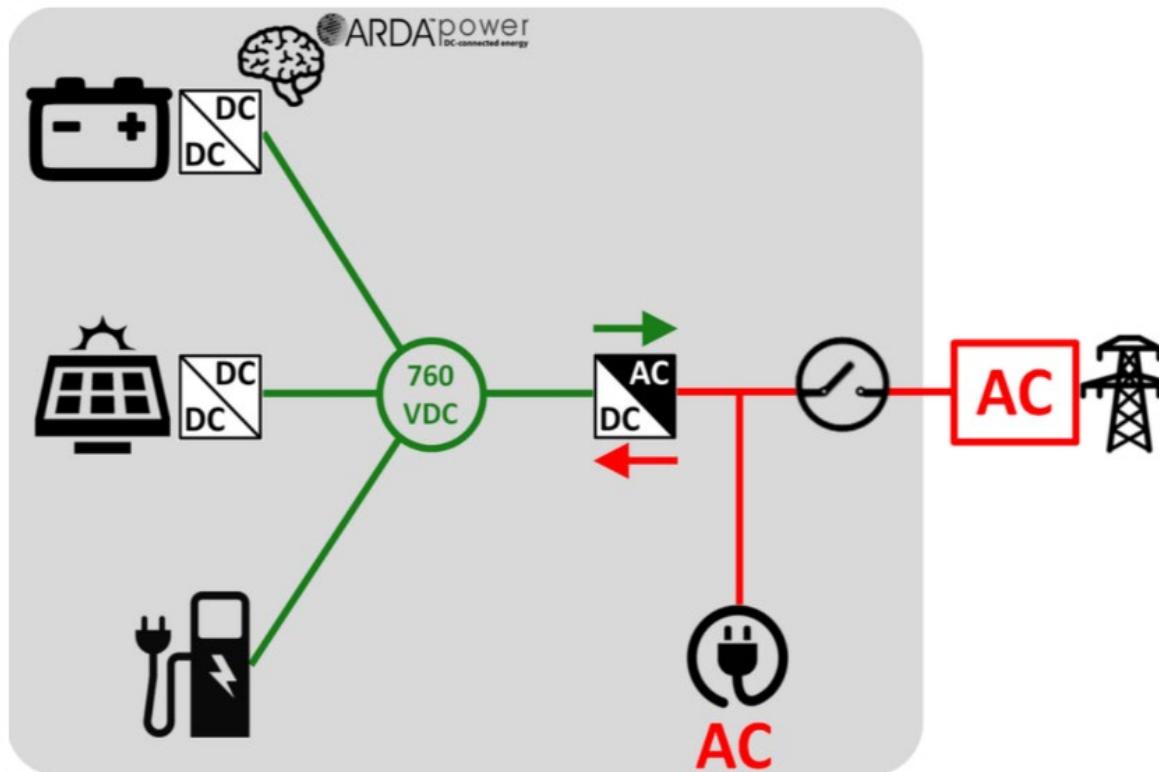
Research Collaboration Framework For NUS as a Living Laboratory

Interdisciplinary research collaboration with Industry



Key Industry Partnerships

Keppel Infrastructure



Hybrid AC/DC micro-grid



District cooling

Key Industry Partnerships



BIODIVERSITY CONSERVATION AND EDUCATION

Singapore's Southern Islands as A Focal Point for Marine Biodiversity Conservation

The Southern Islands

A LIVING LAB

Unprecedented opportunities to

- ✓ Advance marine science
- ✓ Protect Singapore's rich biodiversity and ecologically important habitats
- ✓ Develop sustainable solutions for conservation action



