Use of graphene by an energy utility
ENGIE – A global player in the energy business (2015)

Power
- No.1 Independent Power Producer (IPP) in the world.
- No.1 producer of non-nuclear power in the world.
- 115.3 GW of installed power-production capacity.
- 10.5 GW of power capacity under construction

Natural gas
- No.2 purchaser of natural gas in Europe.
- No.3 importer of LNG in the world.
- No.1 distribution networks in Europe.
- No.2 transportation network in Europe
- A supply portfolio of 1,296 TWh.

Energy services
- No.1 supplier of energy and environmental efficiency services in the world.
- 1,300 sites throughout the world.
- 202 district heating and cooling networks operated worldwide

74,7 billions € in 2014 revenues, 6-7 billions € of gross investment per year over 2014-2016
152,900 employees – 900 researchers – 11 R&D centers
Operations in 70 countries
ENGIE: Operate across the energy value chain
CRIGEN – An expertise center for energy related technology

CRIGEN creates value through :

- the **conception and the validation of industrial grade solutions** for performance and security enhancement in the whole gas and RE chain of value
- The **development of new commercial offers and services for end customers**
- The **valorization of a high expertise and test facilities unique in EU** for gas and RE industries

Renewable energies & sustainable mobility
- PV test bench
- G-City concept car

High efficiency buildings & connected house
- Experimental building
- Environmental chamber
- Smart-digital lab

Materials & structures
- Corrosion test bench
- PEHD & PO tests
- Metallic & Non-metallic materials characterization

Energy metering & network equipments
- Meters test bench
- Security & operational equipments test benches

Gas quality, detection & odorization
- Gas composition & energy content (GC & LC)
- Sulfur content analysis
- Trace compounds analysis

Industrial processes
- Industrial furnaces
- Industrial boilers

72 M€ of incomes, 7 test facilities, 360 employees, 1 HPC center
Three development axis linked to Graphene

Drones
- Services
- Security
- Operations

IoT
- Smart homes
- Smart cities
- Smart grids (gas & electricity)

Nanotechnologies
- Nanosensors
- Nanostructured processes
- Nanomaterials
- Energy harvesting
- Wireless communications
Activities: Bridging industrial needs and technological breakthroughs

- **Industrial ecosystem**
  - End user
  - Operational need
  - Functional need

- **Development**
  - Startups, companies
  - Product: Functioning prototype
  - Proof of concept
  - Industrial prototype
  - Possible exchange level
  - Translation of functional need into technical solution

- **Innovation ecosystem**
  - Startups, companies, academics
  - Concept
  - Technological building block
  - Adaptation of technological building block

Increasing abstraction
Drones & Robotics Lab: Cover BUs businesses

Businesses oriented approach

SERVICES
- Public relationship
- Telepresence
- Person helping & services
- Comfort & cleaning
- Logistic

SECURITY
- Outdoor and indoor security monitoring (watchdog)
- Indoor environment monitoring (Datacenter, offices, …)

OPERATIONS
- Handling
- Detection and analyze
- Inspection
- Industrial cleaning
- Cartography / topography / 3D reconstruction
- Installation

Adapted tools

PLATFORMS & SENSORS
• UAV: Drones
• UAG: indoor, outdoor robots
• UUV robot: sub-sea robot
• Services Robots
• Sensors: thermography, LIDAR...
• Navigation: indoor & outdoor

FABLAB
• Programming stations
• Mechanic stations: 3D printing, laser cutter
• Electronic conception stations
• Simulation stations

QUALIFICATION AREA
• 700 m² industrial indoor area
• 100m² secured aerial area
• 20ha industrial & urban outdoor area

SHOW ROOM
Under construction …
Integrating smart management at every levels of ENGIE’s businesses
Nanotechnologies for energy and associated services

Nano-instrumentation
  e.g. Gas analysis
  • Low unit cost
  • Low-power
  • Natively communicating

Nano-structured processes
  e.g. Catalysis
  • Low Capex
  • High efficiency
  • Modular

Nanomaterials
  e.g. Graphene based batteries
  • Energy conversion
  • Energy storage
  • Appliance and processes efficiency

Energy harvesting
  e.g. Heat network
  • Ambient energy sources
  • Energy storage and management
  • Low energy consumption sensors

Long-range radio systems
  e.g. industrial infrastructure
  • for sensors monitoring
  • Low energy

Drivers: techno-economical efficiency, environmental impact et life cycle.
Graphene: A Cross applications material

All printed RFID

Flexible light weight energy storage

Flexible low energy sensors

A detectable, connected polyethylene gas pipeline developed at CRIGEN in conjunction with RYB (max. depth: 1.5 m, accuracy: 1 cm).

Graphene is an enabling material with industrial applications at hand.
Better processes

Membranes for chemical purification

Solar electricity production

Running: 201 MW
Building: 30 MW
Planning: 749 MW

Energy storage

Energy conversion (catalysis).

Core business includes services to energy networks, cities, offices and home.

Security of on field operators is a key issue.

Graphene may be a key component to smart professional clothing.
ENGIE is an operative company in a wide variety of activities.

R&D activities focus on bringing competitive advantages to those business end-users.

ENGIE 3D Strategy:
- Digitalization
- Decarbonization
- Decentralization

This three axis require disruptive innovations.

ENGIE Lab CRIGEN notables R&D activities:
- Drones & Robotic
- IoT
- Nanotechnologies & Sensors

Graphene applications are enabling technologies. ENGIE is an end-user and is willing to develop the right network of partners in order to develop the right solution for energy business.