NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE | Energy Research Institute @ NTU

ERI@N

Energy Smart, Research & Innovation

MW-scale Modular and Scalable Microgrids dedicated to Critical Facilities and Data Centers : Asia-Pacific Context

Integrated Sustainability : Reliability and Resource Efficiency || Decarbonization : Environmental Impact and Resiliency

Prasanna I V, ERI@N. NTU

15-18 June 2026

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Future Grid Transformation and Energy Transition

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20 April 2026





Outline:

i. Background & Motivation

ii. Future Grid Platform

iii. Benefits & Impact

iv. Partnership Models

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Section-I

Background and Motivation

Energy Transition : Singapore and Asia Pacific Region

SCENARIOS FOR ENERGY 2050

Clean Energy Renaissance

A world that rallies together against climate change and encompasses progress in technology and concerted collective action. Both energy and digital technologies develop rapidly, while strong global cooperation continues through the next three decades. Under these circumstances, Singapore decarbonises smoothly and achieves a diversified supply mix in 2050.

Climate Action Bloc

Countries band together for climate action in a supportive geopolitical environment that favours global solutions but technology advancement is slow, especially in energy technologies. Singapore arrives at 2050 with electricity imports as a mainstay source of supply while waiting for low carbon technologies to mature.

Emergent Technology Trailblazer

A world that is fragmented geopolitically while technology development accelerates closer to 2050. Under these circumstances, Singapore makes proactive investments in new technologies to decarbonise and banks on hydrogen as its main source of supply.

Reference : EMA Regional Imports

Four Switches

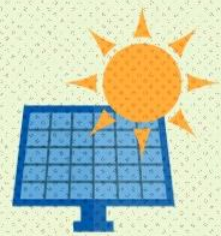
Singapore will harness four Switches to transform its **energy supply.**

1



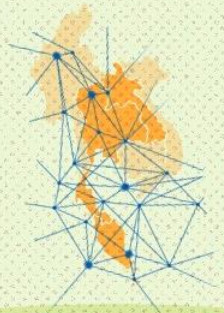
Natural Gas

2



Solar

3



Regional Power Grids

4



Emerging Low-Carbon Alternatives

Empowering Singapore's Energy Future

6 GW

Target for low-carbon electricity imports.

2035

Target year for 6 GW of low-carbon electricity imports.

1/3

Proportion of Singapore's electricity supply through imports in 2035.



Regional Grid

Laos

STATUS: Pilot commenced on 23 June 2022

- First multilateral cross-border electricity trade involving four ASEAN countries
- Up to 100 MW of renewable hydropower is imported from Lao PDR to Singapore through Thailand and Malaysia via existing interconnectors
- Second phase will see electricity trading double to a maximum of 200 MW where the additional supply will come from Malaysia

Laos – Thailand : 0.2 GW

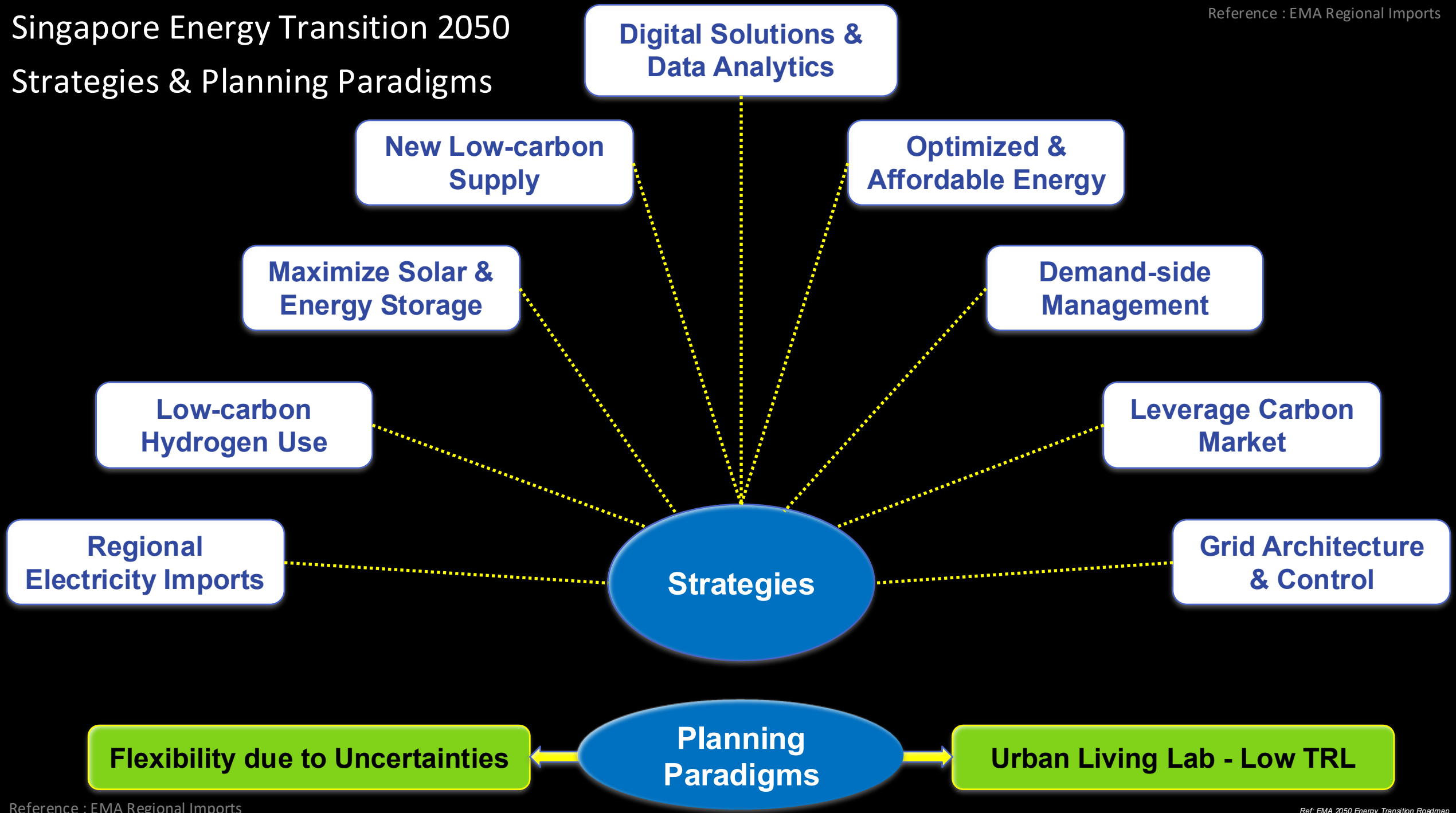
Cambodia : 1 GW

Vietnam : 1.2 GW

Indonesia : 3.4 GW

Australia : 1.75 GW

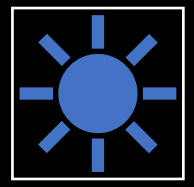
Singapore Energy Transition 2050 Strategies & Planning Paradigms



Reference : EMA Regional Imports

Ref: EMA 2050 Energy Transition Roadmap

Green Data Center Roadmap - Singapore



Prioritize renewable energy to ease grid congestion



Aim to add 300 MW capacity with green energy



Improve energy efficiency in hardware and software



Expand green energy use & smartgrids for sustainable growth



Meet IMDA standards: PUE ≤1.3, WUE ≤2 m^3/MWh



Implement Tropical IT Energy Efficiency Standard (SS 715:2025)



Promote green software via workload consolidation &virtualization

Reference : EMA Regional Imports

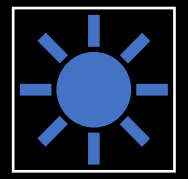
Singapore National Platforms - Strategic Priorities



Balance Energy Security, Economic Competitiveness, & Environmental Sustainability



Reduce Emissions To 45-50 Mtco2e By 2035, Building On 2030 NDC



Use Natural Gas, Solar, Regional Grids, & Low-carbon Alternatives



Diversify Energy Supplies While Maintaining Energy Security



Quadruple Solar Energy Deployment By 2025, Target 2 GWp By 2030



Improve Energy Efficiency with Nation-wide Programs



Import Up To 6 GW Low-carbon Electricity by 2035 from APAC neighbours

PIONEERING THE SUSTAINABLE GROWTH OF DATA CENTRES (DCs)

Singapore is a regional DC hub with a total capacity exceeding 1.4 gigawatts. DCs are fundamental to the Digital Economy, propelled by growing use of:

- AI compute workloads
- Autonomous and robotic systems
- Immersive virtual interactions



DCs are heavy users of power and water. As a compact city-state, Singapore is uniquely positioned to innovate and pioneer solutions to address the global challenge of sustainable DC growth.

Reference: BCA & IMDA Singapore

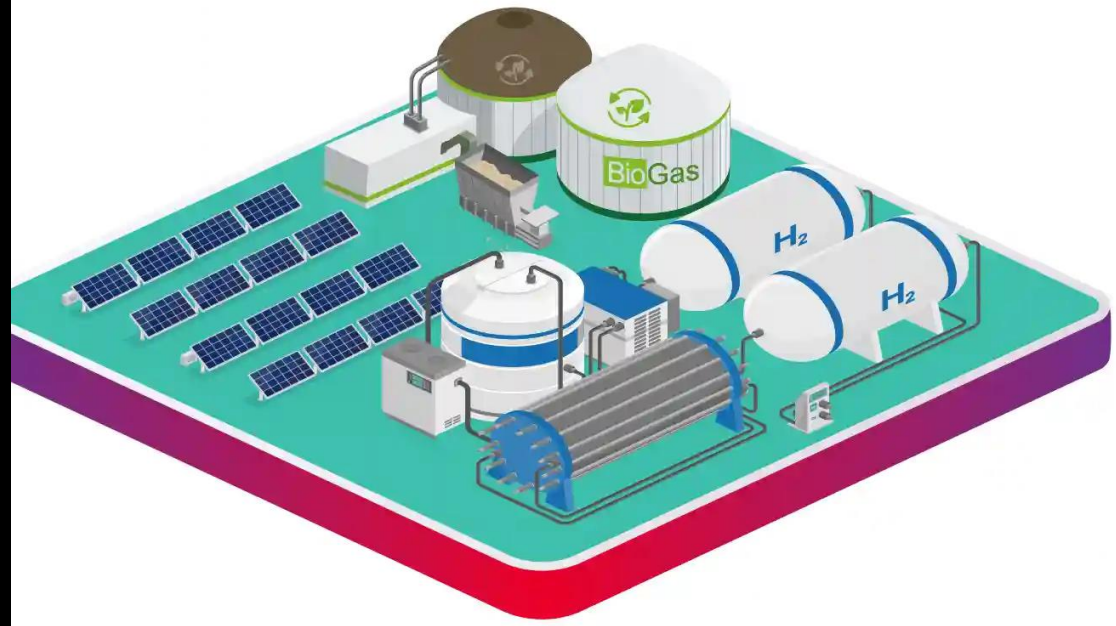
Classification: Restricted

Our Goal

Provide at least **300 megawatts** of additional capacity in the near future, with more through green energy deployments.

An Ecosystem Approach

DCs catalyse key ecosystem partnerships on sustainable development.
We will facilitate these partnerships to push boundaries to:



1. **Accelerate DCs' Energy Efficiency at Hardware and Software Levels**

2. **Accelerate DCs' Use of Green Energy for Growth**

Reference: IMDA Singapore

Classification: Restricted

The government will further support the industry by:

- Incentivising DC energy efficiency improvements and end-users' upgrading to more efficient IT equipment
- Bringing in DCs with the best-in-class technologies for sustainability and economic value for Singapore
- Facilitating DCs to update and adopt energy efficiency standards and forward-looking policies
- Creating innovations that provide commercial value and enable us to reap sustainability dividends



Reference: IMDA Singapore

Classification: Restricted

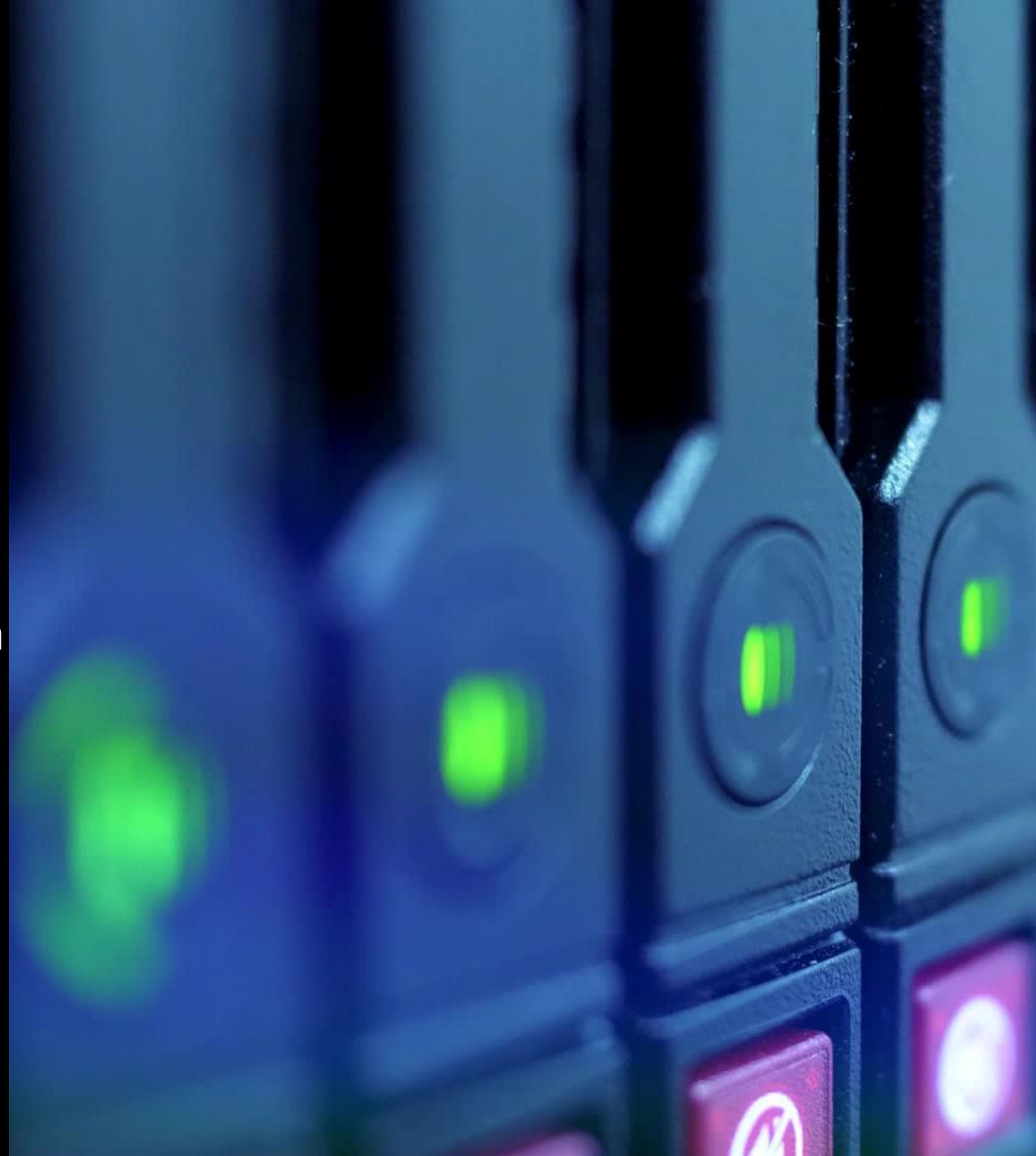


Case Study: Singtel Lands S$643M Green Loan for AI-Ready Data Center

- 58-megawatt (MW) data center in Singapore : New*
- High-density capabilities & most hyper-connected system dedicated to AI, cloud and high-performance edge computing
- Eight-story building will offer 58MW of IT load capacity across 120,000 sq ft (11,150 sqm).
- Current Status : Total IT load of up to 120MW.
- Operational DCs : 3 locations in Singapore