CORAL TRIANGLE BIODIVERSITY CONSERVATION

Conduct joint biodiversity surveys in and around the Southern Islands



MARINE MAMMALS

Explore the role of Dolphin Island in supporting research and education



SPECIES RECOVERY

Restore native marine species and protect Singapore's marine biodiversity



HEALTH & WELLNESS

Understand the benefits of nature experiences to human health and well-being



On-demand driven e-mobility

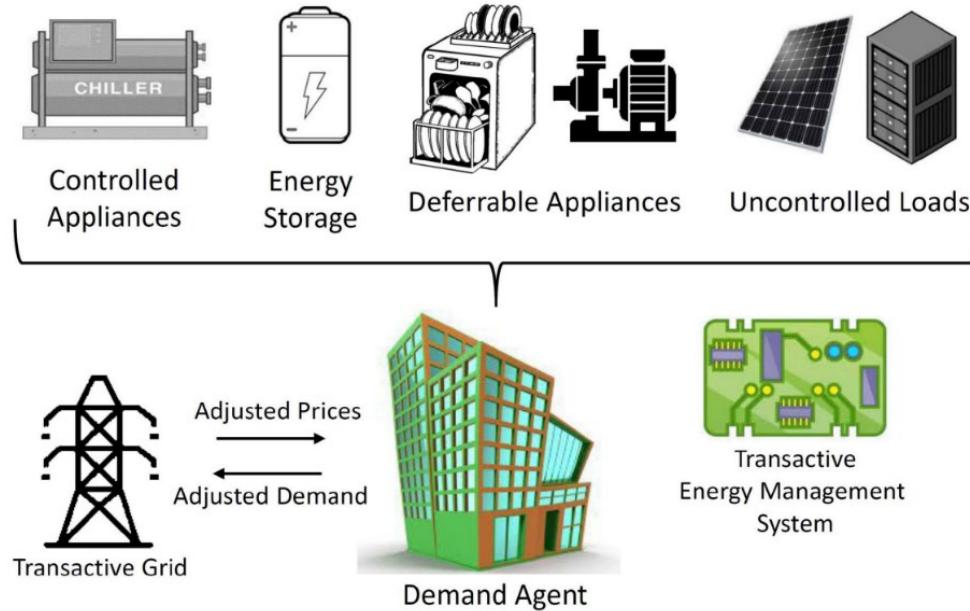


Keppel-NUS Low Carbon Living Lab

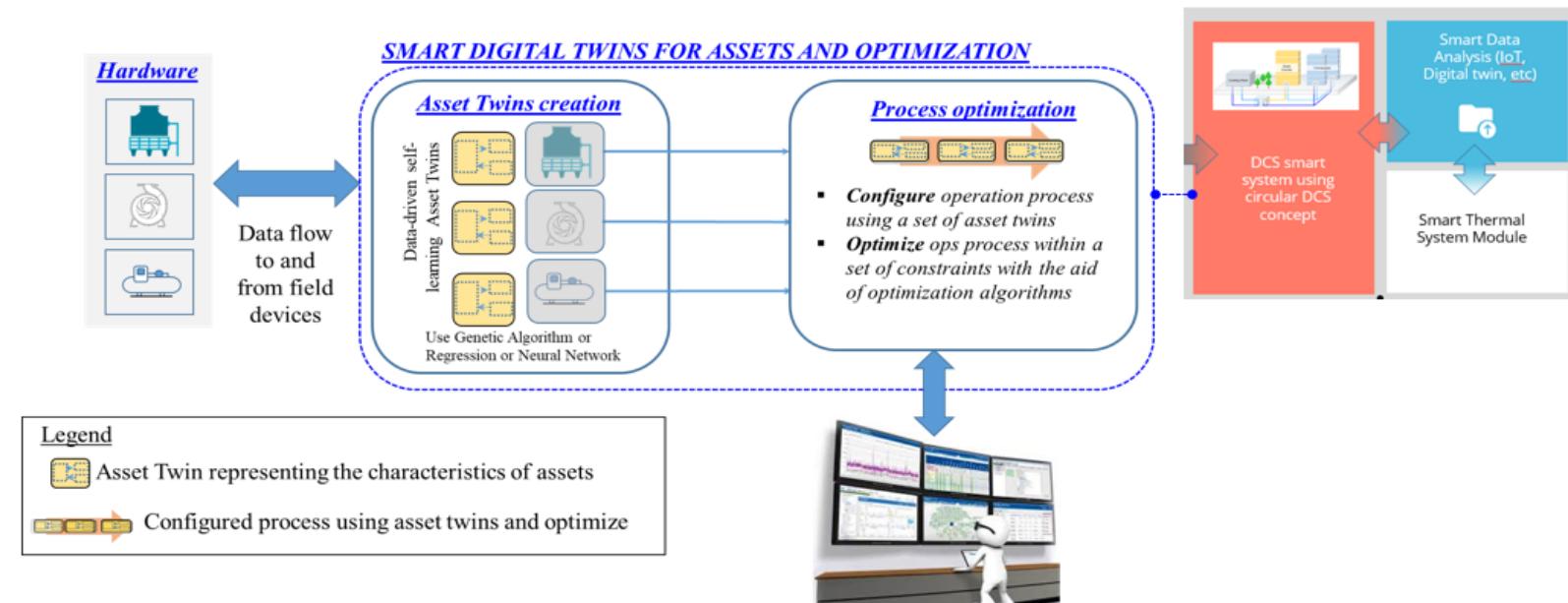
Keppel Infrastructure

Demand side Management

- Deployable solutions of demand response on industrial micro-processors
- Realize energy savings and cost savings through an appropriate incentive/preference structure
- Peer-to-peer energy interactions between *connected communities* (cluster of buildings)



High Efficiency Integrated District Cooling System Solution Part of the Smart Grid



THANK YOU



NANYANG
TECHNOLOGICAL
UNIVERSITY
SINGAPORE

Energy Research Institute @ NTU



Living Labs: Empowering Research Translation

Subodh Mhaisalkar

15 July 2022

<https://erian.ntu.edu.sg/>

Energy Research Institute @ NTU (ERI@N)
1 CleanTech Loop, #06-04 CleanTech One, Singapore 637141
Phone: (65) 6592 1786

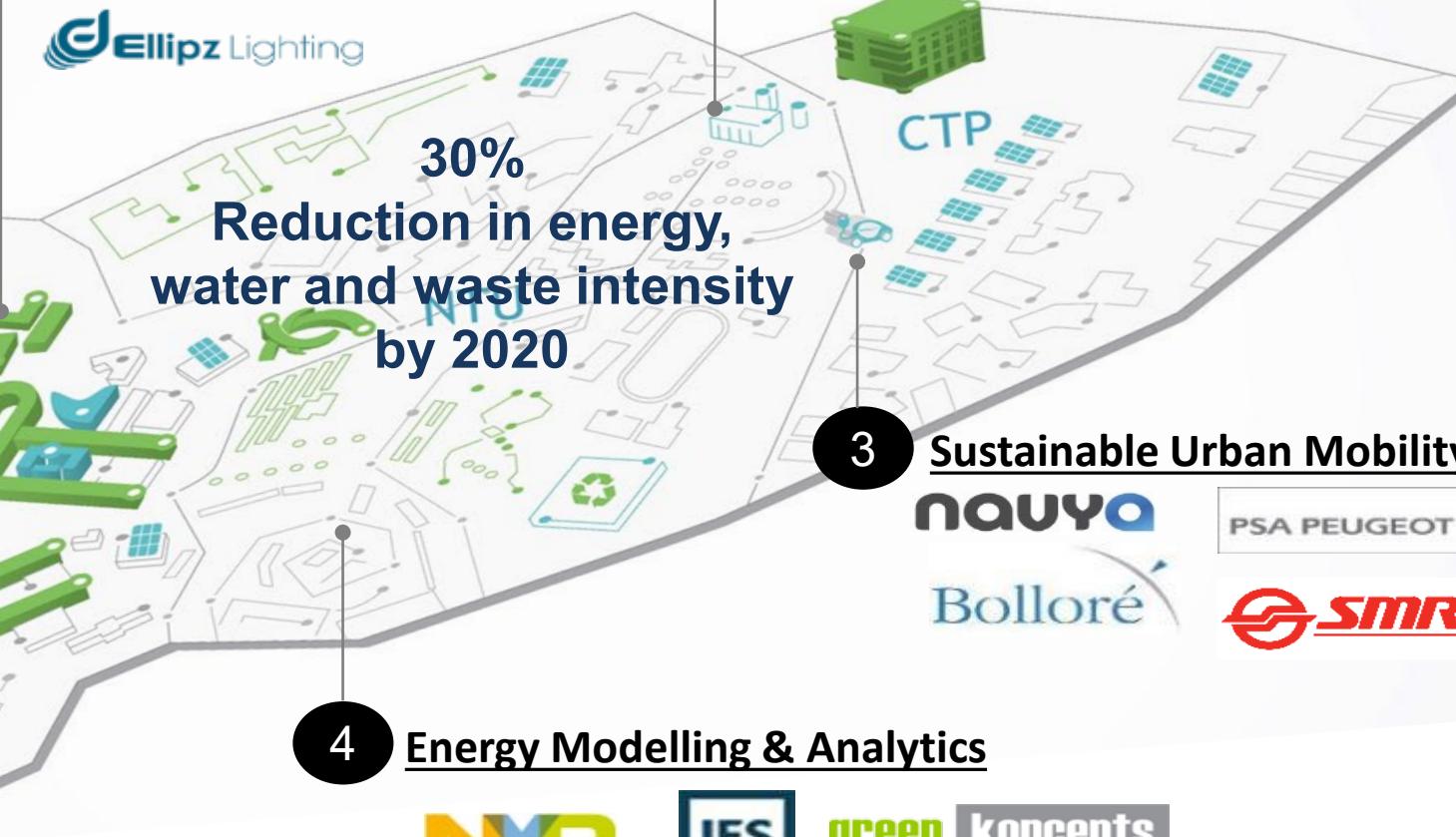
ECO Campus initiative

1 Green Building Systems

Innovative tropical cooling



Envelope, Facades & Lighting



2 RE Integration & Smart Grids



5 User Behavior



EcoLabs: Translator + Accelerator

AIM

- ◆ Accelerate adoption of future energy solutions through corporate partners, SME's, & Start-ups'
- ◆ Attract **Valuable Creative Class** & become the preferred **Clean Tech Innovator's Destination**

