# SPORE@REIDS
# ACEF 2018 - DEEP Dive workshop
# Developing Sustainable Mini-Grids

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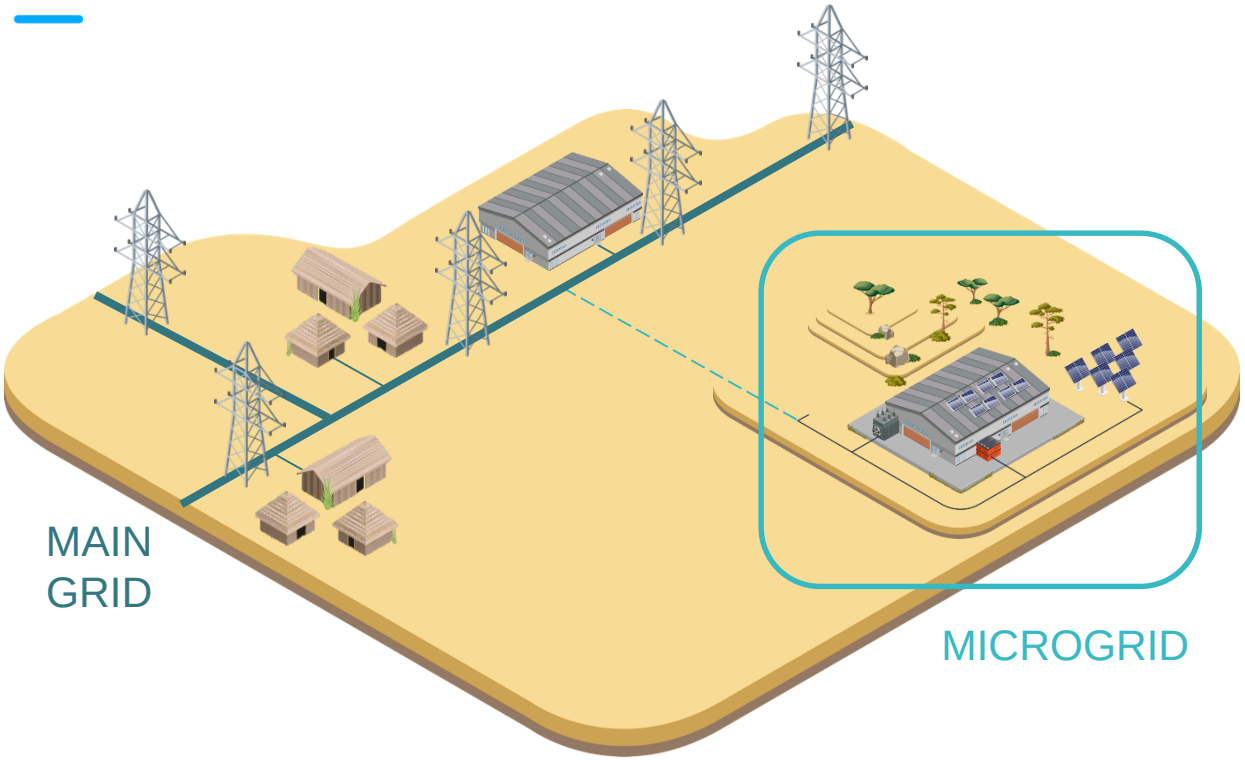
# What is the role of a microgrid?




**MICROGRID DEFINITION**

Small-scale power grid that **can operate independently** or in conjunction with the area's main electrical grid.

It **has its own power resources, generation and loads** and definable boundaries.