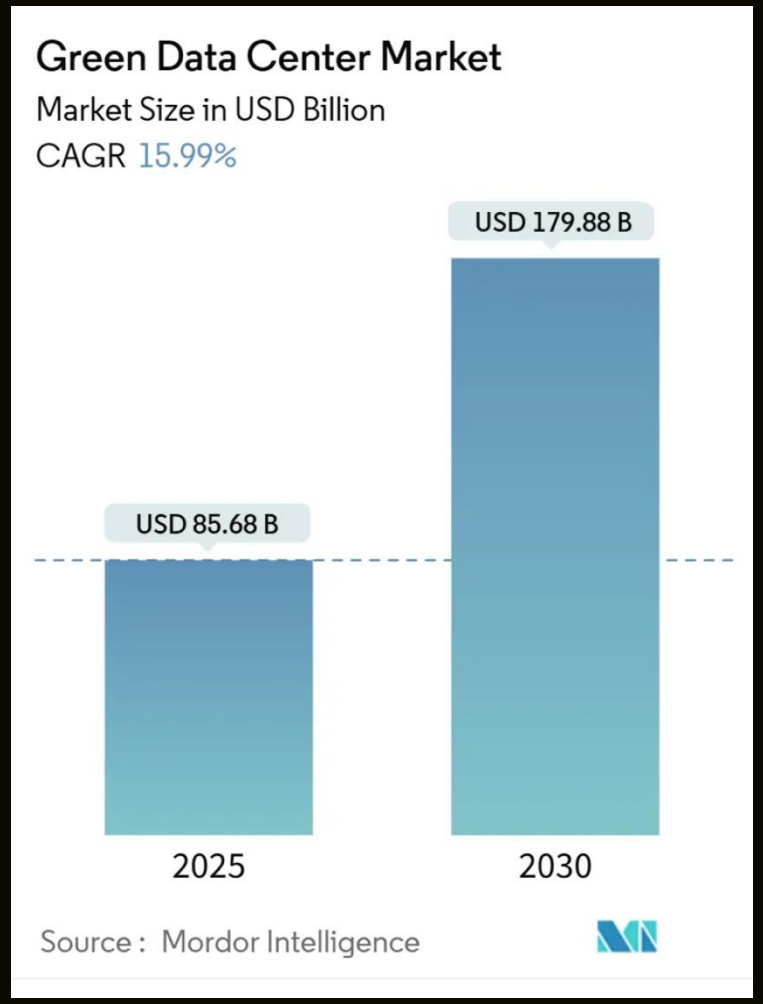
Nxera Initiatives

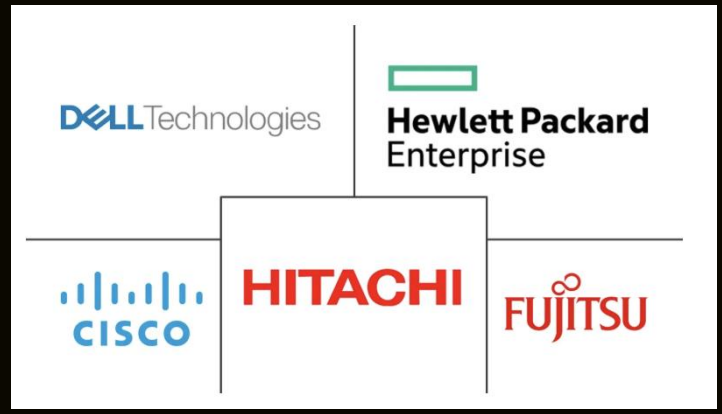
- Net-zero emissions by 2028.
- 41MW DC West facility
- 21MW DC Kim Chuan
- 40MW DC Thailand and 50MW DC Indonesia
- 64MW DC Johor, Malaysia.
- Partnered with Telkom and Medco Power in Indonesia, as well as Gulf Energy and AIS in Thailand, to develop data centers in Batam and Bangkok.

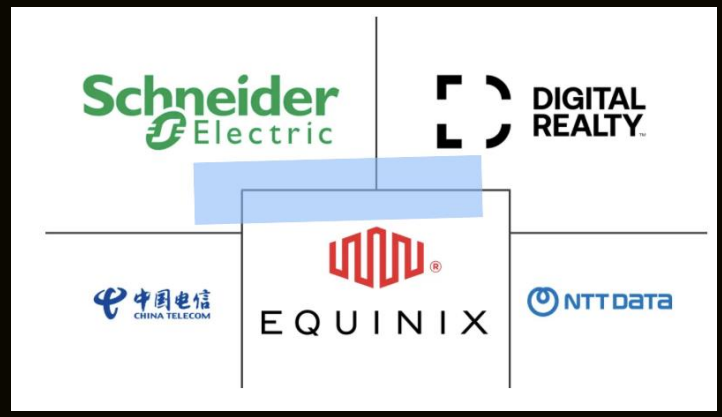


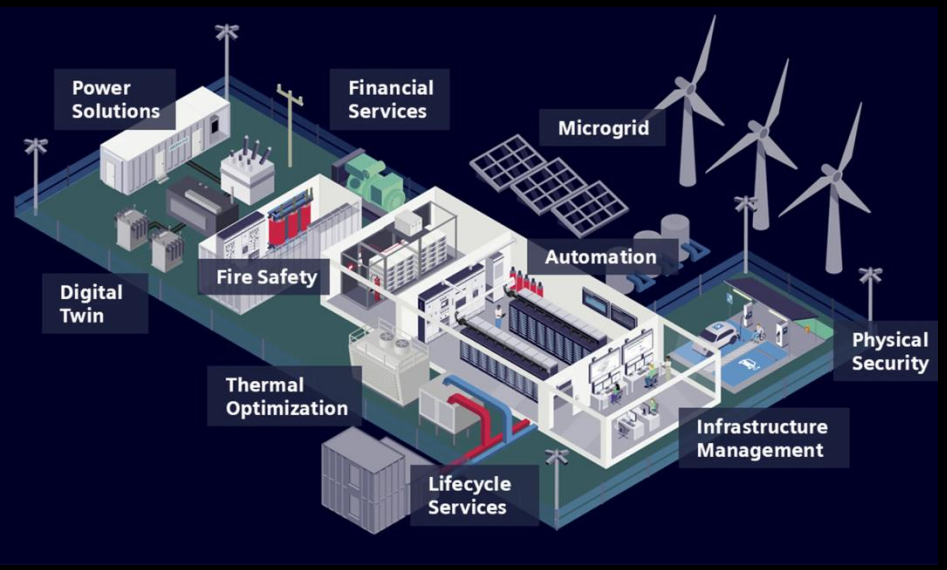
Case Study: Green DC Market Expansion and Leading Industry Solutions Providers



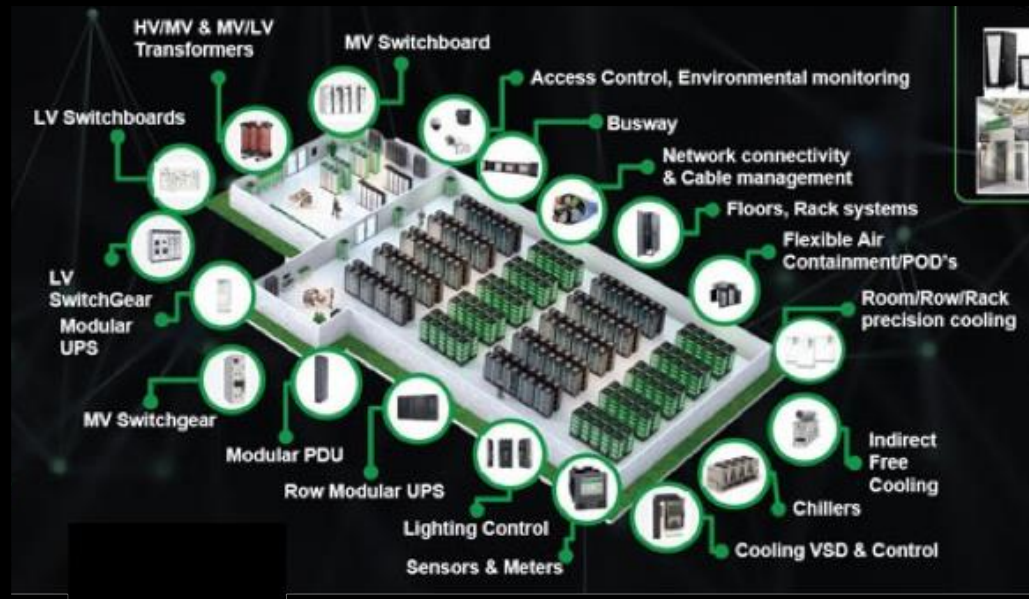


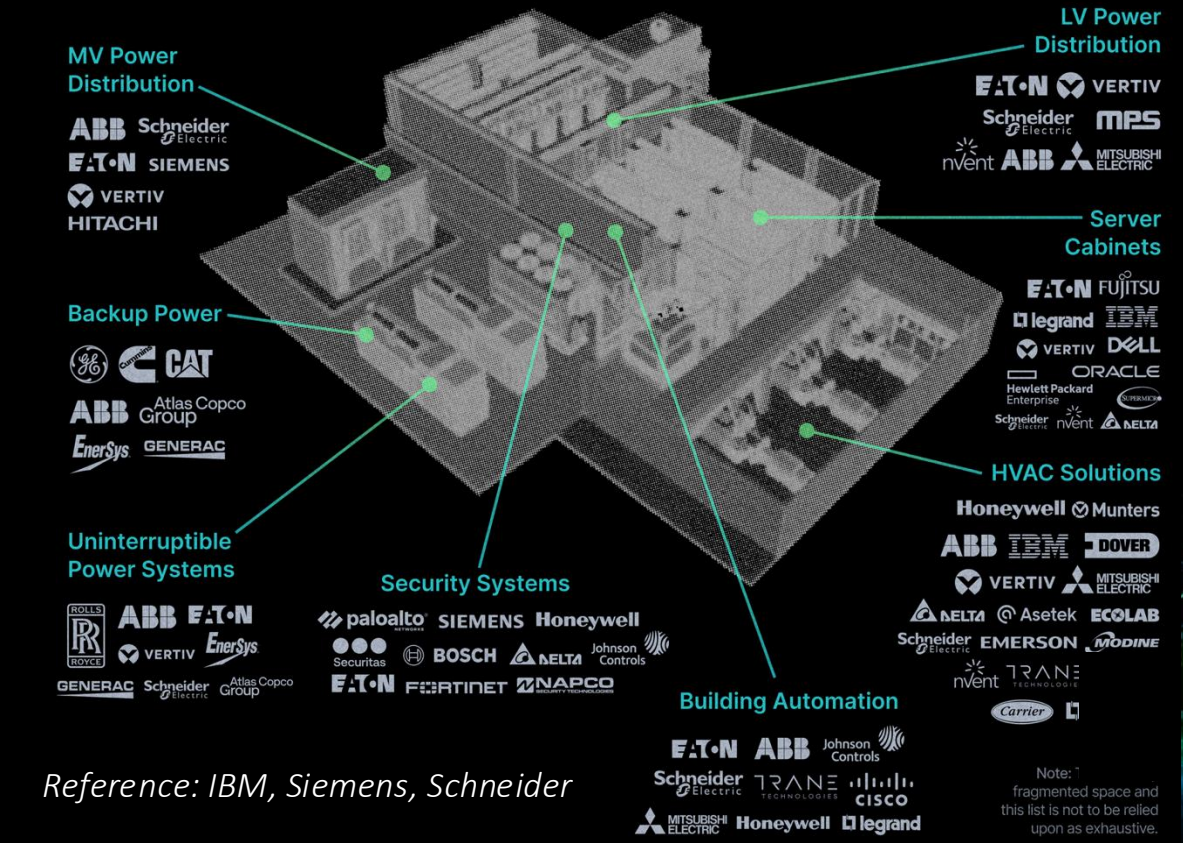






Industrial Solutions and Components Integrated in the Data Center as a System



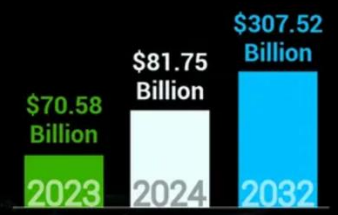


Reference: IBM, Siemens, Schneider

GREEN DATA CENTER MARKET

FORTUNE BUSINESS INSIGHTS

Green Data Center Market to grow at **18.0%** **CAGR** During 2024-2032



INDUSTRY DEVELOPMENT

Liberation Technology Services (LTS) joined hands with E-New Data Corp. to build a environmentally friendly facility in 2024.