Key Goals

Host 12-15 Start-ups/yr, Engage 50+ SMEs/yr

Establish 30+ Test-bed sites across SG

Building dep-tech capability for Energy Transition & Sustainability

E-Mobility EV/AVs

Energy Storage

Wireless / Smart Charging

Unmanned Aerial System

Mobility Services

Data Security / Block Chain

Smart City, Big Data IoT, AI



SCOOTEE

amperics

TFI TRANSFERFI

ALT AEROLION TECHNOLOGIES

Zipster

T-RECs.ai

KYIKOO

A-Fahren

Anzene

RESYNC

AIQuon

RUSHOWL

PYLON CITY

TEALE

Sponsor
Enterprise Singapore

Core Partner
SEAS
Sustainable Energy Association of Singapore

Supporting Partners
MISTLETOE
jtc
IncuVest

FROST & SULLIVAN

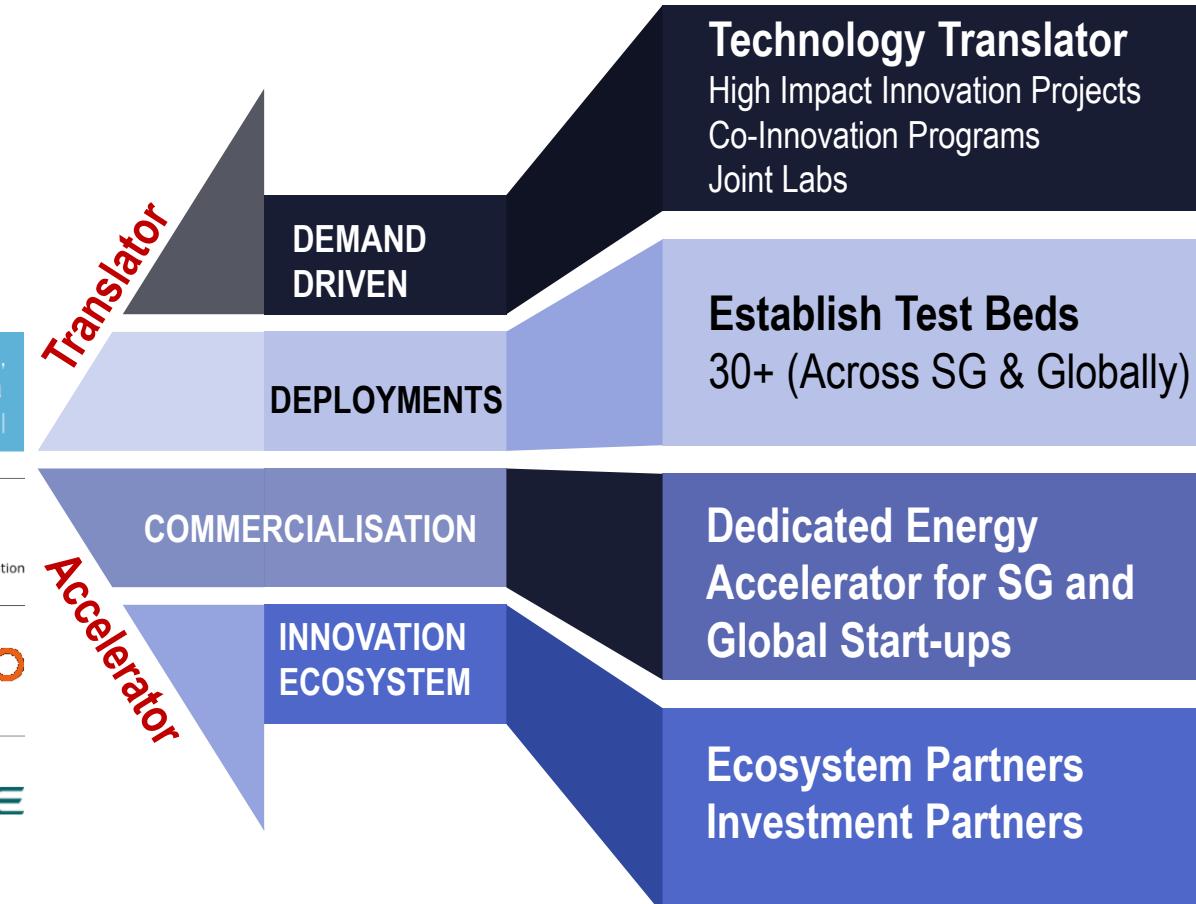
SUPPLY CHAIN ANGELS

LITHAN

SparkLabs Global Ventures

SGINNOVATE

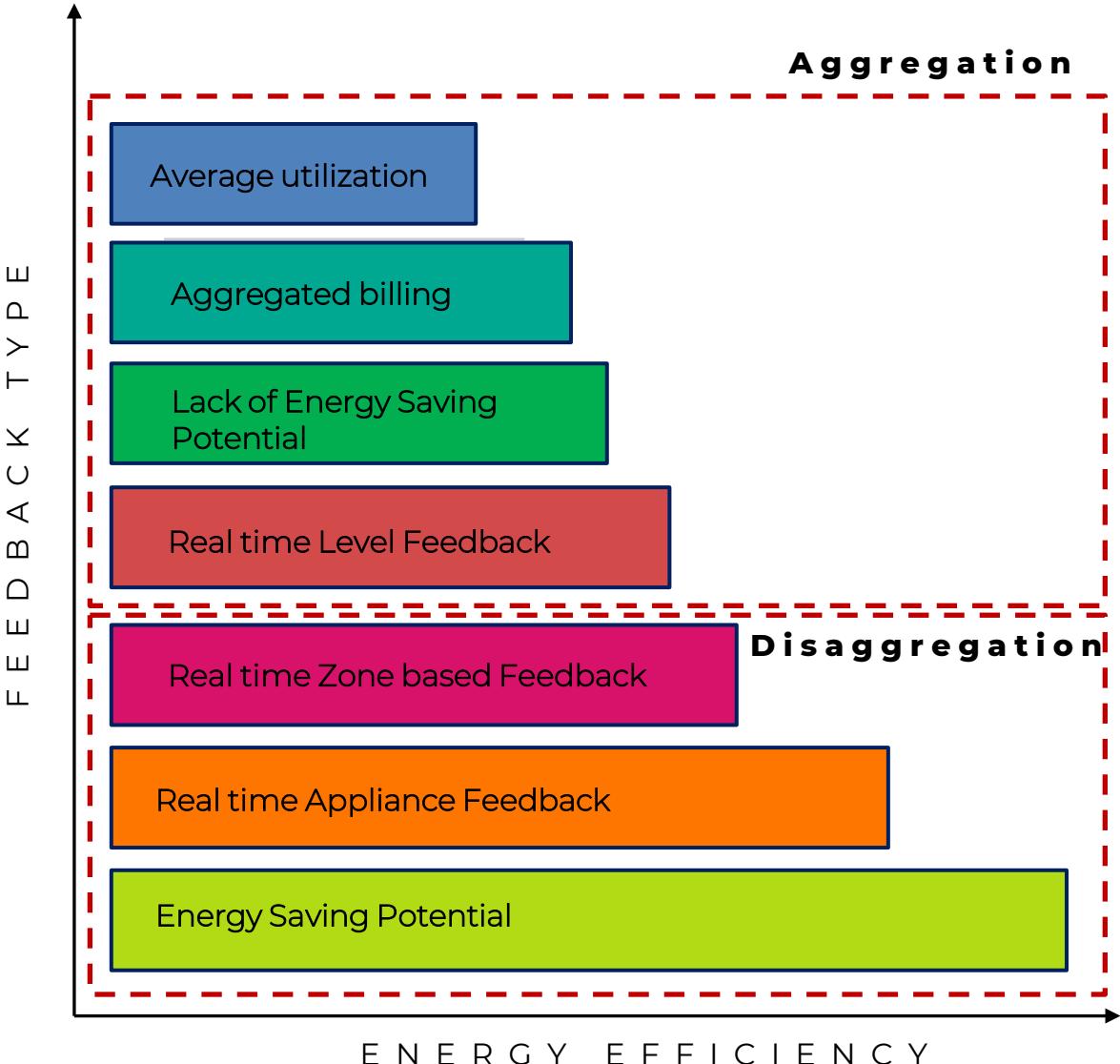
NTUitive
NTUitive Pte Ltd



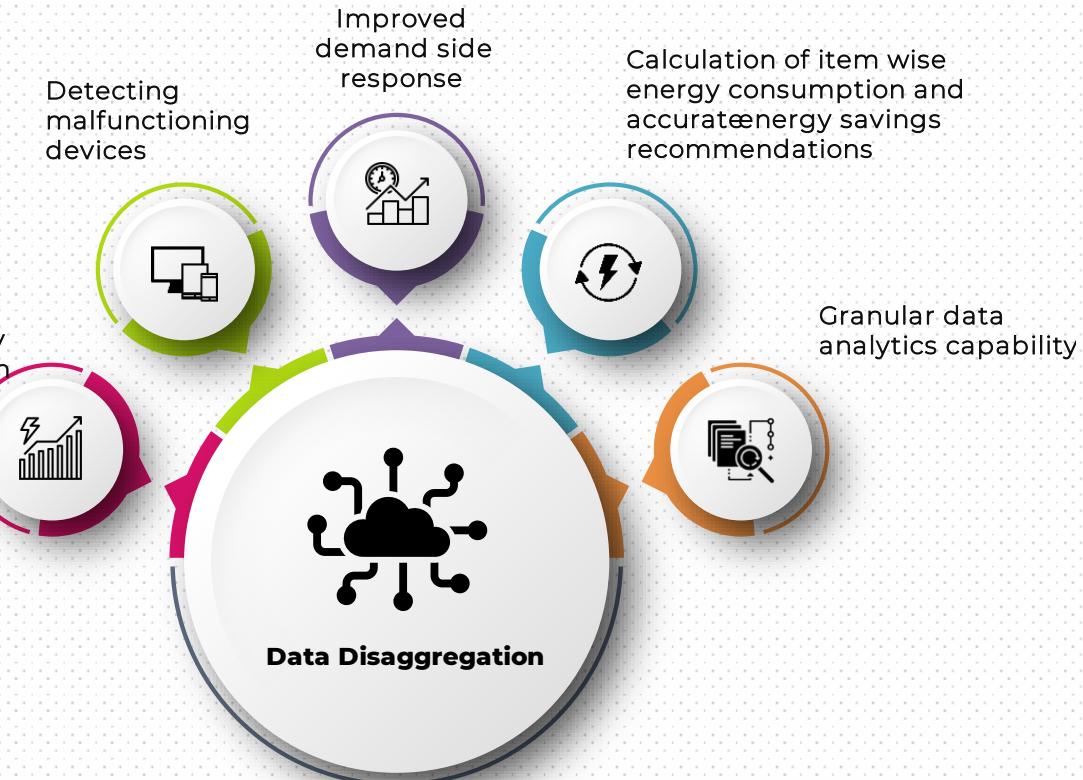


ECOLABS DIGITAL TWIN Living Lab

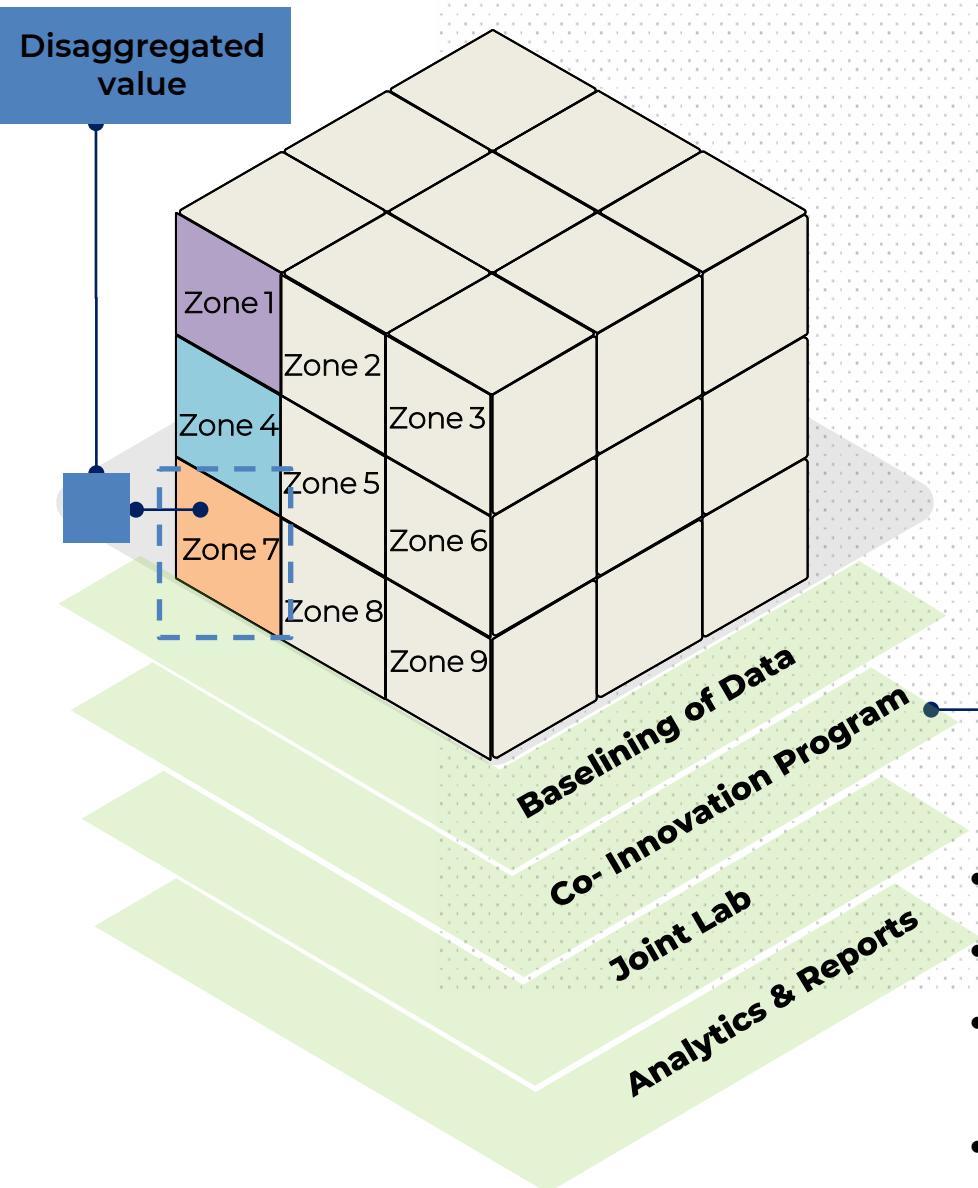
Aggregation Vs Disaggregation To Energy Efficiency