**Microgrids Operating Modes**

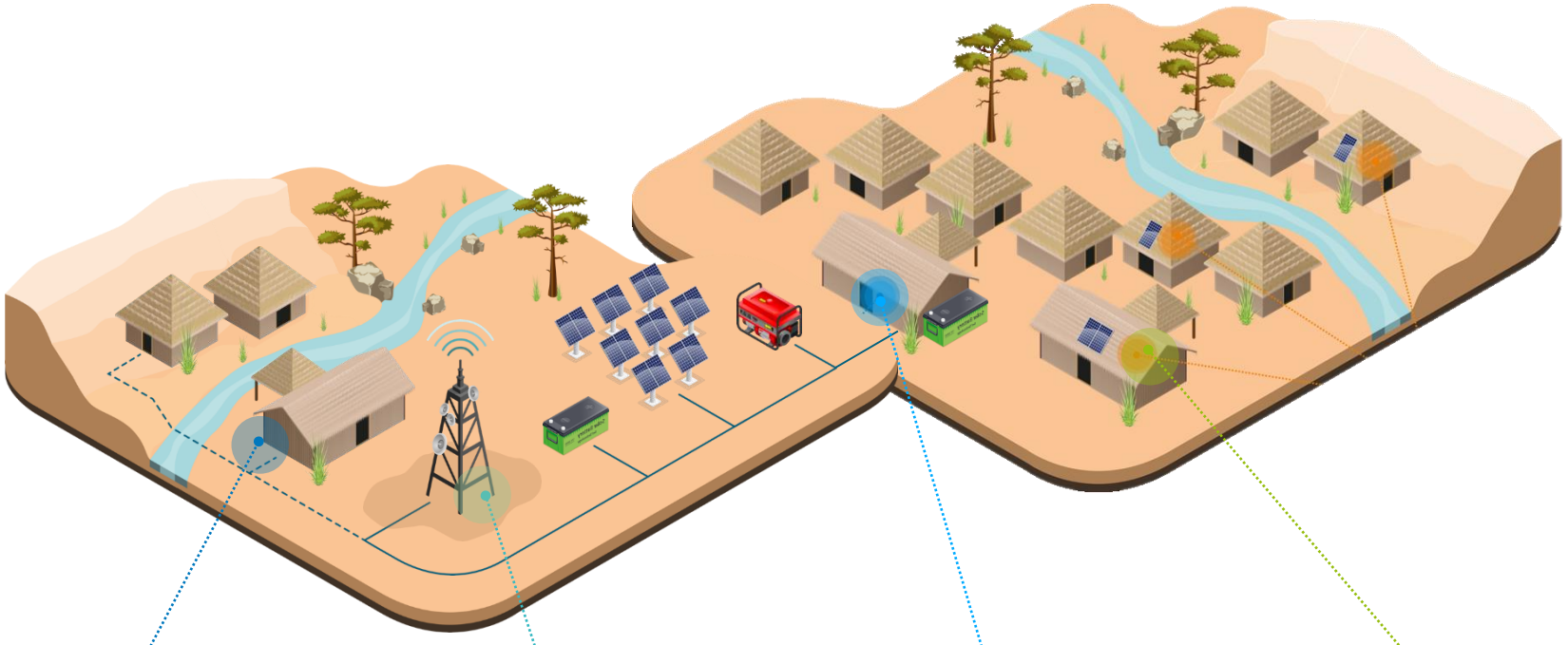
| | |
|---|---|
| Offgrid microgrid | Disconnected mode (always) |
| Ongrid microgrid | Connected mode |
| | Disconnected mode |

**When connected to the grid, a microgrid acts as a complement to it. It can be used to…**

- **Back up the main grid**, in case of outage or grid failure
- **Bolster the main grid** when the demand is heavy
- Incorporate **renewable energies** generation into the main grid, at a time when pollution is increasing an fossil fuels are depleting
- Gradually **modernize the existing grid**, adding modular bricks piece by piece

# In rural offgrid areas, Engie can also behave as a local utility or as an Energy Hub

## Example with a telecom tower as Anchor Load



**Minigrid approach**
Leverage on mobile network to set up a micro e-payment energy solution for individual/cluster of homes

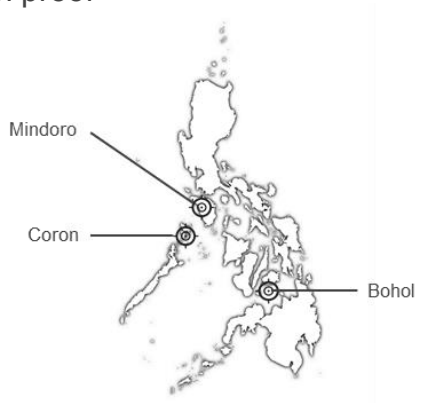
**Anchor Load**
Engie deploys PV and batteries for the tower, decreasing diesel consumption.

**Energy Hub approach**
Leverage on local retailers to set up a energy hub where people can charge their batteries and applicances for free

**Rooftop approach**
Allow residents with more consumption to charge their battery at their house, thanks to rooftop PV

# A sociological study has been conducted to improve our offers

- **Green Energy is not expected: Locals want Cheap and Reliable Energy**
  - **Let's beat Diesel ! O**ur target is to have a more competitive LCOE than Diesel Powered genset in remote location
- **Adopt a step by step approach**
- **Local context makes it very difficult to remove once and for all diesel gensets**
- **REIDS solution should be scalable**
- **Solution must be reliable in Tropical Conditions** and sometimes "typhoon proof




- **ENGIE µgrid should be able to connect to the national grid**

— Micro-grid as a back-up system (as grid quality can be a problem )

— National grid extension strategy represent a commercial opportunity

- **Innovative approach Innovation is not only about technology**

— RES are not always well known and welcomed → Raising awareness is required

— Our offer needs to include "Training of the locals" (First Basic O&M know-how)