DRIVERS

Emergence of Artificial Intelligence in Power & Cooling Technologies

TRENDS

Adoption of Renewable Energy Resources

NORTH AMERICA



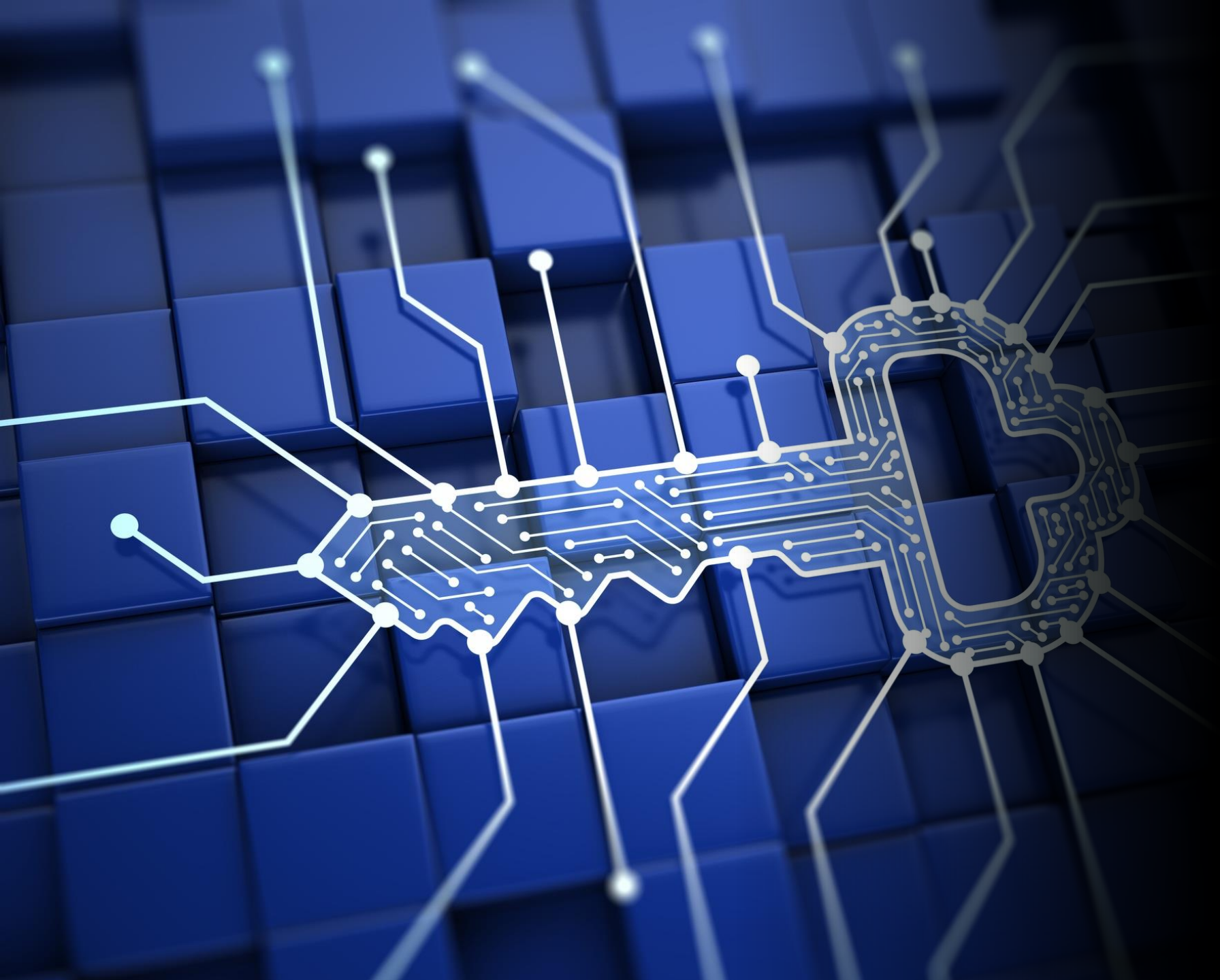
$26.72 Billion	$30.33 Billion
2022	2023

Asia Pacific
Middle East & Africa
South America | Europe

U.S. BY USER, 2023
Enterprise 41%
Cloud Service Providers (CSPs)
Colocation Providers

BY USER, 2023
Enterprise 41%
Cloud Service Providers (CSPs)
Colocation Providers

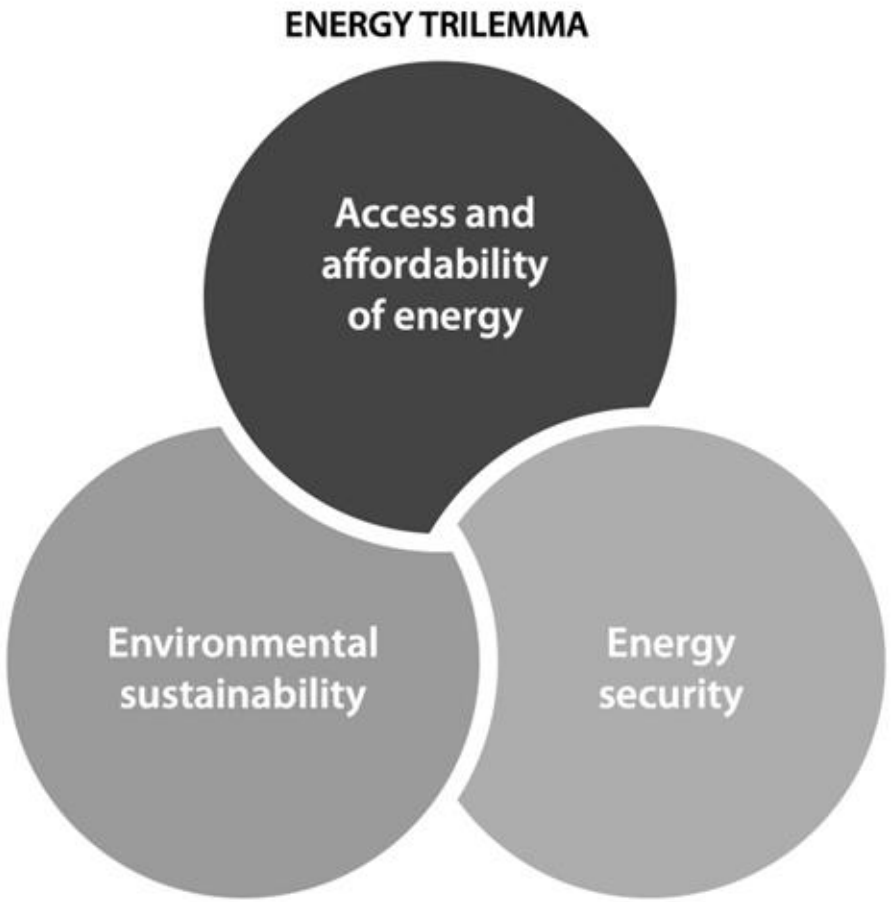
BY COMPONENT
Solution | Services

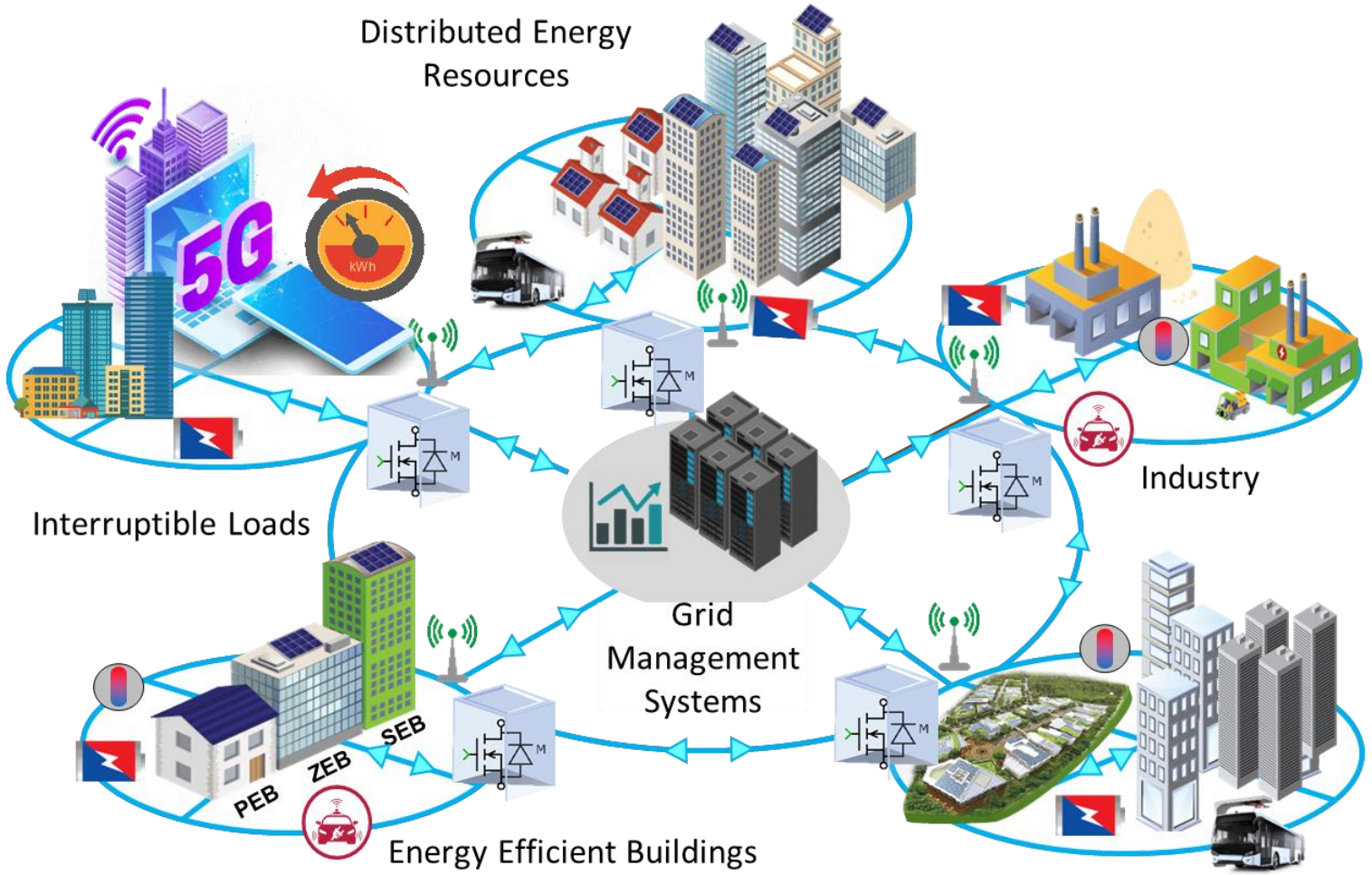


Section-II

REIDS NTU Future Grid Platform

APAC Energy Transition : Electrification, Decarbonization and Integrated Sustainable Districts





Integration

Grid Assets & Energy Resources

Interoperability

Cyber-Physical Systems

Resiliency

Energy Security & Grid Stability

Energy Transition - Competitive Landscape : Singapore & APAC Region



As the power sector of Singapore's aspires to achieve net-zero emissions by 2050, it is critical to build a flexible, affordable, resilient, and reliable Grid of the future with the enablers of grid digitalization & decarbonization.



The evolution of Singapore's future energy market needs to be addressed to facilitate the adoption of regional electricity imports, electric mobility targets & participation of consumers.

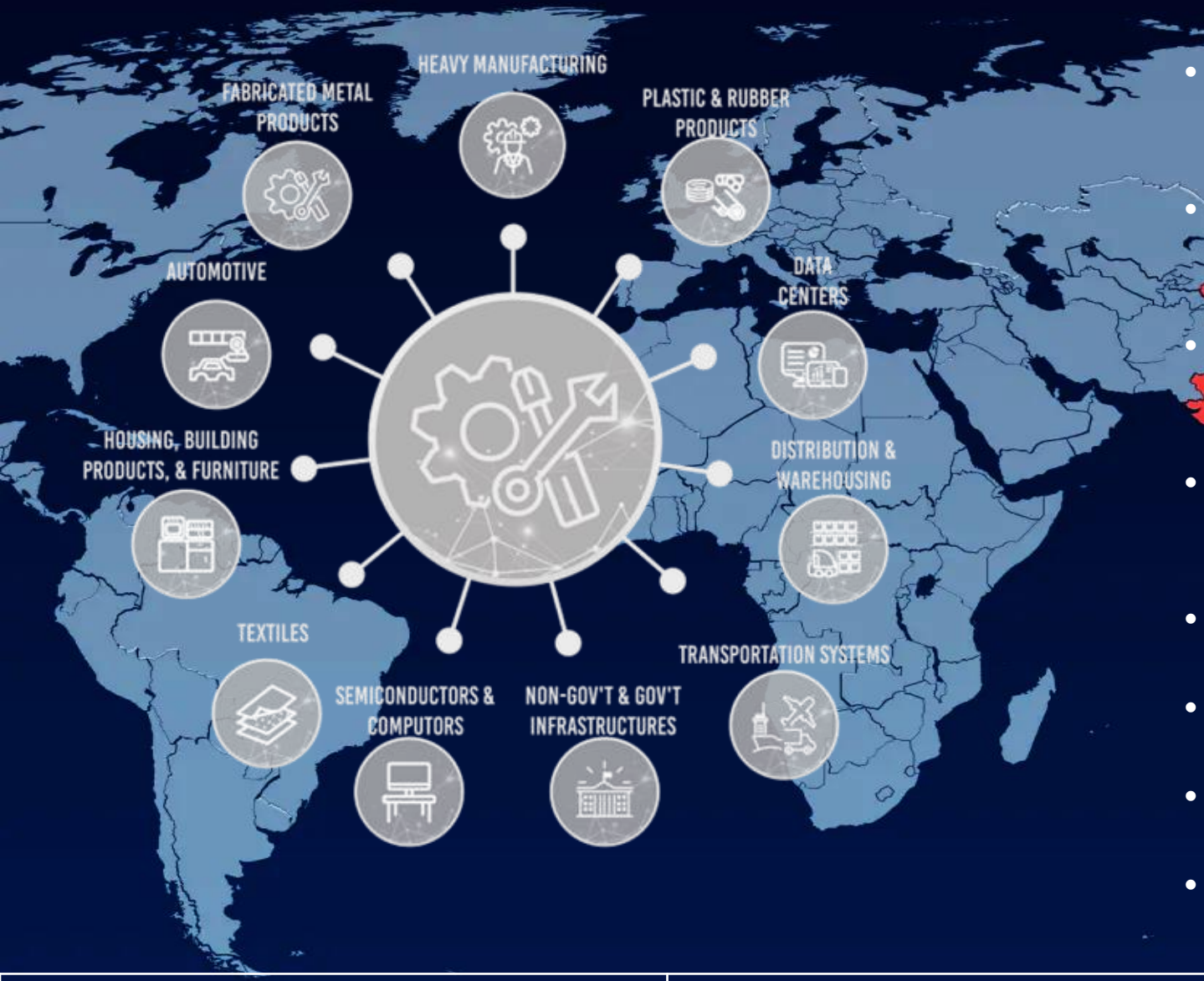


The novelties and complexities of the data-intensive infra upgrades & consumer assets warrant RD&D efforts to establish the strategic industrial partnerships on Singapore's transactive energy network.