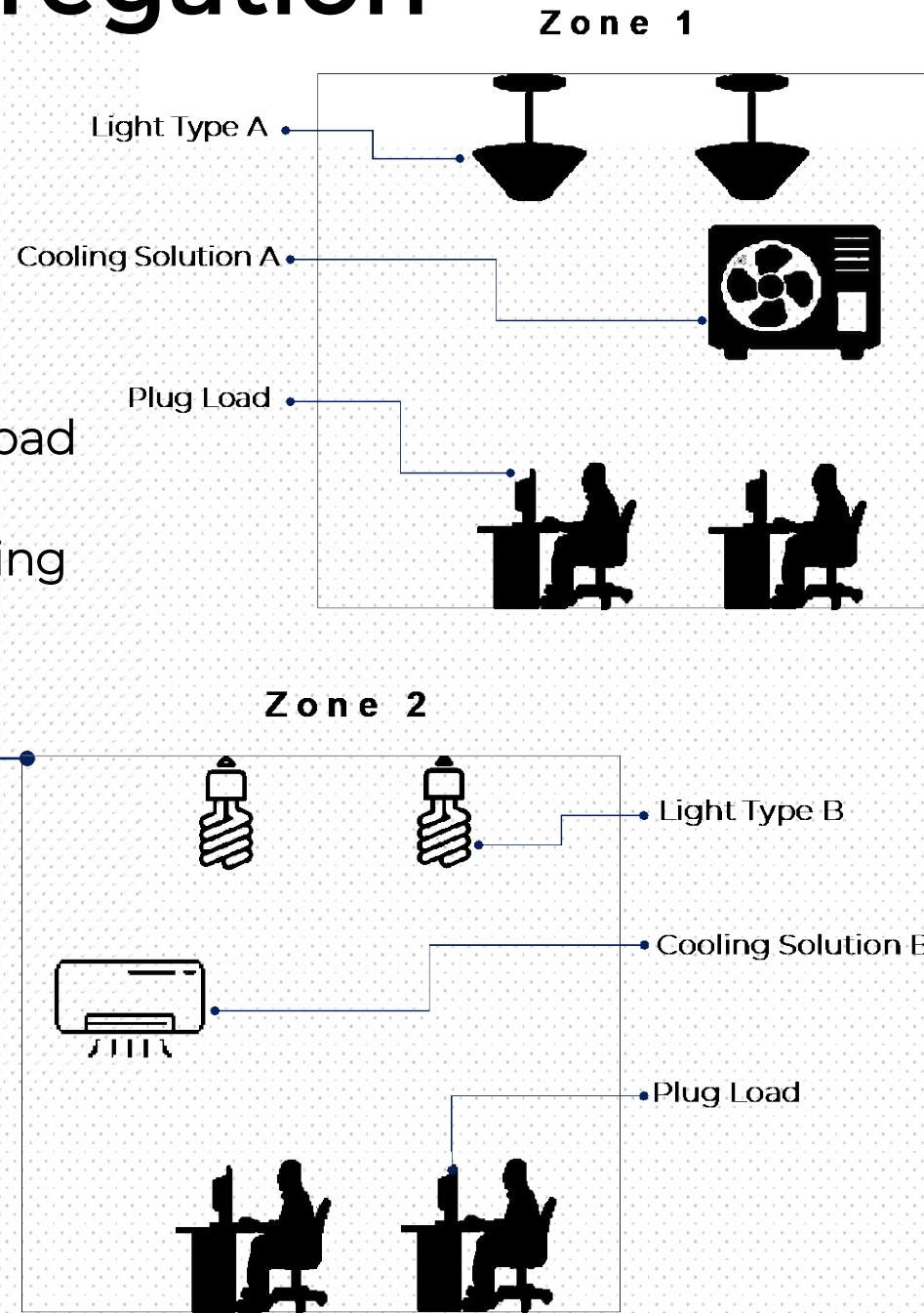
DATA- A Key For Disaggregation



Lowest Order of Disaggregation



- Comparative study of cooling solution A & B
 - Zone wise Plug Load monitoring
 - Plug Load & Lighting Load comparative analysis
 - Realtime Data Monitoring
-
- Benchmarking
 - Baselineing
 - System integration and solutioning
 - Lowest order carbon footprint



Decarbonization projects with local SME/Startups in progress



Energy & Plug load Monitoring

Pylon City, Allocate Space and Ampotech have deployed energy metering and load monitoring at the lab, for detailed and intricate monitoring of all connected devices and appliances of the space.



Novel Cooling Solution- Cooling as a service

G Energy collaborated with EcoLabs COI to deploy innovative cooling solutions using Solar and Thermal VRF systems, which could achieve energy savings of at least 20%.



Load Disaggregation: Non-Intrusive Load Monitoring

NILM estimates the power consumption of individual devices given their aggregate consumption. Resync is implementing its proprietary deep-tech AI enhanced Energy Management and Load Disaggregation solution to optimize energy utilization through energy efficiency.



Call for decarbonization projects with companies



Product Benchmarking

Consumption data collected from the lab, will be validated and used to quantify the energy efficiency rating of energy star appliances and devices, against Singapore current standards for energy efficiency.



Carbon Mapping

Real time consumption data from the lab, will be converted into carbon emissions, which could track individual employee carbon footprint and carbon mapping of individual zones.



Energy Test Data Open Repository

Energy data will be stored, which can serve as an important data repository for commercial buildings in Singapore and the tropics. This will align to Singapore Green Building Masterplan Initiative.