- **Innovative Business Model**

— Regulation is a key issue

— Public grants are required for poor communities

# 02

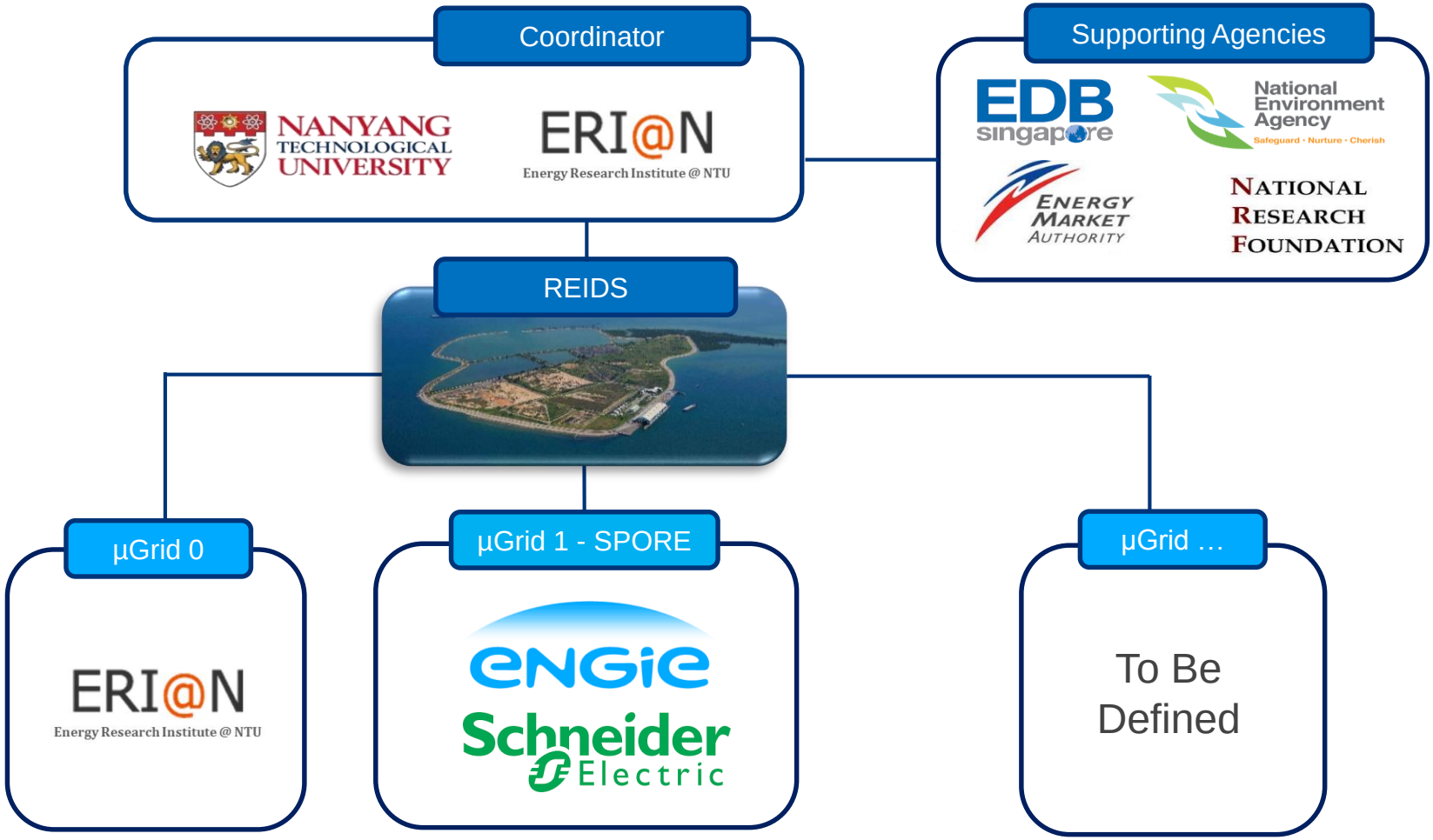
# Why SPORE @ REIDS ?

# Singapore Launches REIDS Project for South East Asia Islands

- **REIDS will be a demonstration platform for South East Asia** with the aim to deploy the technology in South Asian Islands.
- **REIDS is heavily subsidized by the Singaporean government** via its Economic Development Board, from 30% to more than 50% depending on the type of expenses.
- **REIDS is under the responsibility of NTU University, a partner of ENGIE Research,** and will be **its new applied R&D facilities located on Semakau Island**.