Future Grid Urban living lab is needed for research, development, deployment and demonstration, feasibility analysis & performance validation.

Challenges and Opportunities - Environmentally Impactful Applications : SG & APAC Region



- Decarbonisation targets and Clean Energy Mix Load Profile & ESS Management
- Grid forming Operation for Continuity of critical operations
- Inrush current support during Ramp up condition
- Seamless transition from Islanding & Reconnection
- Peak Shaving & Low-inertia Weaker Grid Support
- Energy Traffic Congestion Management
- Feeder Sectionalization capabilities
- Black-start, On-Grid & Off-grid services

APAC Region Market >> Opportunities >>	Challenges Faced >> Problem Statement >>	R&D Approach >> Solution Demonstration >>

- MW-scale reconfigurable & flexible distribution grid network built-upon a multi-layer communication platform that interconnects more than 12 different microgrids.

- Energy storage systems & integrated grid ancillary services and energy dispatch market functions.

- Bi-directional power & information flow management among the community of grid systems that enable Peer-to-peer energy trading.

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NTU's MW-scale Grid Testbed

Semakau Landfill, Singapore

Current Energy Generation Capacity

1.2MWp Solar Arrays

Current Energy Storage Capacity

~2MWh Battery ESS

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NTU Platform Testbed Land space

64,000 sqm (6.4ha)

Potential Capacity to Upgrade

6MWp Solar + 10MWh BESS



NTU's MW-scale Grid Testbed

Semakau Landfill, Singapore

NTU Testbed on Semakau Landfill

Research Platform for Singapore's Future Grid Transformation and Energy Transition

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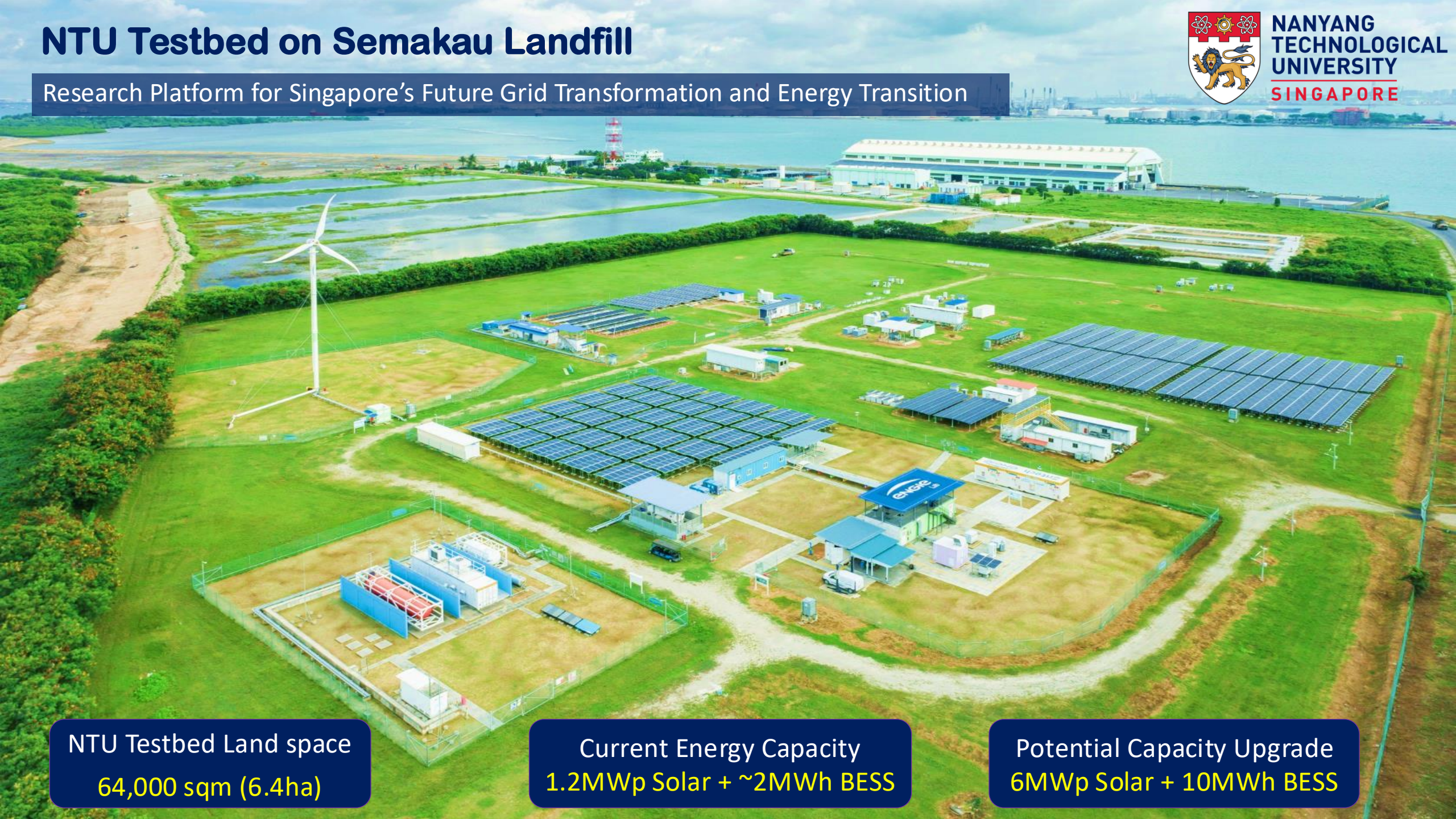


NTU Testbed Land space
64,000 sqm (6.4ha)

Current Energy Capacity
1.2MWp Solar + ~2MWh BESS

Potential Capacity Upgrade
6MWp Solar + 10MWh BESS

Potential Opportunities for Industry Partnerships

Energy Storage Systems

- 250kWh / 500kWh / 1 to 5 MWh
- Lead Acid or H2 or Li Ion (LFP / NMC)

Power Conversion Systems

- 100kW / 200kW / 500kW / 2 MW
- Grid-forming, Grid-tied * Bi-directional

Grid Management & Control (PMS/EMS)

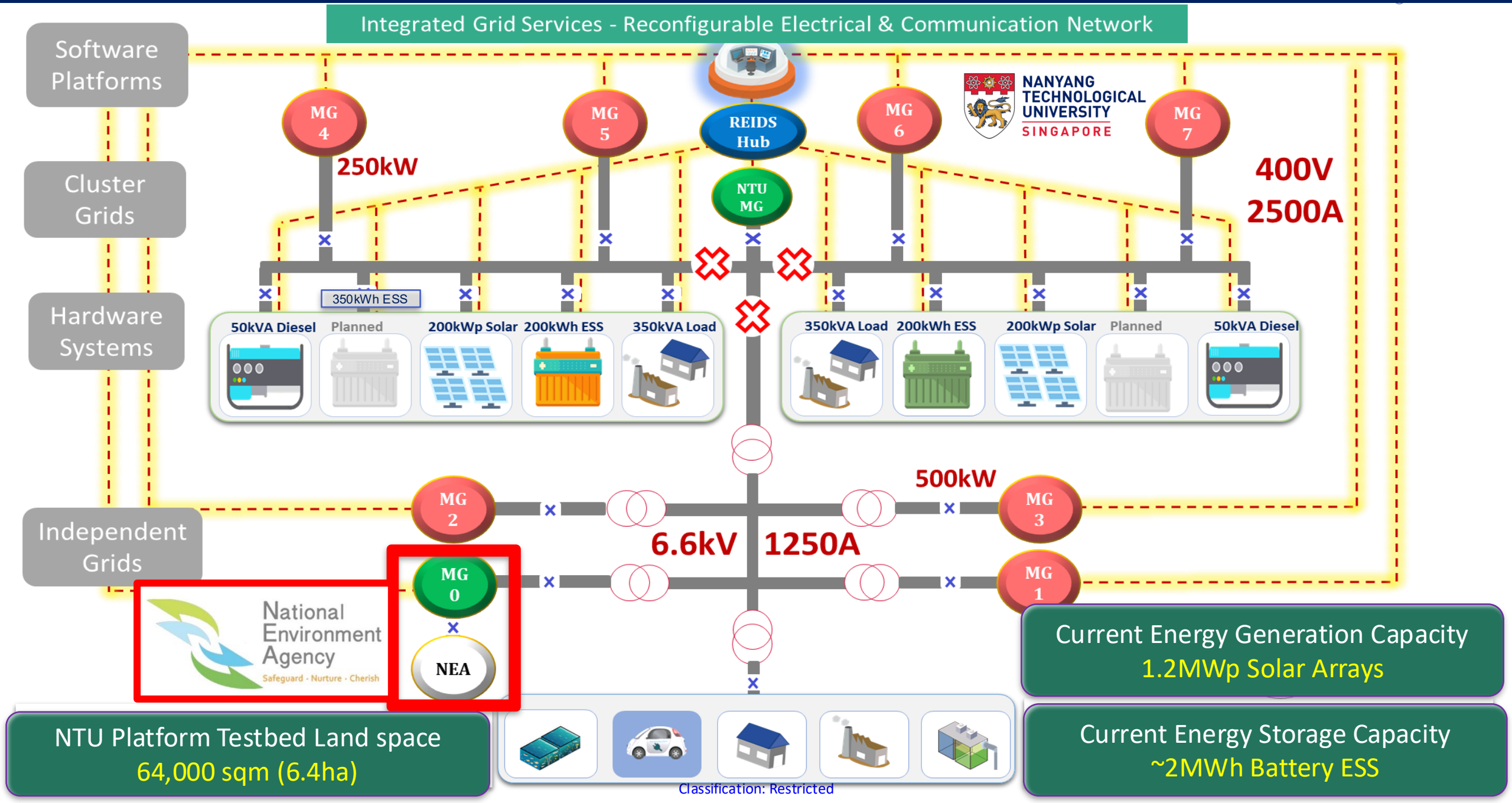
- Power/Energy Flexibility, Quality
- ModbusTCP, DNP3, IEC61850, IEC104

Cloud Platforms - AI/ML Tools

- System Optimization, Cost Savings
- Grid Reliability, Data Analytical Tools



Multi Energy Grid Cluster Platform to deploy and validate the performance, effectiveness and feasibility



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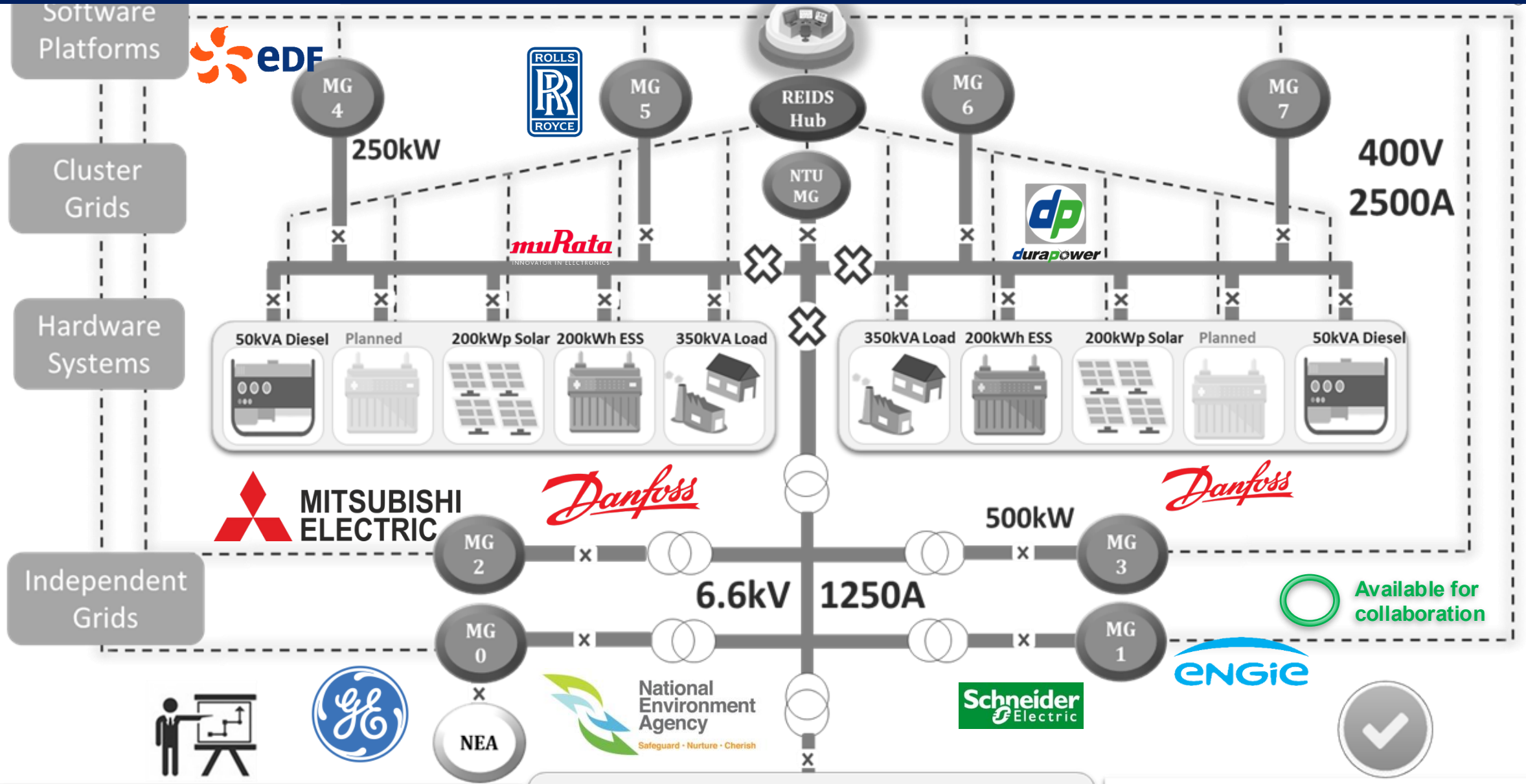
High TRL Research Collaboration Projects in the NTU Testbed : Leading Energy Sector Players and Industrial Partners

