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

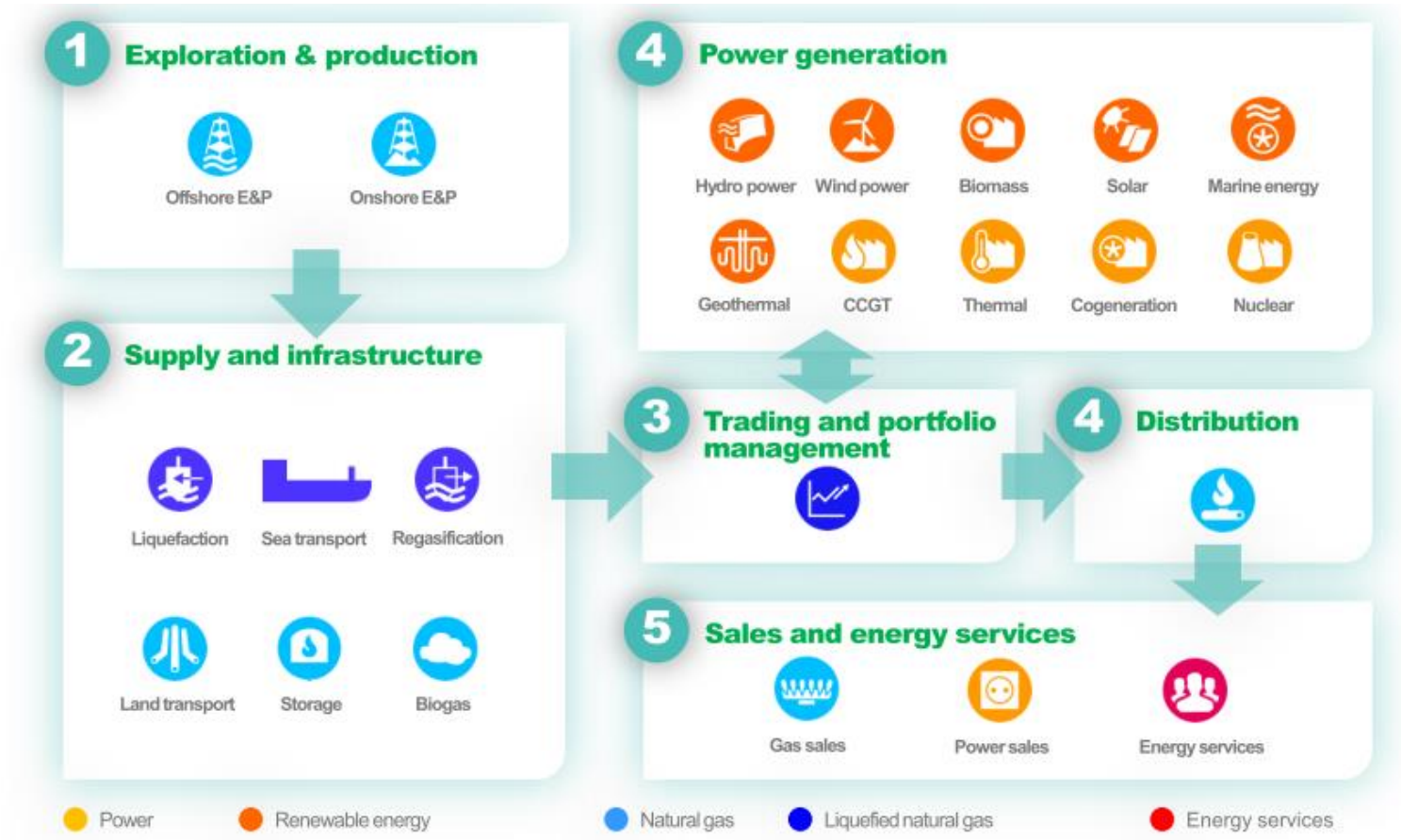
- No.2 purchaser of natural gas in Europe.
- No.3 importer of LNG in the world.
- No.1 distribution networks in Europe.
- No.2 transportation network in Europe
- A supply portfolio of 1,296 TWh.

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

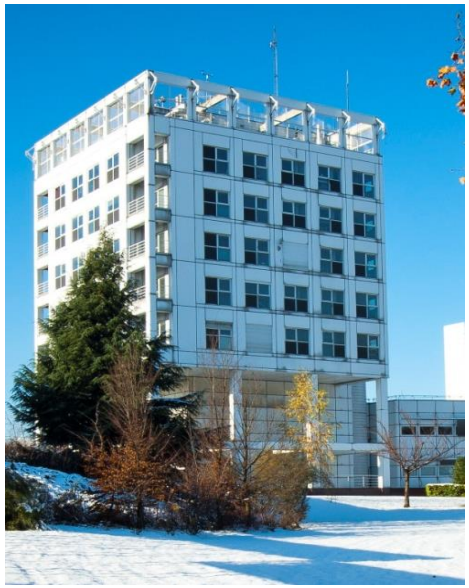
- PV test bench
- G-City concept car

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

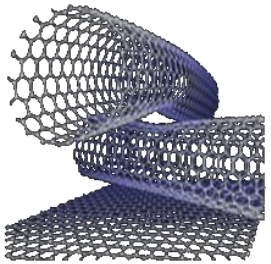
Operations

IoT

Smart homes

Smart cities

Smart grids
(gas & electricity)