- *REIDS : **R**enewable **E**nergy **I**ntegration **D**emonstrator at **S**ingapore*
- *In October 2014, ENGIE signed an **MoU to become an official partner , and attended signature ceremony with other interested parties** (each one signed an non biding document showing its interest)*
- ENGIE project in REIDS is named **SPORE : *Sustainable Powering Off-grid REgions***

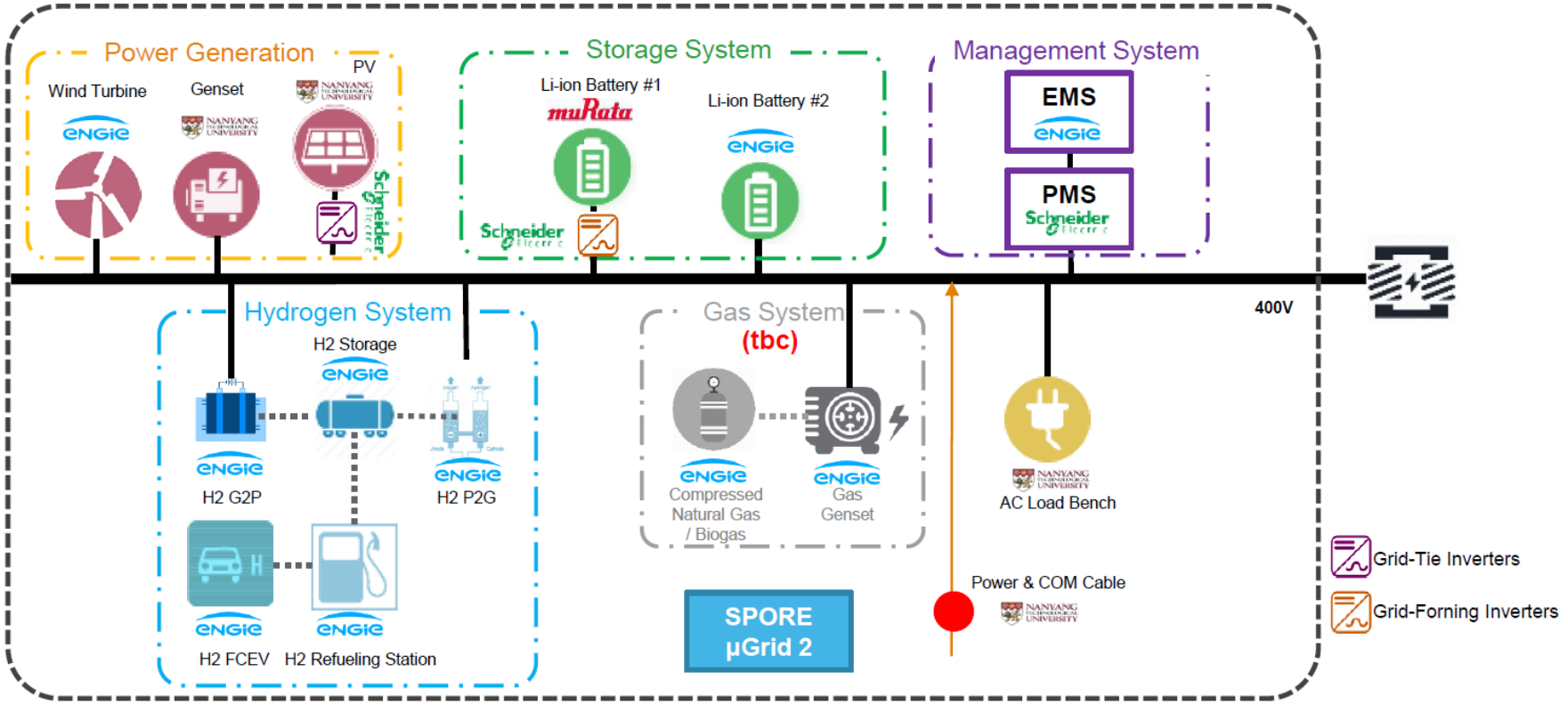
# **REIDS:** An ambitious program



# How does SPORE complete Engie's microgrids' projects?

| Projects | ELECTRIC VINE INDUSTRIES | powercorner brighten up your life |   |
|---|---|---|---|
| Type of project | Commercial Offer | Commercial Offer | R&D project |
| Region | Indonesia/APAC | Africa (Arusha/Tanzania) | Singapore/APAC |
| Power Capacity | **1,2kWp** per block | **16 kW** | **< 10MW** |
| Energy Sources | | + (back up) | + + + |
| Hydrogen Ready | - | - | ✓ |
| Engie entities involved | ENGIE (BU Indonesia) ENGIE Lab | TRACTEBEL ENGIE | SYMBIO ENGIE Lab TRACTEBEL ENGIE ENGIE Ineo ENGIE Laborelec electro ENGIE Services |
| Services provided to the final user | | | |
| Potential Market Target | Remote Villages | Remote Villages | Islands, Remote Villages and Resorts, Eco Districts, Campus, Industrial sites |
| Business model | Pre-paid | Pre-paid | R&D Project – No Offtaker |