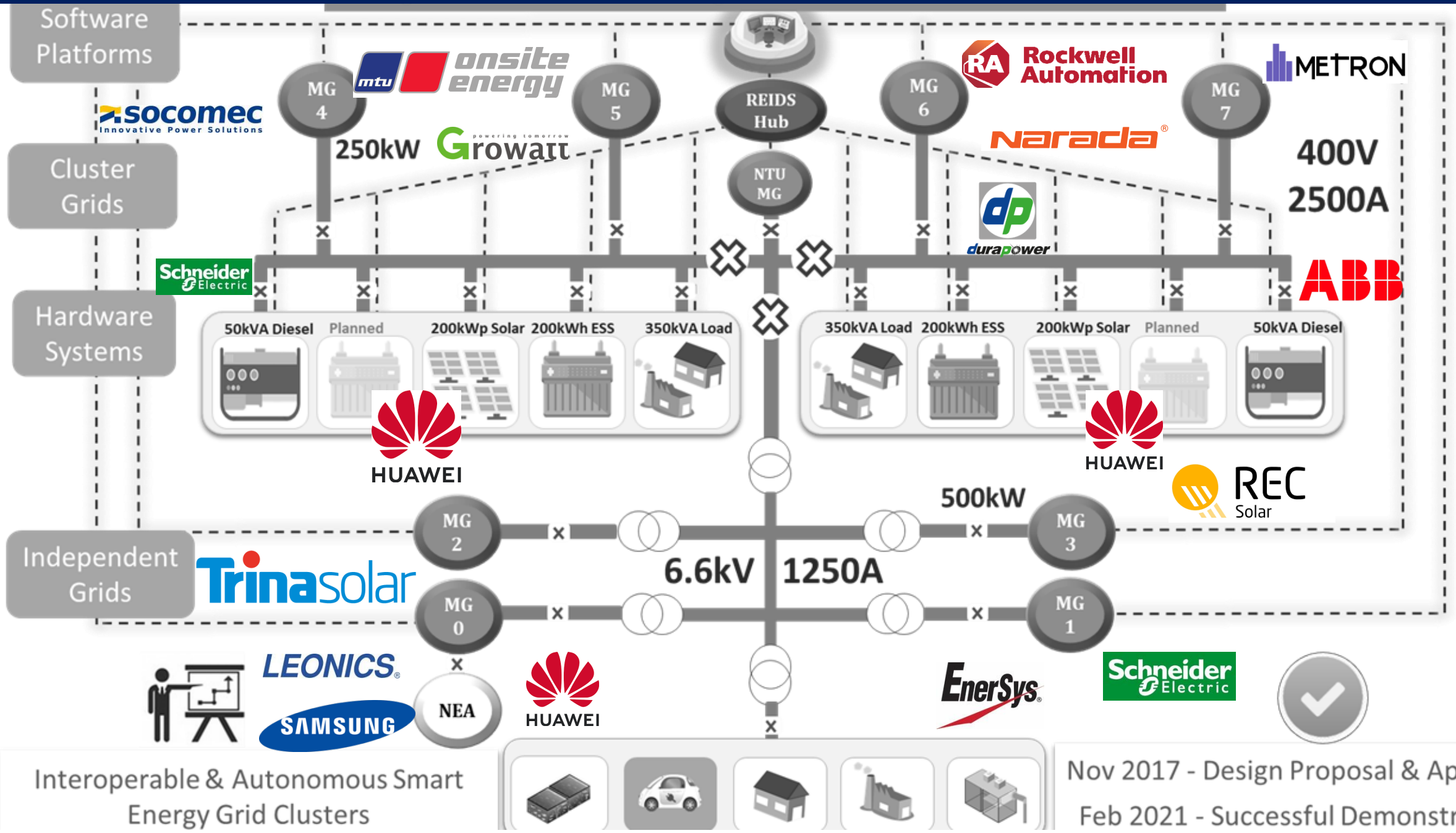


Interoperable & Autonomous Smart Energy Grid Clusters

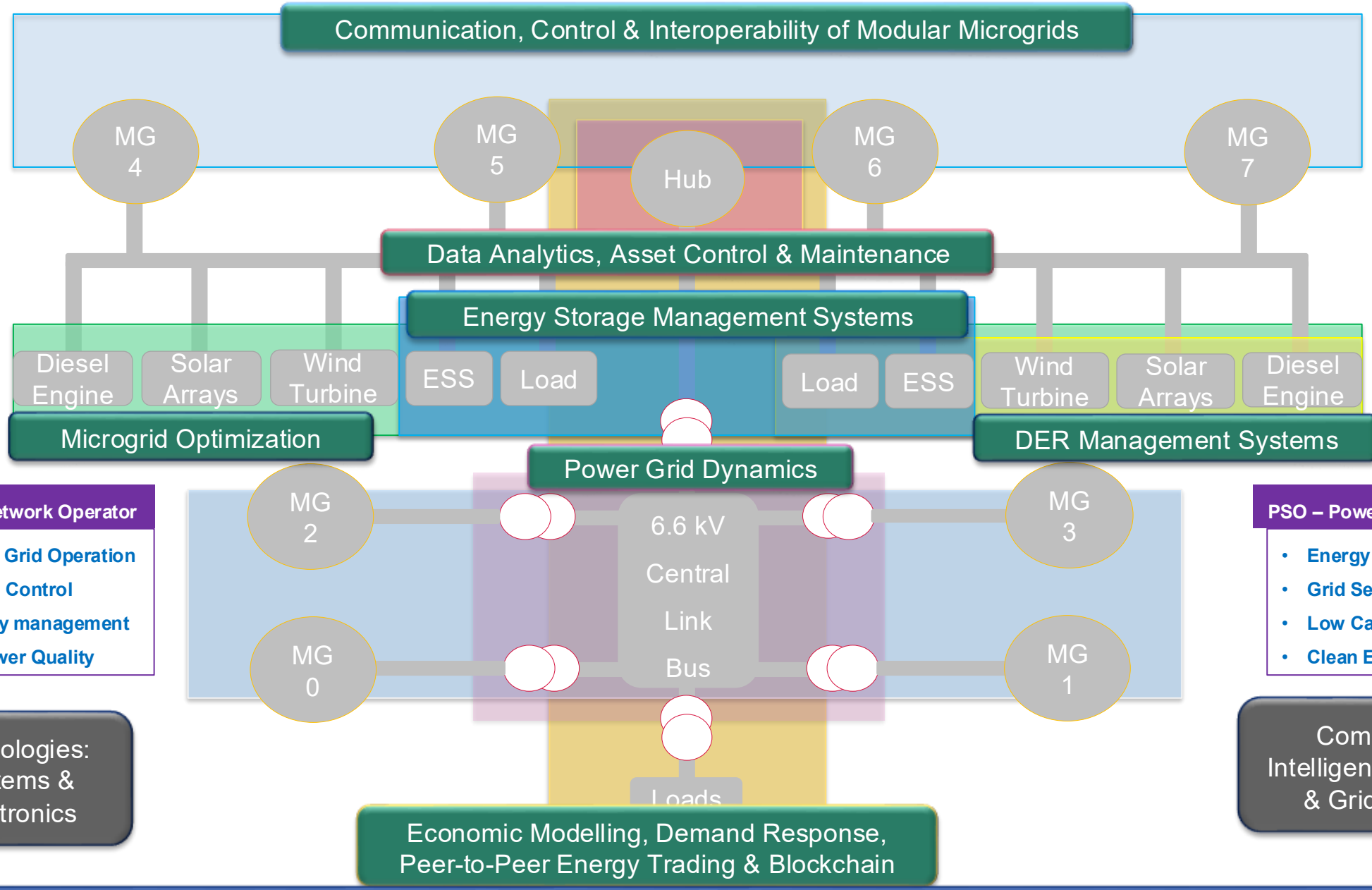
Nov 2017 - Design Proposal & Approval

Feb 2021 - Successful Demonstration

NTU deployed Industry Solutions that are crucial for Singapore's Energy Transition : Multi Vendor Eco System



NTU Testbed - Research Platform for Future Grid Capabilities and Energy Market Services



DNO - Distribution Network Operator

- Future Distribution Grid Operation
- DERs Integration & Control
- Demand & flexibility management
- Grid Stability & Power Quality

PSO – Power System Operator

- Energy Market interface
- Grid Services Settlement
- Low Carbon Credits
- Clean Energy Trading

Novel Technologies: Power Systems & Power Electronics

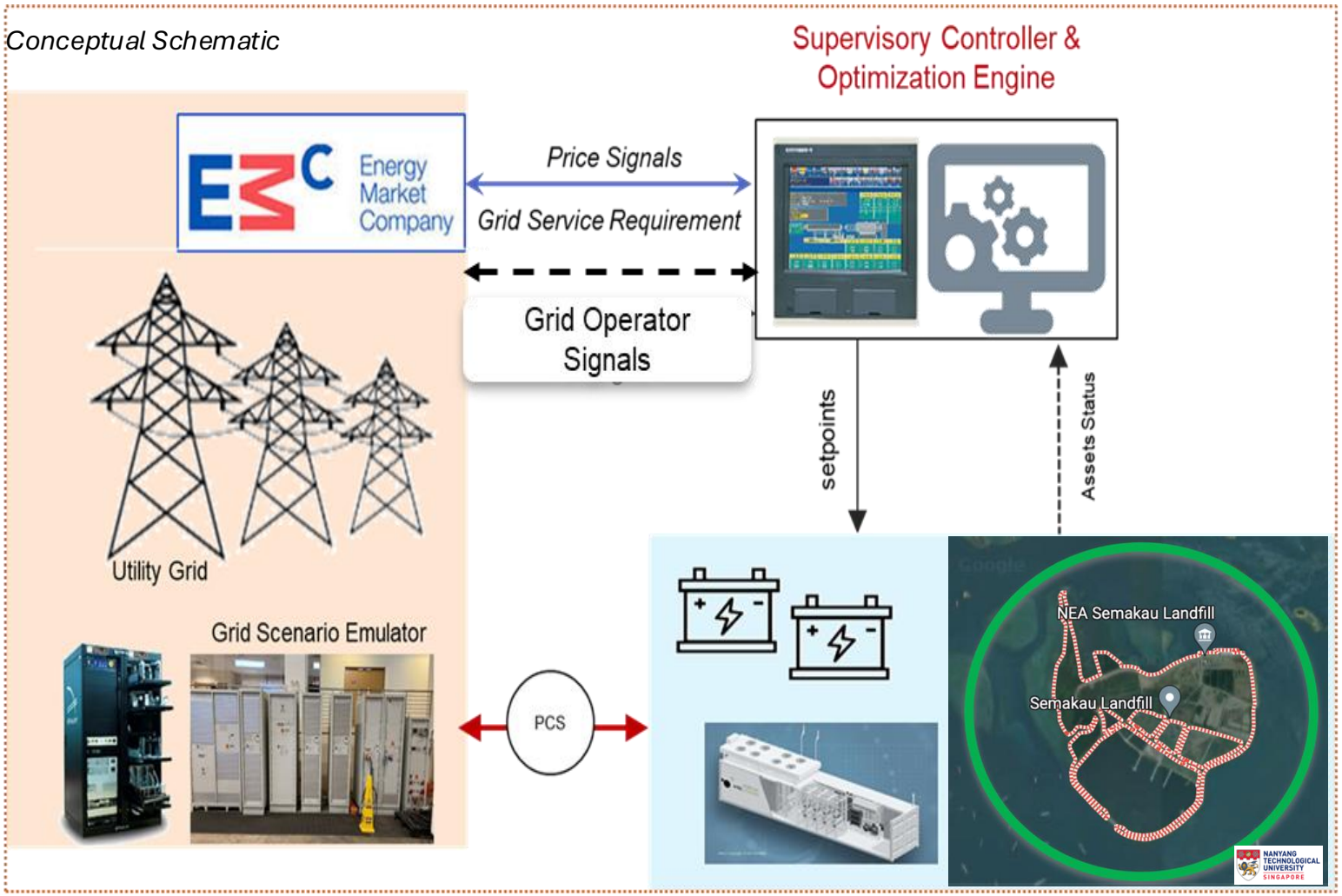
Computational Intelligence: Resiliency & Grid Reliability

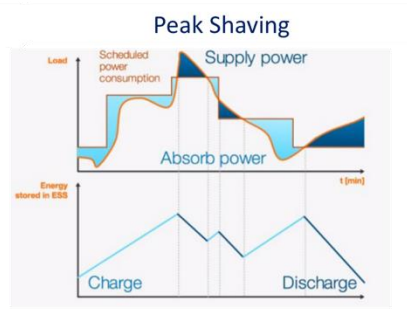
Hi-fidelity EMT and RMS Grid Modelling: Hardware + Software in the loop HIL/SIL platforms driven by real-world data.

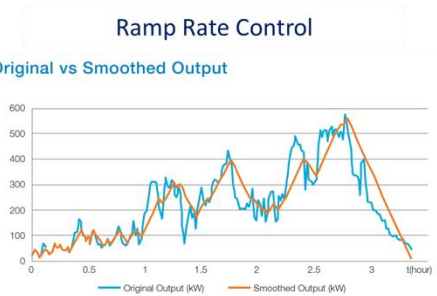
Grid Ancillary Services & Use cases - Provision of Grid Services to enhance Resiliency & Reliability

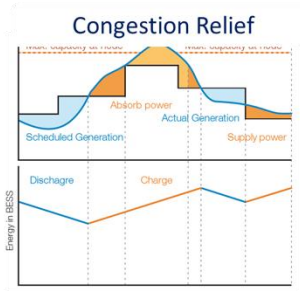
Singapore Energy Grid Transition – Testing and Validation

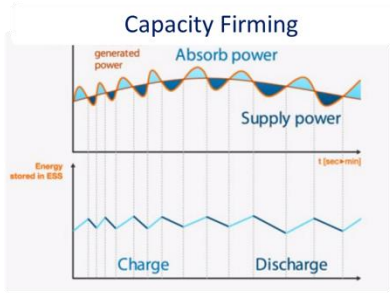
Conceptual Schematic

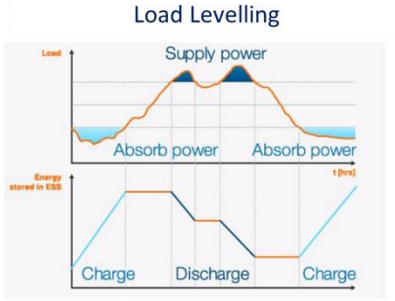


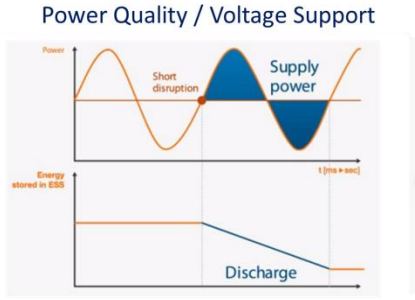


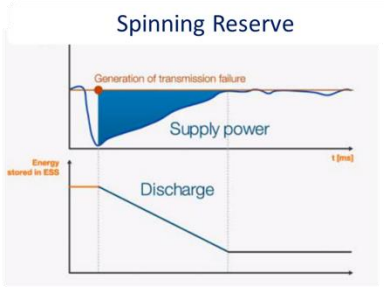


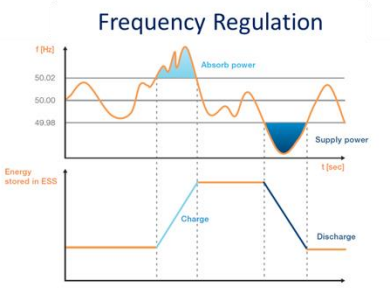












- ✓ Future Ready Grid Architecture to operate seamlessly Off-grid and On-grid conditions
- ✓ Co-exist harmoniously with potential new projects (Regional Electricity Imports & Solar Farm)
- ✓ Enabler for supporting the national targets and new project developments in APAC and SG

Section-III

Benefits and Impact



Renewable Energy Integration Demonstrator – Singapore

REIDS



REIDS is a Research, Development and Demonstration (RD&D) platform dedicated to designing, demonstrating, and testing sustainable and cost-effective energy solutions for SG & APAC region.