Nanotechnologies

Nanosensors

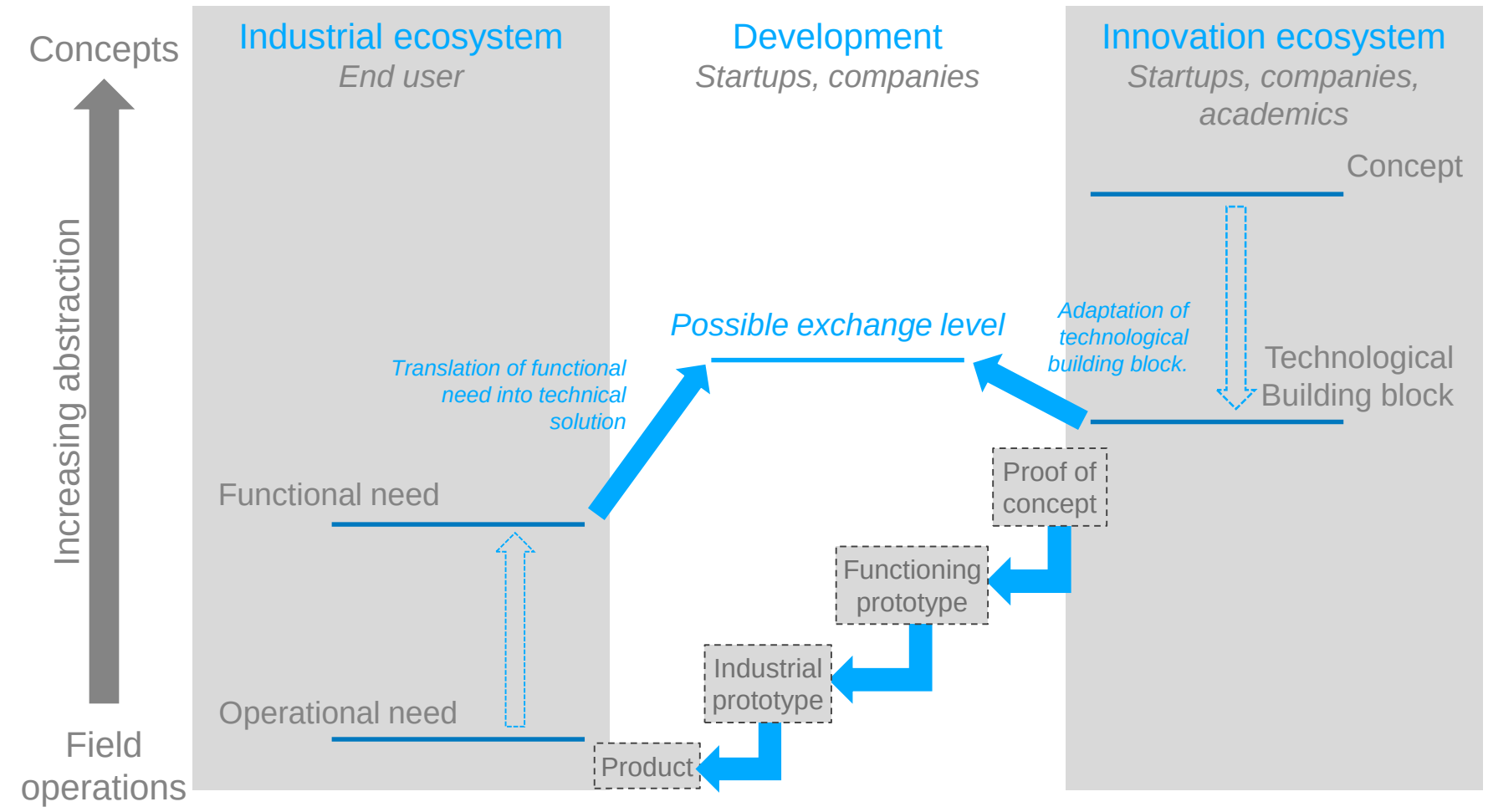
Nanostrutured processes

Nanomaterials

Energy harvesting

Wireless communications

Activities: Bridging industrial needs and technological breakthroughs



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

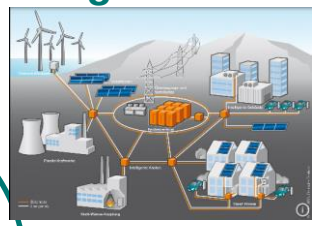
SHOW ROOM
Under construction …

IOT lab

Integrating smart management at every levels of ENGIE's businesses

Gazpar

Smart grid



ENGIE Ineo

Smart City

ENGIE Cofely

SIGFOX

VERTUOZ

Smart Bulding

Smart Factory

ENGIE SIGFOX M2M

homni

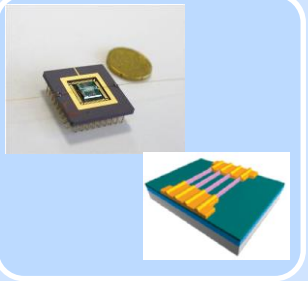
Quby

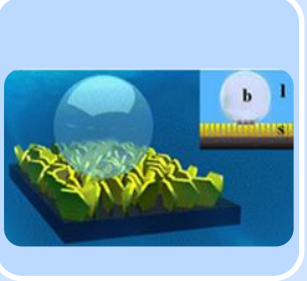
Smart Home

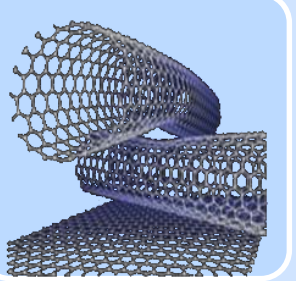
storengy RTLS

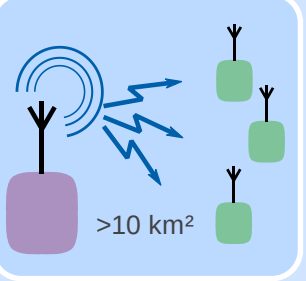