# S'PORE Objectives : Setting up a demonstrator and test technologies in tropical environments



# More then 25 contributors: ENGIE is present on all the links of the value chain, a “reference factory” for the group

The REIDS/SPORE team

ENGIE Lab Singapore

Schneider Electric

The REIDS/SPORE contractors

BOLLORÉ LOGISTICS

ENGIE Services

Cripton Environmental Engineering (S)

Local entities

NANYANG TECHNOLOGICAL UNIVERSITY

EDB singapore

URBAN REDEVELOPMENT AUTHORITY

DSTA Defence Science & Technology Agency

BCA

National Environment Agency

CAAS Civil Aviation Authority of Singapore

SCDF The Life Saving Force

The REIDS/SPORE assets vendors:

ENGIE Ineo Ineo Sclé Ferroviaire

XANT

electro POWER SYSTEMS GROUP

SYMBIO

McPhy energy

The REIDS/SPORE consultants:

TRACTEBEL ENGIE

Asiamec Engineers

ENGIE Laborelec

ENGIE Lab crigen

JACOBS

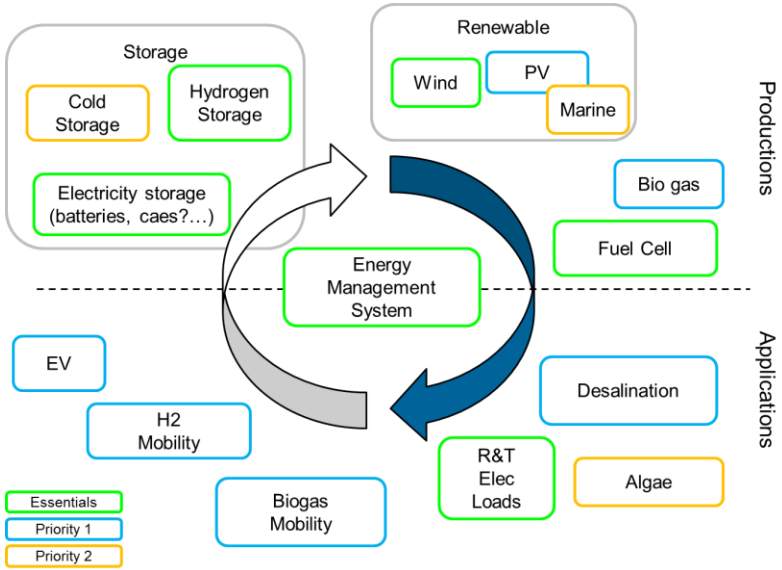
architects TEAM 3

ESC

**Engie develops collaborative R&D Programs with local Universities/Industries and bring an eco-system of partners and Start-Ups**

# What are multi-fluid microgrids ?

- **Typical microgrid solutions contain a limited number of energy sources**
  - Chosen based on the availability of energy at the location
  - Chosen based on what is commonly available (PV, Wind, …)
  - As a result : not all available energy sources are addressed, solutions are vendor dependent
  - As a result : not all energy needs of users are addressed by the microgrid
- **Multi-fluid microgrids contain other energy vectors than electricity**
  - Bio mass/ bio gas
  - Hydrogen
  - Heat/Cold
- **Multi-fluid microgrids address more applications / energy needs**
  - Mobility, cooking/heat, waste management, drinkable water production, Hybrid storage of energy
  - More diversity → more flexible → addressing more applications



# Microgrid challenges
# Interoperability

- **Manufacturers of inverters often limit compatibility with external systems**
  - Interface with the grid → power management system
  - Often kept ‘internal’ and difficult to expand beyond other external products
  - Intermediary solutions offered: regarding external products as variable loads
  - → vendor-lock limits other products in full potential
- **Often the client lacks technical expertise to provide enough counter weight with the manufacturer**
  - For smaller projects → off-the-shelf solutions (one manufacturer) → compatibility issue when expanding these systems
  - For bigger projects, a clear need for integrators which address the needs of customers by chosing the best fit of technology

# Added Value for ENGIE

1. **Support business development** *Massive media communication, references for the group, unique experience on remote island, biggest showcase in APAC, detection of new potential partners*
2. **Generate references for Engie entities**, *especially Engie Services (O&M, training…) and TE*
3. **Be part of the biggest microgrids initiative in APAC**: *test wide range of technologies, training, develop in-house tools and off/on-grid ready solution* **in tropical environment**
4. **Develop a prototype of multifluid Energy Management System**
5. **Capitalize, develop & share know-how** *based on a unique Return on EXperience*
6. **Promote Hydrogen**: *storage + mobility*
7. *Enable Engie to* **strengthen** *its* **bond with Local's ecosystem** *(authorities, universities,…) for lobbying and capturing future opportunities*
8. **Foster technical and commercial collaboration with an Industrial Partner**