Advanced Microgrid with Battery solutions

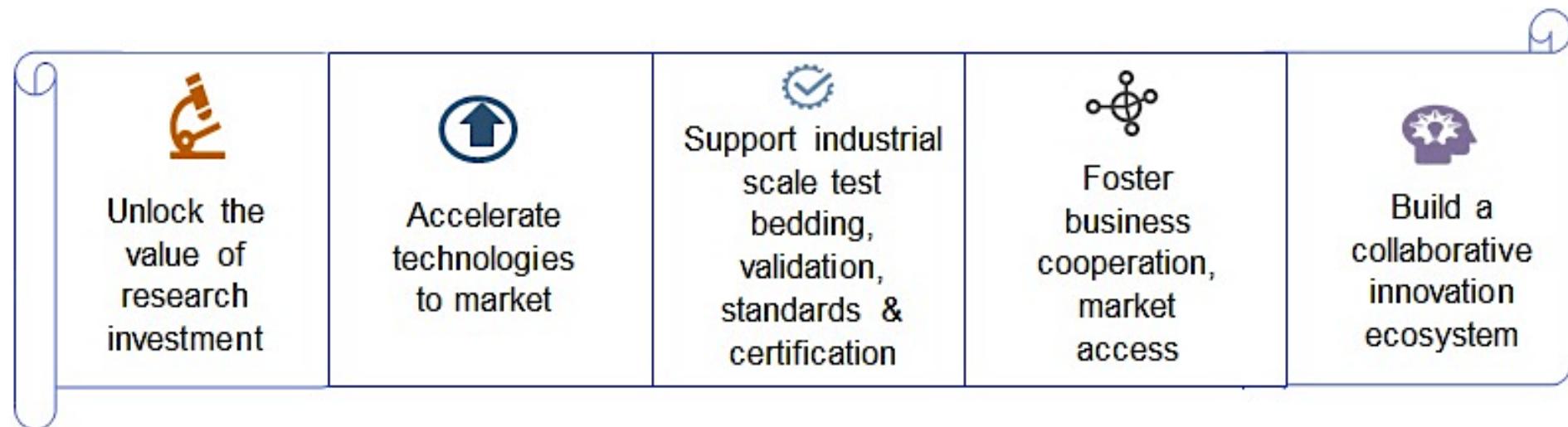
Microgrid solutions could tap on various energy sources, coupled with innovative battery solutions.

Smart Grid & Power Electronics Consortium Singapore

AIM

- To catalyse IP translation and create a networking platform to connect commercial companies and institutes of Higher Learning (IHLs) / Research Institutes (RIs).
- To co-develop commercialisation projects in Smart grid & Power electronics technologies.

Mission



Supported by

NATIONAL
RESEARCH
FOUNDATION
PRIME MINISTER'S OFFICE
SINGAPORE



EDB:
SINGAPORE

Enterprise
Singapore

 Agency for
Science, Technology
and Research
SINGAPORE

SPECS IS AN ECOSYSTEM TO ADOPT RESEARCH INNOVATION.

MEMBERS

LLE



MNC



BOSCH



SME /
Start-up



Associate partners



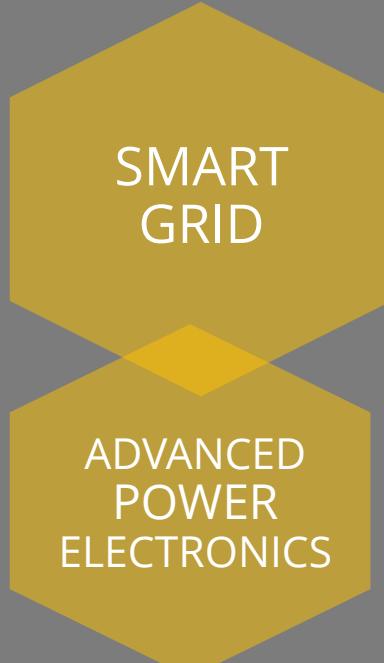
IHLs / RIIs engaged



40+ on-board

CAPSTONE
your TECH iNNOVATION
with a
FORE-RUNNER advantage

in

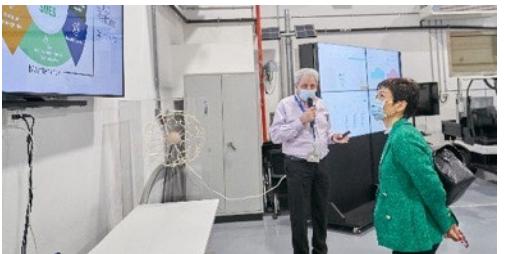
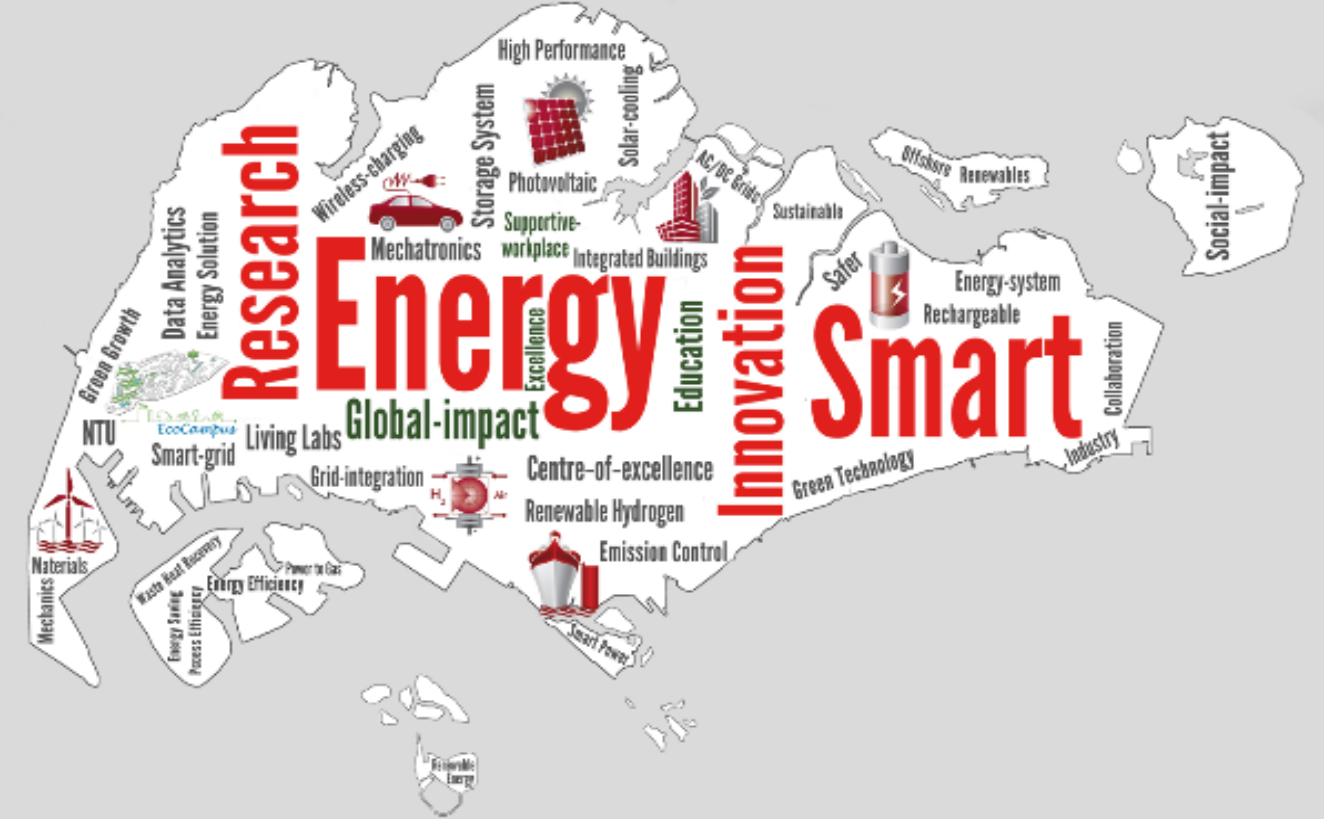