Paving the way towards sustainable multi-activity off-grid communities, REIDS fosters systemic research and development in the broad energy arena in support of Singapore corporate and public stakeholders, thereby strengthening their position on the rapidly growing renewable energy and microgrids markets.



REIDS Multi Energy Clusters Platform on Semakau Landfill is a Future Grid living lab for industries, researchers and government agencies to explore next-generation distribution grid solutions and to solve engineering, economic, environmental and societal energy transition challenges for off-grid and urban communities.



Bolstering flexible reconfiguration capabilities, REIDS platform offers grid of grids test scenarios such as dynamic system optimization, smart grid clusters network management, energy trading, interoperability & cybersecurity which are instrumental to explore pre-competitive RD&D opportunities in energy sector.

NTU Testbed – R&D Projects on Singapore Energy Transition, Grid Transformation & Market Evolution









ENGIE

REIDS-SPORE multi-energy-system management. Demonstration Towards Carbon Neutrality with Hydrogen

EDF

MASERA Fully integrated microgrid, easily deployable, affordable, plug & play solutions

MITSUBISHI ELECTRIC

Advanced Energy Management System for Decarbonization related Clean Energy System Use cases

Danfoss

Bidirectional Power Converters in Energy Storage Integration, Grid Control & Management.

muRata INNOVATOR IN ELECTRONICS

dp durapower

Performance analysis of grid-scale ESS & Second life EV BES Grid Ancillary Services

Rolls-Royce

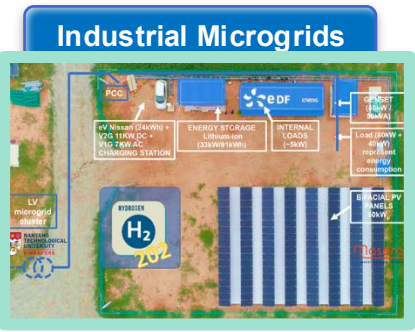
Rolls-Royce Experimental Microgrid Intelligent Demonstrator Singapore (REMIDS)





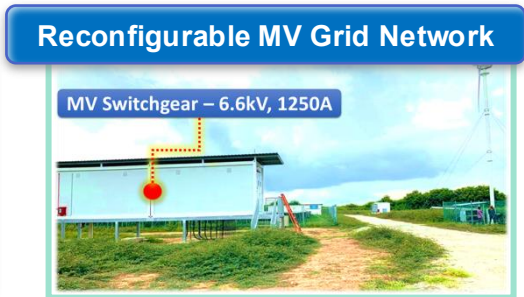










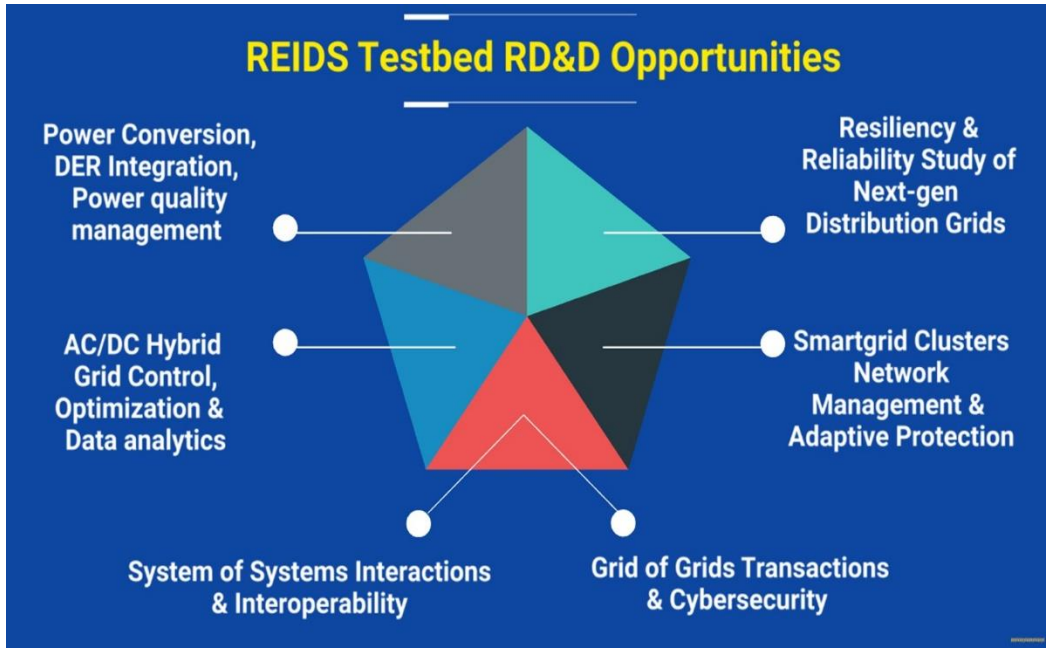


REIDS-SPORE multi-energy-system management - Towards Carbon Neutrality with Hydrogen



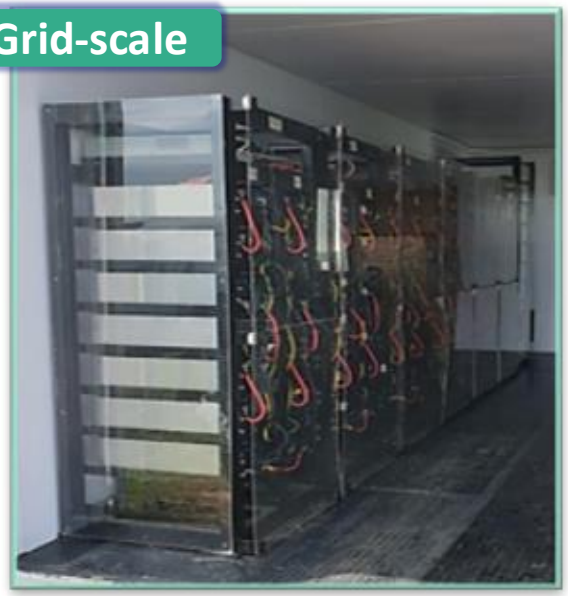
Distributed Energy Storage Systems R&D - Energy Market & Grid Services















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Demonstration of Distributed Control and Optimization of DERs and Utility-scale Batteries



Translation

Phase-I 20%

Phase-II 100%

Phase 1 : 20% Green Energy Mix

- Microgrid Optimization and Distributed Control
- Using the NTU grid assets, increase Green Energy Mix from 3% to 20%
- 24x7 demonstration for 2 months
- Day: Solar Energy Balancing with Diesel Genset
- Night: Energy Storage Support

300kWh Battery ESS

400kW Solar Arrays

Grid Management









Demonstration of Distributed Control and Optimization of DERs and Utility-scale Batteries

NEA Facility on Semakau Landfill

24x7 Critical facility for Singapore runs on 97% Diesel Fuel

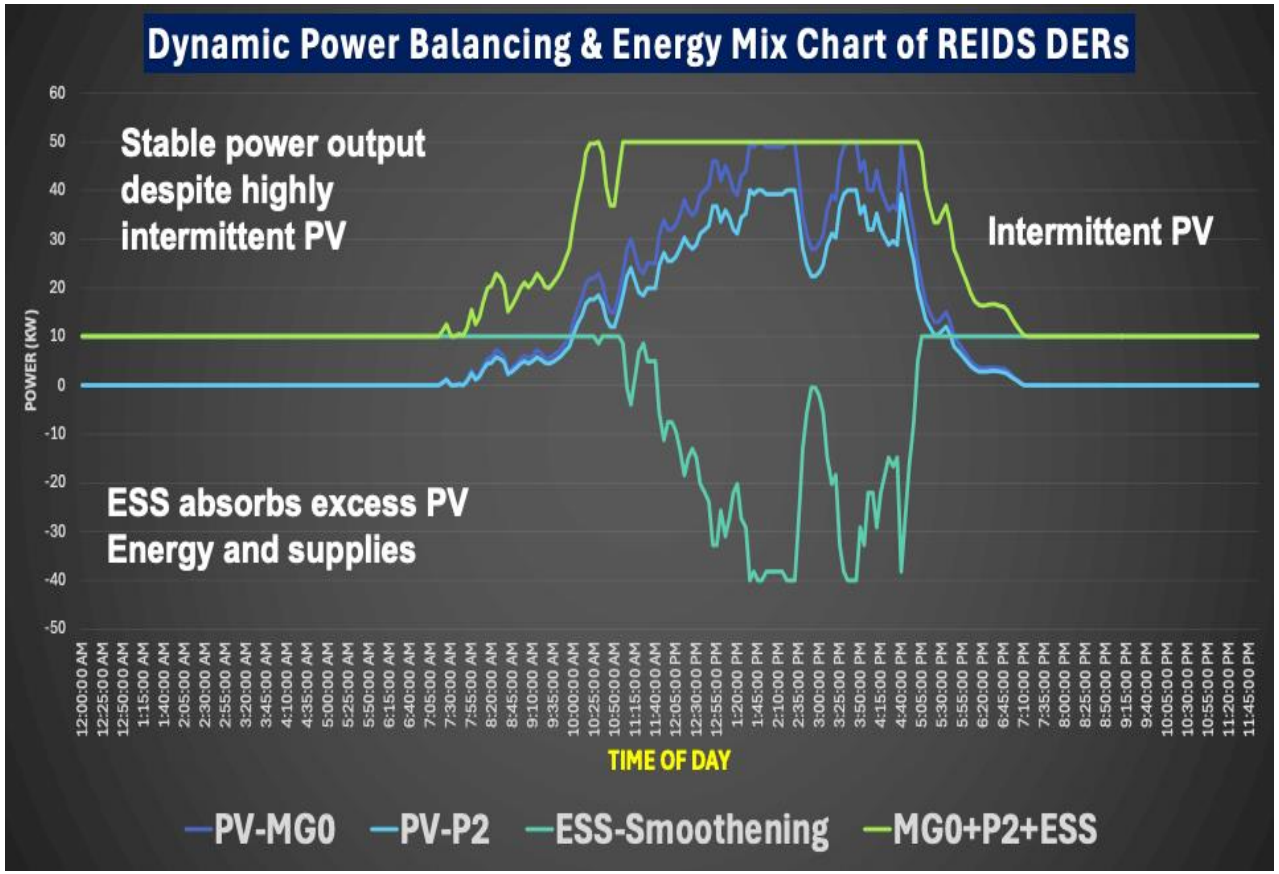
Diesel Generators are used as energy source (1000 Tonnes CO_2)

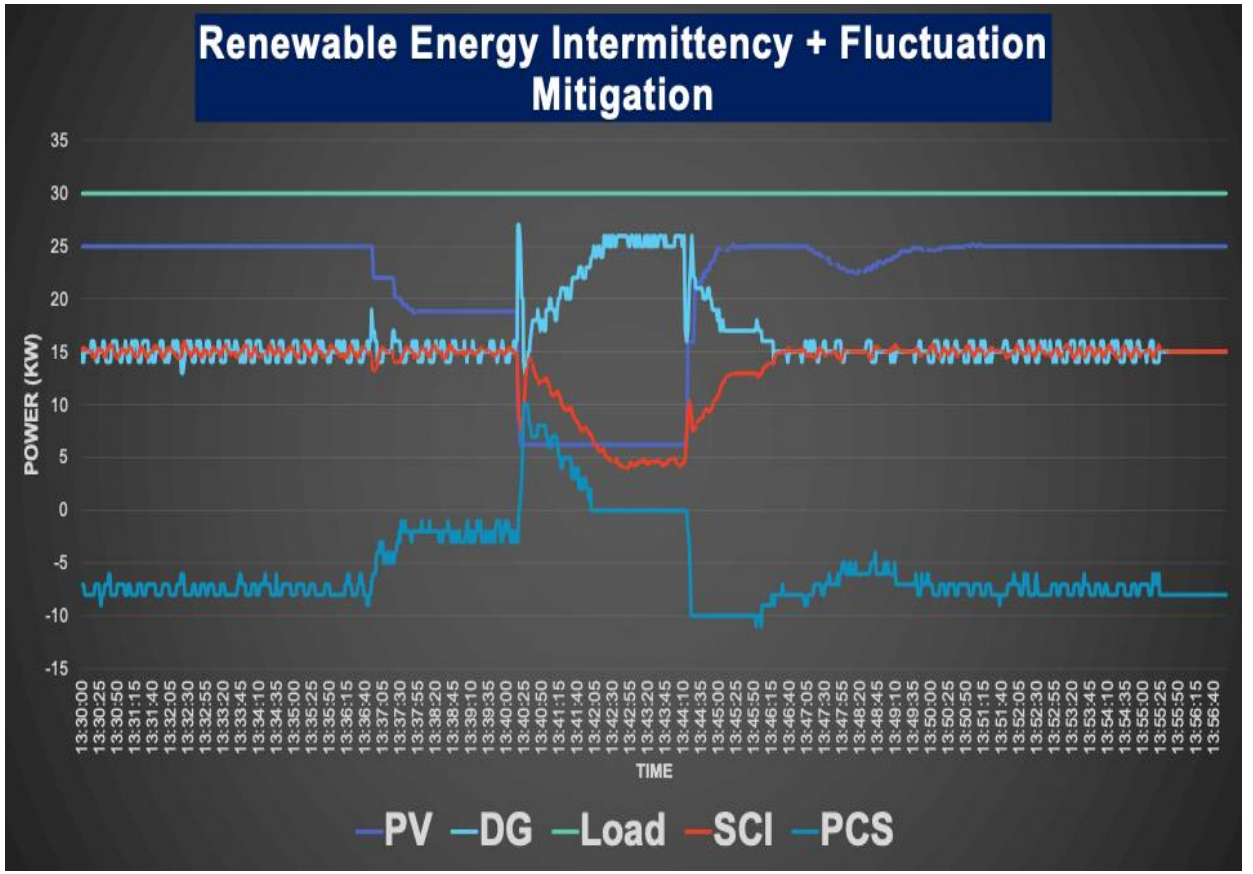
Potential to power the facility towards Decarbonization