# 03

# SPORE@REIDS
# Project achievement & next steps

# Main Deliverables and Achievements in 2017


## Design of the Microgrid

- Single Line Diagram
- Communication Architecture
- Technical Use Cases
- Test Protocols

## EPC of the Microgrid

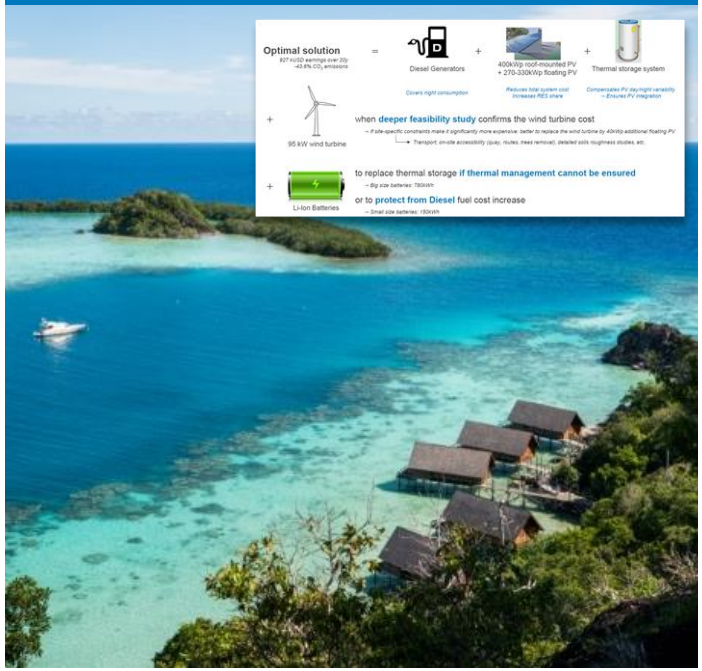
- Procurement of assets
- Logistics
- Permitting
- Installation of the assets

## R&D

- Pioneer sociological study of microgrid markets in Philippines
- First prototype of SCADA
- Communication with PMS

A First Business Case Brought by SPORE:

**Island Greenfield Project**



# Main Deliverables and Achievements in 2018

Completion of first version of ENGIE/SEI common EMS/PMS/SCADA solution

Full commissioning of the microgrid and corporate communication

Complete part of the tests defined and provide report on the results

Continuous EPC REX especially on O&M of microgrid

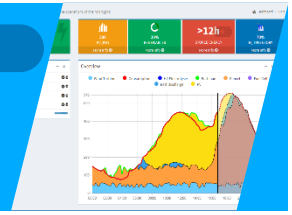
INNOVATION YEAR 2018
FRANCE SINGAPORE

# Proposed Roadmap 2019 – 2021

## R&D Tests and Analyses

- Multifluid microgrid performance tests with hydrogen
- Microgrid standards and grid code
- Microgrids interoperability

## In-house Tool Development



## Corporate Communication

## Return on Experience

## Microgrid Technology Evaluation

## Microgrid Services Evaluation


## Develop R&D Activities in APAC


**REIDS-SPORE**

- Demonstrates consortium model with NTU and SEI
- Massive media coverage in APAC region
- Becomes a real reference for ENGIE BUs


**Business Units**

- Recognizable work in various APAC countries
- Group strategy to push renewable and microgrids
- Very dynamic and good relation with ELS

**References Worldwide**

- ENGIE won a 50-year Comprehensive Energy Management Contract with The Ohio State University with

THE OHIO STATE UNIVERSITY

ENGIE (50%) and Axium Infrastructure US (50%) have won a 50-year concession valued at $1.165 billion USD to address The Ohio State University's energy sustainability goals for its 485-building campus in Columbus, Ohio, one of the largest university campuses in the United States.

https://www.osu.edu/

## Customer at a Glance: The Ohio State University

**Utility System Management**

485 buildings
24 million square feet
Consumes 676 GWh of power
1,896,860 kLbs of steam
67,055K kTon-hrs chilled water

**Supply Procurement Consulting**

676 GWh of power
4 BCF of natural gas and other energy commodities

**Sustainability Program Implementation**

Guaranteed minimum 25% reduction in energy consumption per square foot within 10 years
within a $250 million or less ECM program

**Academic Collaboration**

$150 million investment in academic initiatives
$50 million of which is devoted to a new Energy Innovation Center

## Academic Collaboration

As part of the Ohio State Energy Partners agreement, a $1.015 billion upfront payment was made to the university, representing the largest single investment in support of Ohio State's academic mission to date. An additional $150 million commitment was made to support academics in those specific areas requested by students, facility, and staff during the bidding process. These include:

- **A $50 million Energy Advancement and Innovation Center for energy research and technology commercialization.** The center will be a hub where faculty members, students, alumni, ENGIE researchers, local entrepreneurs, and industry experts can work together on the next generation of smart energy systems, renewable energy, and green mobility solutions.
- **A $25 million endowment for undergraduate, graduate, and post-grad/professional student financial aid projected to generate at least $1 million a year in student support for at least 50 years.**
- **Funding of $5 million for at least 500 internships over the life of the agreement.**
- **An investment of $20 million in sustainability and staff development**, including $15 million to support sustainability initiatives outside the scope of the Ohio State Energy Partners.
- **The dedication of $9.5 million in endowment funds to support five faculty positions.**
- **Contributions of $40.5 million to university-related philanthropic organizations.**

*https://www.osu.edu/energymanagement/index.php?id=65*

# Appendix

# Interest and Complexity of SPORE

The largest Wind- Turbine in Singapore: 42 meters and 100 kW

A multifluid system that combines electricity and hydrogen

Innovative technology to increase renewables integration up to 100%

Different storage technologies (li-Ion, supercapacitor, hydrogen)

Efficient and powerful microgrid management solutions

# Engie can bundle its energy services with other services

## Example of a mine

**We can offer additional services within the PPA**

- Security services
- Heat and cold
- Water treatment
- Waste disposal
- Diesel supply
- Facility management
- Maintenance of the local telecommunication equipment

**Miners live next to the mine and might need energy, water, heat and cold supply at home**

**Processes such as leaching or hydrocyclones require clean water**

**Processes such as pyrometalurgy require heat or cold**

**Trucks and mobile machines run on diesel**

**After filtration, chemical wastes must be disposed or treated**

**The mine requires facility management (security, cleaning etc)**

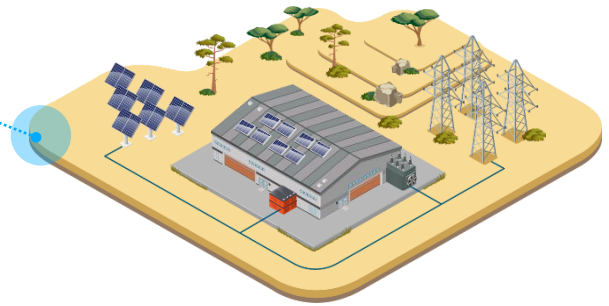
# Examples of microgrids applications

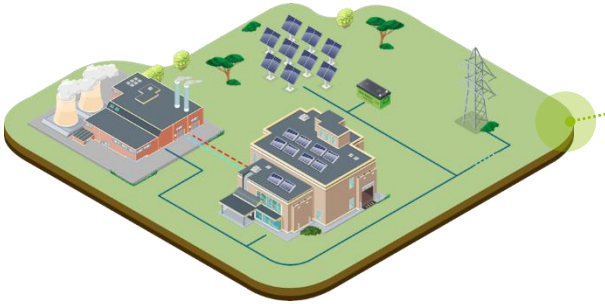
## Telecom Towers Electrification

Access to energy
O&M cost reduction (enhance lifetime of gensets)
Fuel consumption reduction
Constant power supply

## Backup Power for Industrials enduring frequent outages

Constant power supply
O&M cost reduction (enhance lifetime of gensets)
Fuel consumption reduction





## Grid connected Microgrid for a Datacenters

Super reliable power supply
Power quality increased
Ability to hedge against grid tarrif fluctuations

# Battery & Energy Storage System

Storage System

## The technology

◊ **SCLE BATTGRID 100** = energy storage system

◊ **LG Li-ion battery modules** for an installed capacity of **200kWh**


## What are the benefits

◊ **Easy transport and installation** = entire system inside a single container

◊ **Modularity** = ESS working **regardless of the type of battery selected** (Li-ion, lead). Power and capacity can be increased to 400kW & 800kWh with same ESS

◊ **Resistant to tropical conditions** through an isolated and air-conditioned container