SMART GRID

ADVANCED POWER ELECTRONICS

solutions for
GRID-LEVEL deployments





Thank you!

<https://erian.ntu.edu.sg>

For further information please contact:
Executive-Director ERI@N
Email: D-ERIAN@ntu.edu.sg



Energy Innovation 2022

Workshop 1:
Technology Translation in
Energy Transition

15 July 2022

Keppel Infrastructure

Overview of Keppel Group

Charting Keppel's future as an integrated business providing solutions for sustainable urbanisation

Strengths & Differentiators

- 1 Engineering track record
- 2 Project management
- 3 Efficiency in capital allocation
- 4 Focus on sustainability
- 5 End-to-end business model

Focus Areas

Energy & Environment



Urban Development



Connectivity



Keppel Infrastructure
Keppel Offshore &
Marine

Keppel Land
Keppel Urban Solutions
Sino-Singapore Tianjin
Eco-City

M1
Keppel Data Centres
Keppel Logistics

Asset Management

Keppel Capital
Eco-system of private funds and listed REITs & Trust

Keppel Infrastructure | Leading the development of sustainable infrastructure

- Established in May 2013 from the integration of Keppel Energy and Keppel Integrated Engineering
- Our goal is to improve quality of lives and living environments by delivering innovative and reliable solutions for sustainable infrastructure
- We invest in, develop, own and operate competitive energy and environmental infrastructure solutions and services

Power and Renewables



- Experienced international developer, owner and operator of power plants
- Vertical integrated renewable, power and gas business
 - Gas Retail
 - Renewable & Brown Electricity Retail
- Developer, owner and operator of a network of integrated utilities and sustainable energy solutions

Environment



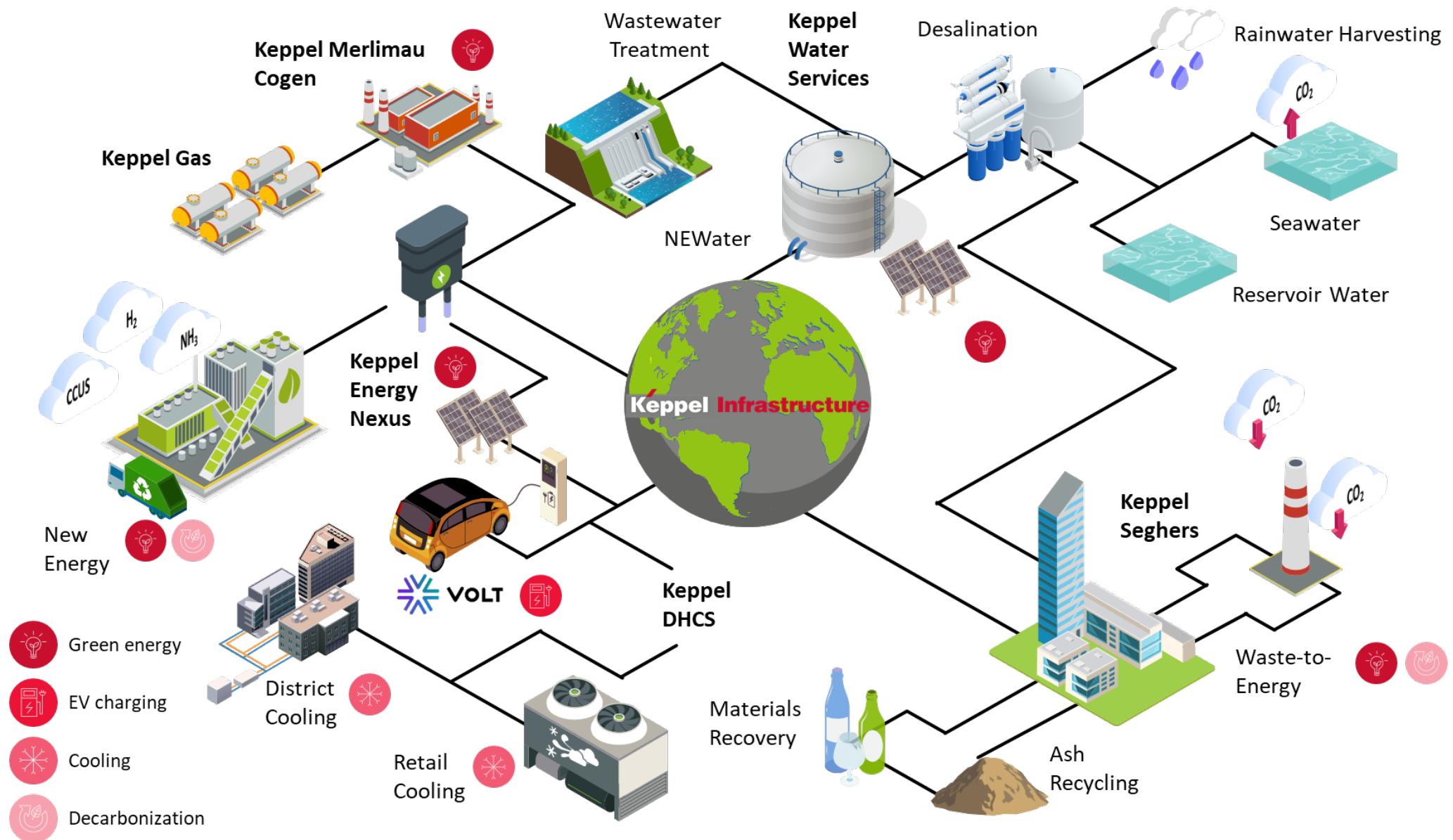
- Global player in environmental technology and solutions
 - Waste Treatment
 - Water and Wastewater Treatment
- 100% owned in-house technology, design and engineering expertise
- Track record of over 450 projects in 25 countries