~2GWh Annual Consumption : (~120MWh monthly)

~250kW power consumption throughout the day and night

~Solution : 10% Green Energy Mix from NTU Grid platform





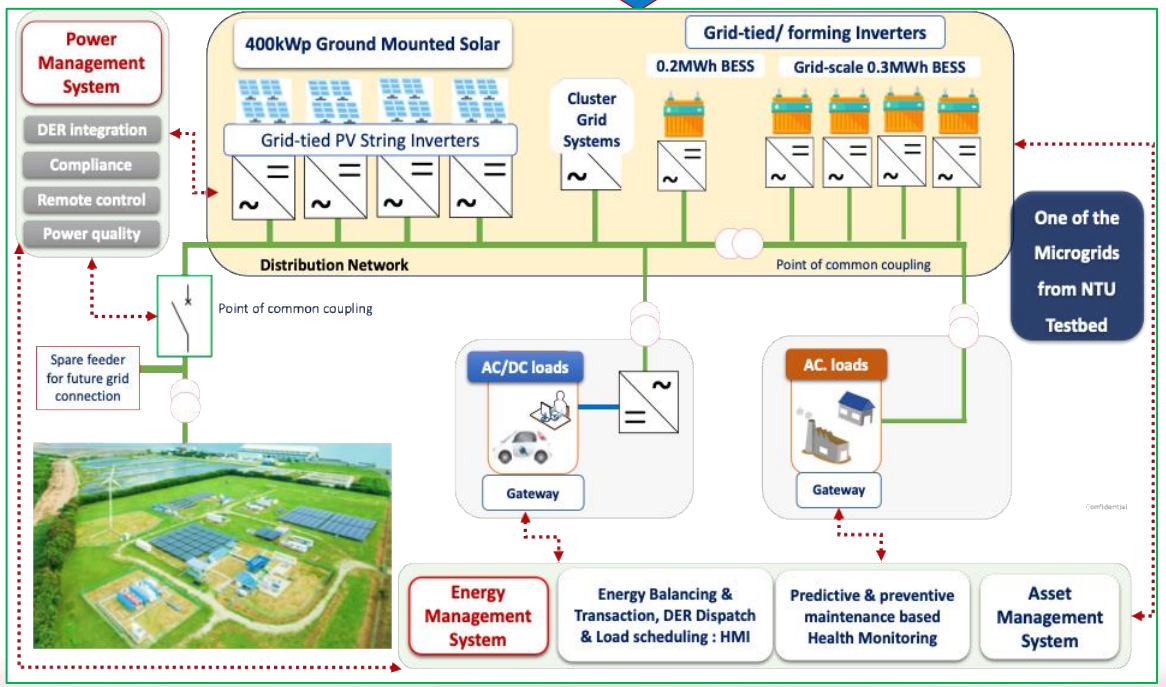
RENEWABLE ENERGY BASED SMARTGRID OPERATION	Grid formation using ESS Inverter for autonomous power balancing
	Grid tied operation using ESS Inverter for Power injection & absorption
	PV penetration using maximum power point & curtailment modes
	Load variation threshold identification in view of uncertain solar energy harvest
	Efficiency comparison of novel power electronic inverters from zero to full load swing

CYBER SECURITY ANALYSIS	Intrusion Detection/Prevention system in DER architecture
	Secure communication with assets and primary, secondary & tertiary controllers
	Key cryptography application for SCADA/EMS platforms
	Penetration testing in Multi-smartgrid environment for vulnerability assessment

IMPACT OF MAXIMUM DERs / RENEWABLES PENETRATION	Maximized Grid tied solar injection without affecting stability
	PV inverter operation with active and reactive power curtailment
	Grid Stability analysis with different DERs ESS
	Protection setting calculation for DER feeders in LV network
	Performance analysis of different battery storage technologies

SMARTGRID NETWORK MANAGEMENT	Adaptive power system protection & low inertia grids stability analysis - Voltage & Frequency : % of variation - MV and LV switchgear fault analysis - Fault locations (internal & external) & Restoration

MW-scale Multi Layer Grid System Testing & Use cases

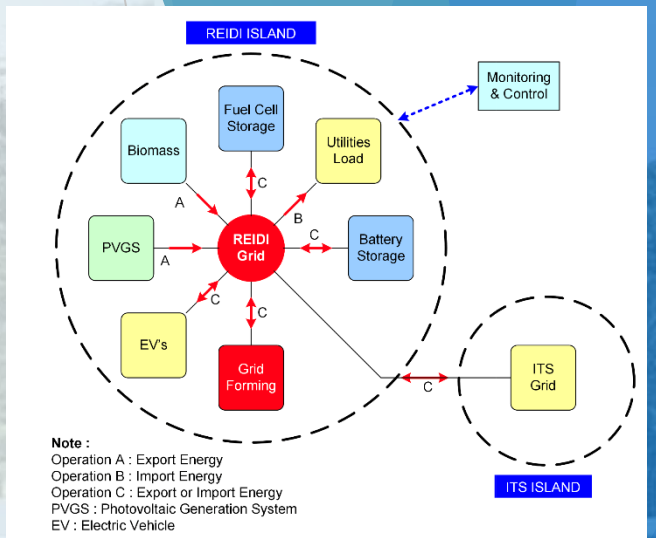


NTU Proprietary Information –prasannaiv@ntu.edu.sg

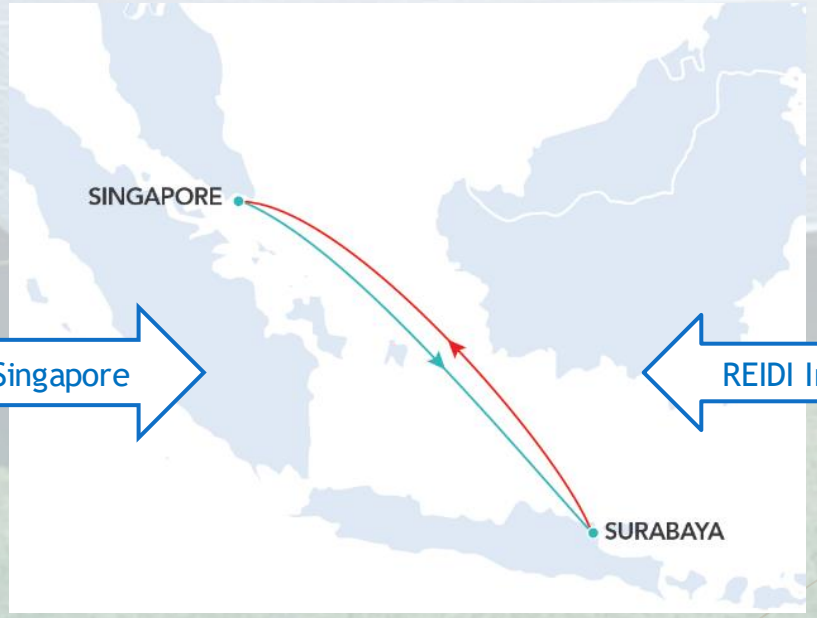
REIDI Renewable Energy Integration Demonstrator of Indonesia

- Renewable Energy Integration Demonstrator Singapore (REIDS) is a platform (6.4ha, ~6MW) developed by ERI@N NTU on Semakau Landfill Singapore.
- REIDI is modelled after REIDS to serve as a hub for Education, Research/Innovation & Industry engagement. (1.5ha, ~1MW)

ERI@N is leading the Megawatt-scale energy system testbedding projects in Singapore and Indonesia to explore the future challenges in view of performance and feasibility of technologies towards the successful realization of SG national targets on Regional Electricity Imports and ASEAN Interconnected Energy Grids.









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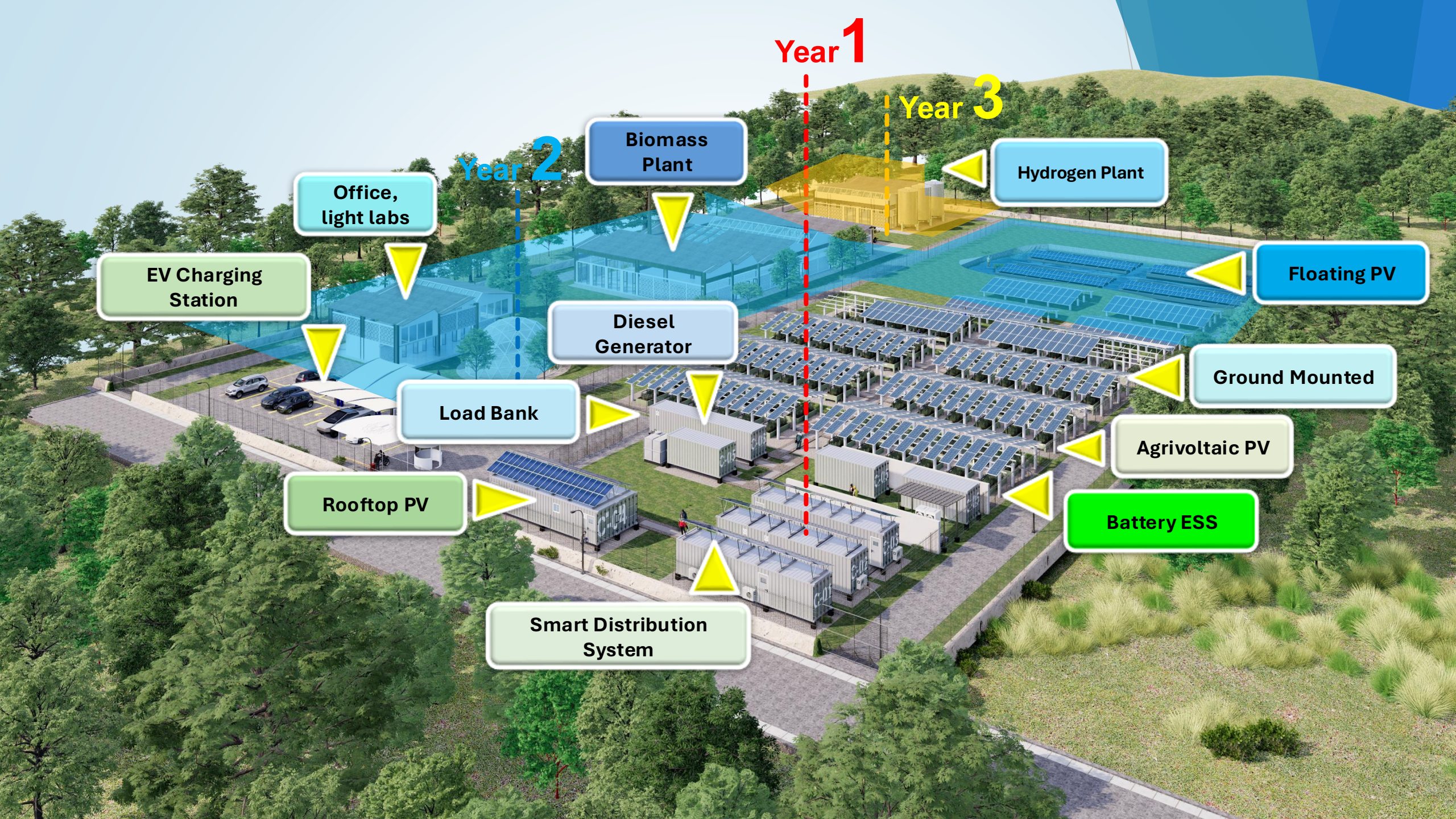

Year 1
Year 2
Year 3
Biomass Plant
Hydrogen Plant
Office, light labs
EV Charging Station
Floating PV
Diesel Generator
Ground Mounted
Load Bank
Agrivoltaic PV
Rooftop PV
Battery ESS
Smart Distribution System

REIDI

Renewable Energy Integration Demonstrator of Indonesia



REIDI: Renewable Energy Integration Demonstrator – Indonesia

INSPIRASI

- Clean Energy Mix & ESS Management
- Grid forming for Continuity of critical operations
- Inrush current support during Ramp up condition
- Seamless transition from Islanding & Reconnection
- Peak Shaving & Low-inertia Weaker Grid Support
- Energy Traffic Congestion Management
- Black-start, On-Grid & Off-grid services



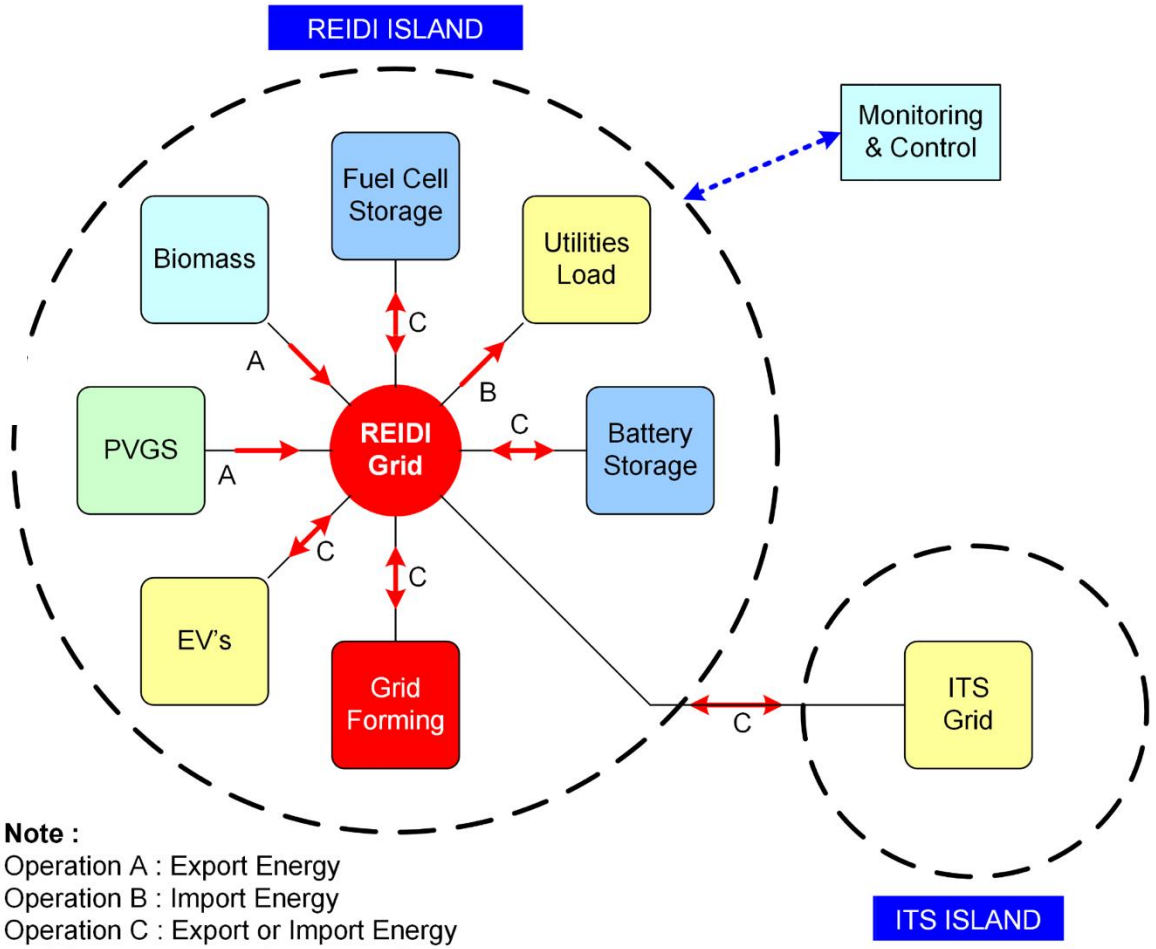


REIDI Testbed Location @ITS



REIDI: Renewable Energy Integration Demonstrator – Indonesia

INSPIRASI



Note :
Operation A : Export Energy
Operation B : Import Energy
Operation C : Export or Import Energy
PVGS : Photovoltaic Generation System
EV : Electric Vehicle