## The Battery & ESS in figures

◊ 30 battery modules of 6.6 kWh

◊ 20 ft Container

◊ Installed Power: 200 kW

◊ 5.5 tons


ENGIE Lab Singapore

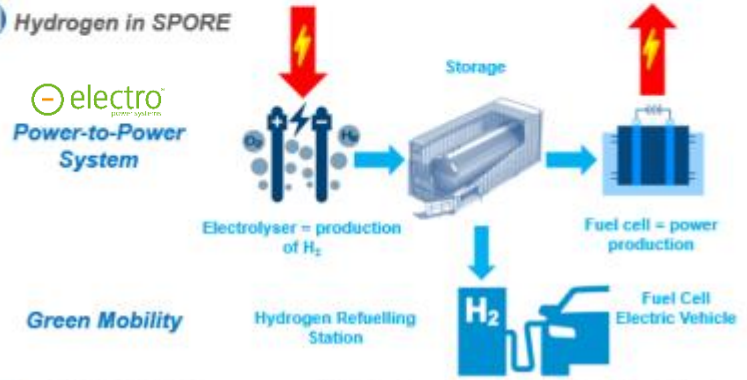
# The Hydrogen Chain 2018

Hydrogen Chain 1

## Hydrogen today

- **Hydrogen** is the most abundant element in the Universe. **Naturally present in the atmosphere,** it can also be **easily produced** from **water through electrolysis**
- Used as **storage**, it allows the **development of decentralized renewable energy**
- Used as fuel, hydrogen makes it possible to **generate electricity using on-board hydrogen fuel cells**. This makes it a **complementary energy for electric cars and vehicles** equipped with gas-fueled internal combustion engines

## Hydrogen in SPORE




- On SPORE, ENGIE showcases a **multifluid microgrid** with a **complete $H_2$ chain** through a **power-to-power system** which can be used to **supply the refuelling station** of the **fuel cell car** or as a **storage facility.**

# Hydrogen Refuelling Station

Hydrogen Chain

McPhy energy

## The technology

- **McPhy McFilling 20-350 = Hydrogen Refuelling Station**
- Hydrogen **compression, storage and distribution** to vehicles up to 350 barg

## What are the benefits?

- **Enable Power to Mobility**
- Corner stone of the **multifluid aspect of the microgrid**
- Up to **20 vehicles refilled per day**

## The HRS in figures

- High Pressure Buffer: 11.2 kg
- Flow rate: 24 $Nm^3/h$
- Nominal pressure: 420 bar

***Refills the car in only 5 minutes!***

ENGIE Lab Singapore

# Fuel Cell Electric Vehicle

Hydrogen Chain H1

## The *technology*

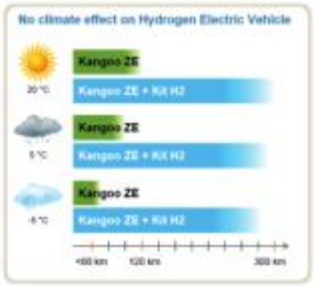
◊ **Renault Kangoo Z.E.** = Electric Vehicle

◊ **Modified by Symbio FCell** to add a **Fuel Cell** = **battery extended with Hydrogen**

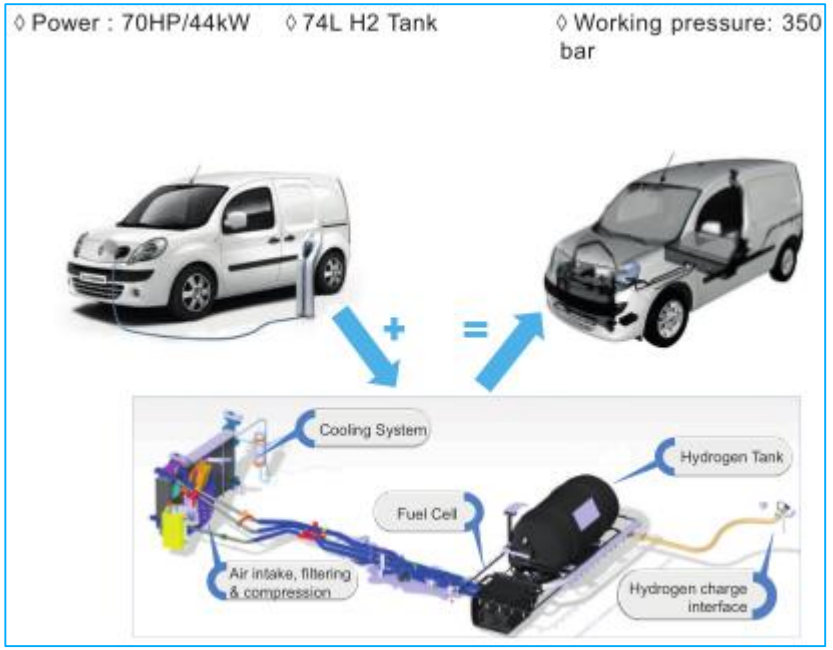
## *What are the benefits?*

◊ **Enhanced cars range** = battery re-charged by the **Fuel Cell**, refilled in **less than 5 minutes** for **200 km autonomy**

◊ **Green mobility** = reduce your $CO_2$ footprint




◊ Power : 70HP/44kW ◊ 74L H2 Tank ◊ Working pressure: 350 bar



# Microgrid Challenges
## Increase the level of renewable energies penetration while maintaining stability

**PENETRATION of renewables**
Peak power of renewables (kW) / average load (kW)

≠

**CONTRIBUTION of renewables:**
Annual solar energy production / annual energy consumed