New Energy

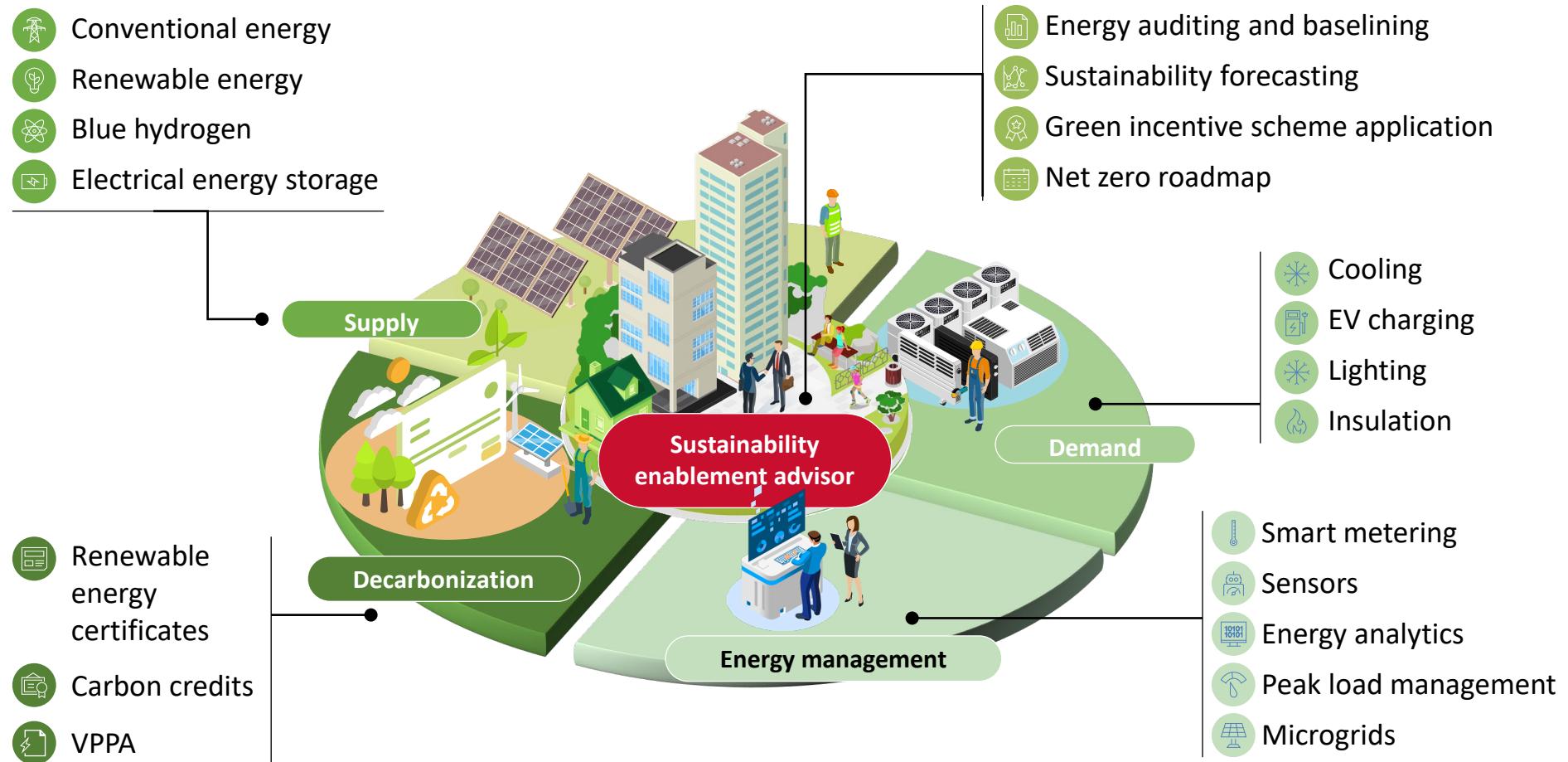


- District Heating and Cooling provider in the region
- Distributed Energy Services
 - EV Charging
 - Energy Storage System
 - Smart Microgrids
- Green Hydrogen
- Carbon Capture and Storage

Keppel Infrastructure | Green and Circularity



Keppel Infrastructure | End-to-End Energy-as-a-Service



KepInfra Energy Transition Centre

KETC, the innovation and technology arm of Keppel Infrastructure, harnesses technological foresights and provide low-carbon living-labs and sand-boxes for test-bedding, demonstration and new technologies development through partnerships with technology providers, Institutes of Higher Learning (IHLs), accelerators, interest groups and funding agencies.

Our Key Innovation Priorities



Multi-layered
Smart Grid
Integration



Renewables and
Low Carbon Fuel
Alternatives



Energy Storage



Water and
Waste-water
Treatment



Sustainable
Waste
Management



Data-driven
Digital Solutions

Fostering Global Ecosystem Partnership

Policymakers

Think Tanks

Institutes of Higher Learning

Industry Experts

Funding Agencies

Interest Groups

Some of our strategic technology collaborators include:



Keppel Infrastructure-NUS Low Carbon Living Laboratory

Creating, test bedding, and scaling up the deployment of commercially viable innovations

SMART AC/DC HYRID MICROGRID

Integrate renewable and distributed energy resources (DC microgrid) into the existing AC grid without disruption



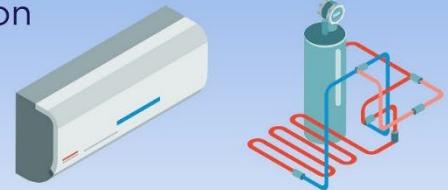
SMART ELECTRIC VEHICLE (EV) CHARGING STRATEGIES

Balance the needs and constraints of the existing electrical network, and charging demand and charging costs for EV owners



DISTRICT COOLING SYSTEM (DCS)

Provide DCS solutions with innovative thermal energy storage using proprietary phase change materials as an energy storage medium, outdoor cooling technology and intelligent process optimisation



SEAWATER DESALINATION PRETREATMENT TECHNOLOGY

Experiment on enhanced seawater desalination pretreatment technology for carbon dioxide sequestration and scalant removal





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Keppel Infrastructure

Energy Innovation 2022

Workshop 1: Technology Translation in Energy Transition



Mr Poh Tiong Keng

General Manager (Corporate Innovation)
Keplnfa Energy Transition Centre
General Manager (Asset Management)
Keppel DHCS



Mr George Loh

Senior Director
(Strategic Collaborations & Partnerships)
National University of Singapore



Dr Subodh G Mhaisalkar

Associate Vice President
(Strategy & Partnership)
President's Chair Professor (Energy)
Executive Director
Energy Research Institute @ NTU (ERI@N)
Nanyang Technological University