- **REIDI is modelled after REIDS to serve as a hub for Education, Research/Innovation & Industry engagement. (1.5ha, ~1MW)**

NTU and Odisha Research Collaboration

RCA signed on 07 December 2025

Parties Involved
- Energy Department, Govt. of Odisha
- IIT-Bhubaneswar
- NTU-Singapore

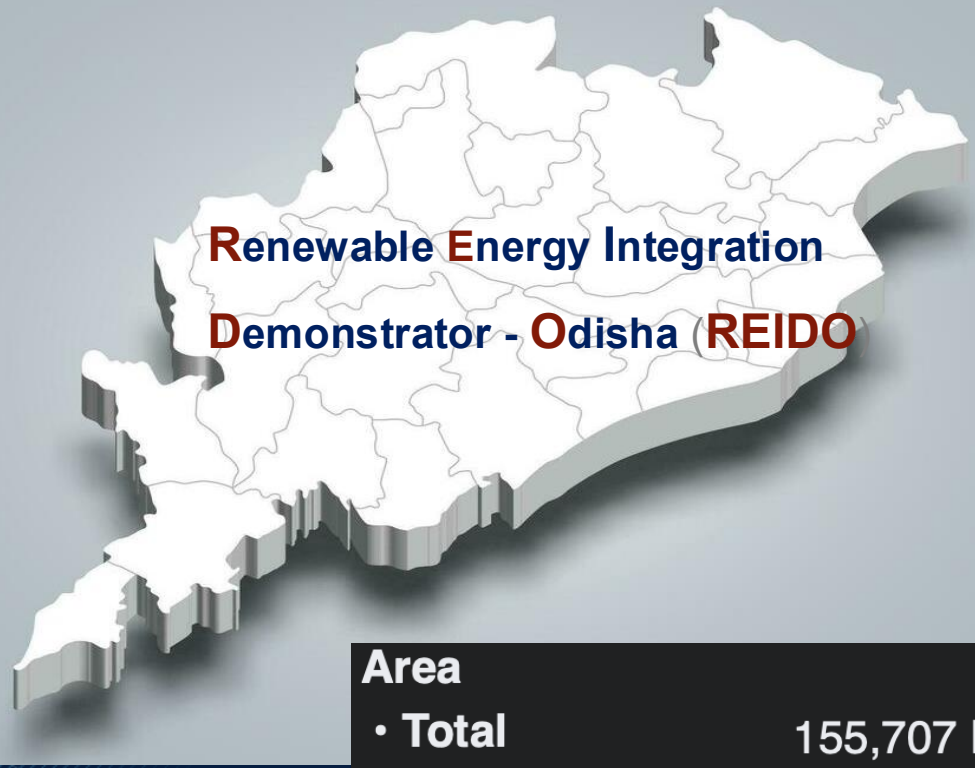
Scope Collaborative research in renewable energy with focus on efficiency improvement and cost optimisation.

Singapore



Area
- Total 735.6 km^2

Odisha



Area
- **Total** 155,707 km^2

"Restricted – Please do not distribute"

Odisha-NTU Collaboration

Multi-Energy-Platform for
Decarbonization and Integrated Sustainability
for the cities and communities in Odisha

Govt. of Odisha, GridCo, IIT-Bhubaneswar & NTU-Singapore

Project-1:
Waste to Energy (~100kW)

Project-2:
Agrivoltaic Solutions (1MW)

Project-3:
Advanced Energy Storage (4MWh)

Project-4:
Intelligent Microgrids (1.6MW)

Research  **Education**  **Industry**  **Community** 

"Restricted – Please do not distribute"

Multi-Energy-Platform for Integrated Sustainability

GRIDCO, IIT Bhubaneswar, Odisha & NTU Singapore

ESS banks



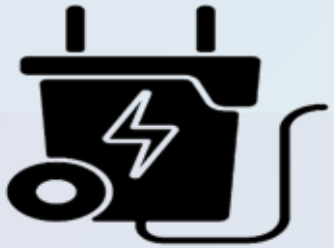
Power/Energy Management

Solar Farm



Decarbonization

Waste to Energy



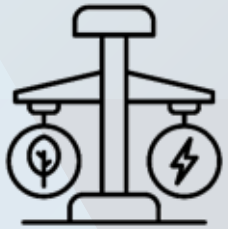
Recycling

Grid Control



Grid Services

Energy Balance



Power Quality

Design, Development, Demonstration and Evaluation of Grid Control Systems for MW-scale renewable energy-based Microgrid Platform Integrated with Waste to Energy & Agrivoltaic Solutions. Performance Validation & Improvements of Power Quality, Communication Architecture, System Reliability, Life-cycle Cost Analysis & Operational Safety Standards.

Project-1:
Waste to Energy Platform

Project-2:
Agrivoltaic Solutions

Project-3:
Advanced Energy Storage

Project-4:
Intelligent Microgrids

Future Grid Transformation and Energy Transition

Research Collaboration Agreement (RCA)

Partnership Framework



- Duration: 2 to 3 years
- R3D (DERs, SW/HW)
- Solutions Validation
- System Design/Control

Integrated Sustainability : Reliability and Resource Efficiency

||

Decarbonization : Environmental Impact and Resiliency

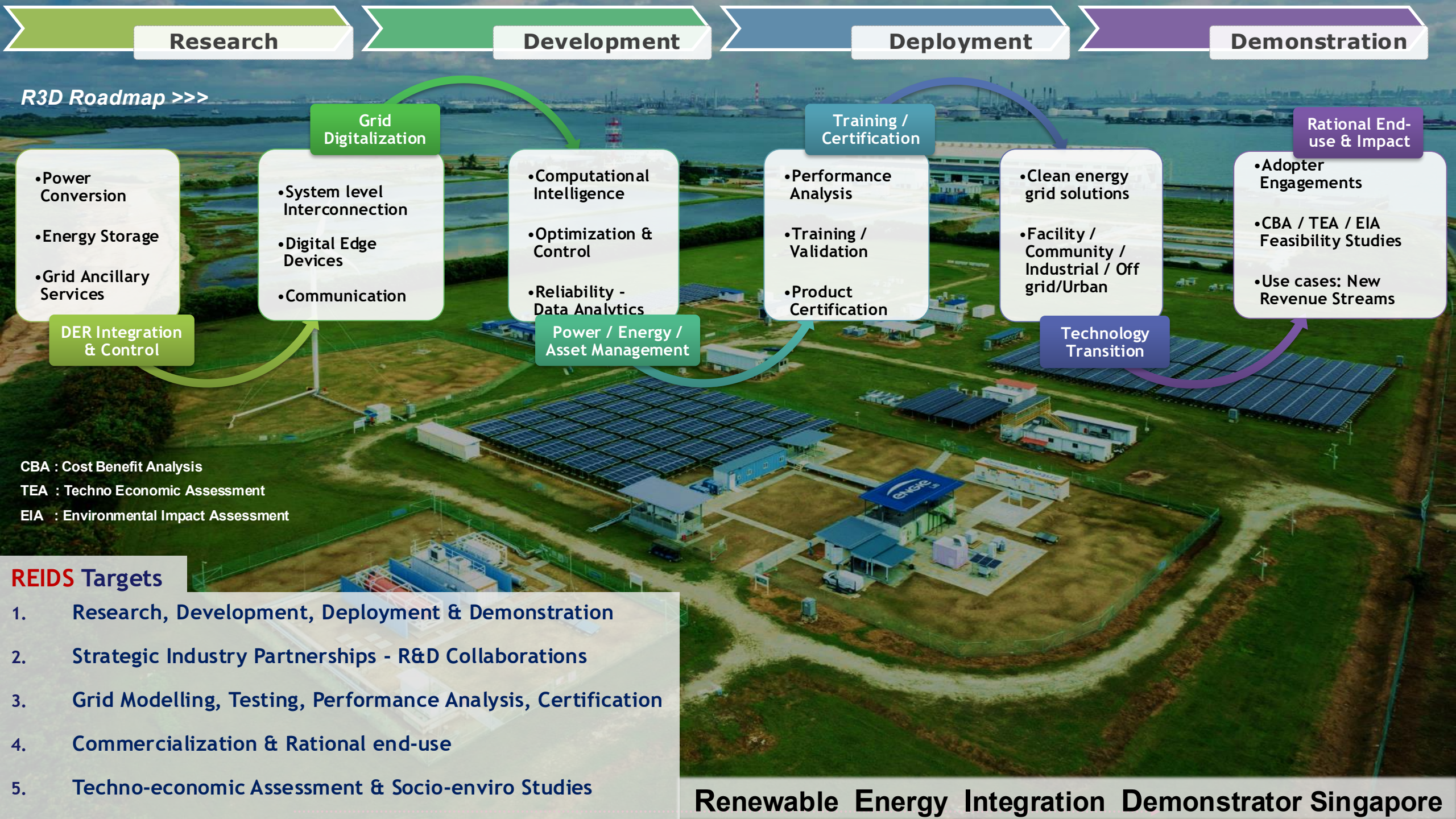
- Use Cases / Scope
- Future Energy Market
- Grid Management
- System Interfaces

REIDS Renewable Energy Integration Demonstrator – Singapore

NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE



- Research Platform for Singapore's Future Grid Transformation and Energy Transition



REIDS Targets

1. Research, Development, Deployment & Demonstration
2. Strategic Industry Partnerships - R&D Collaborations
3. Grid Modelling, Testing, Performance Analysis, Certification
4. Commercialization & Rational end-use
5. Techno-economic Assessment & Socio-enviro Studies

Renewable Energy Integration Demonstrator Singapore



Thank You

For more information on industry partnerships & high TRL R3D collaborations, please contact

prasannaiv@ntu.edu.sg

NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

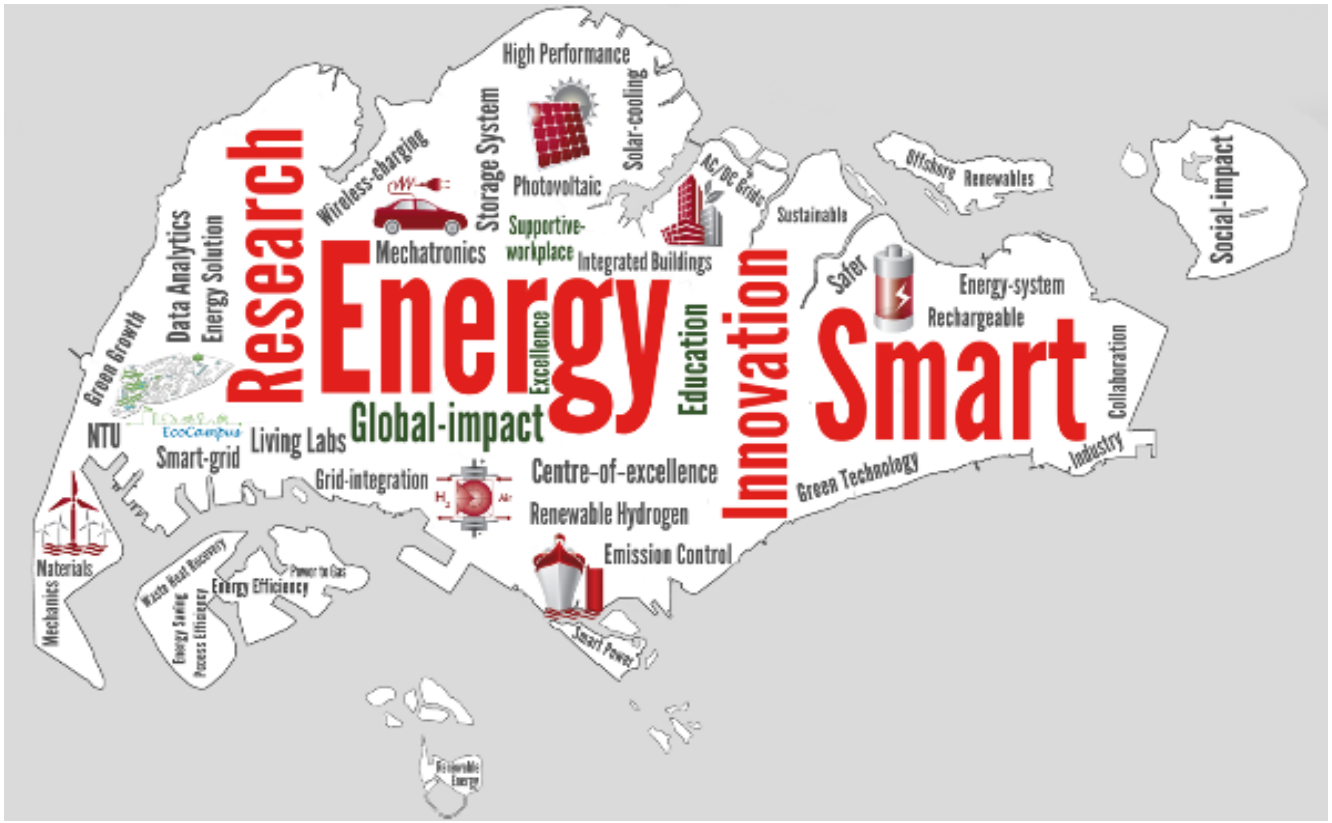
























Thank you!

https://erian.ntu.edu.sg

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