ENGIE PARTICULIERS

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

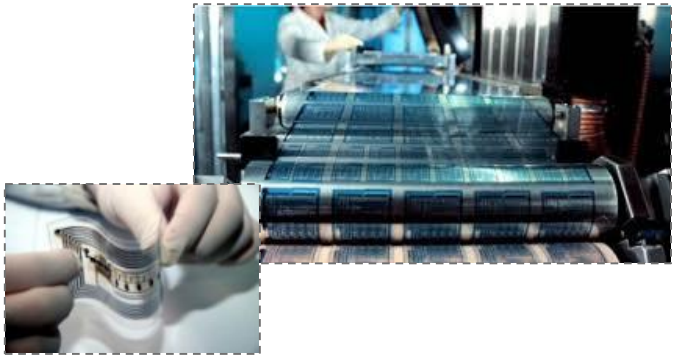
e.g. industrial infrastructure

- for sensors monitoring
- Low energy

Drivers: *techno-economical efficiency, environmental impact et life cycle.*

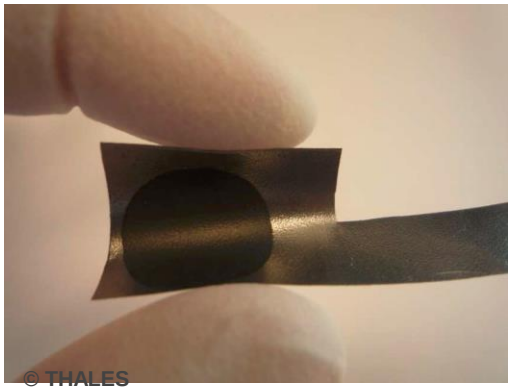
Graphene : A Cross applications material

All printed RFID



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

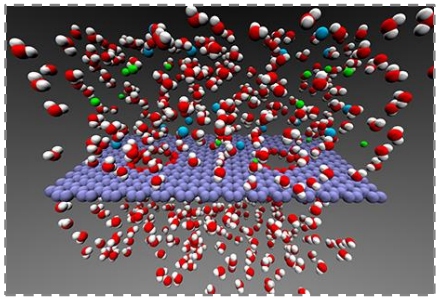
Flexible light weight energy storage



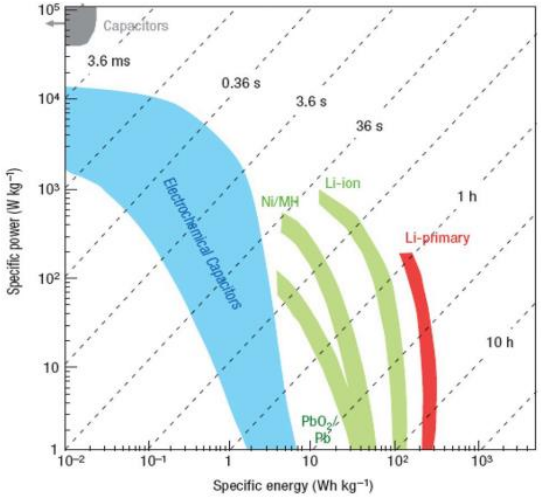
Flexible low energy sensors

Graphene is an enabling material with industrial applications at hand.

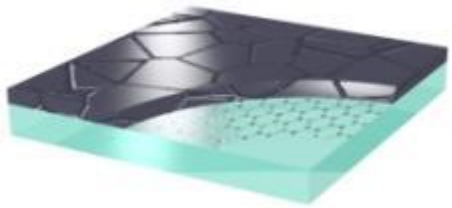
Better processes



Membranes for chemical purification

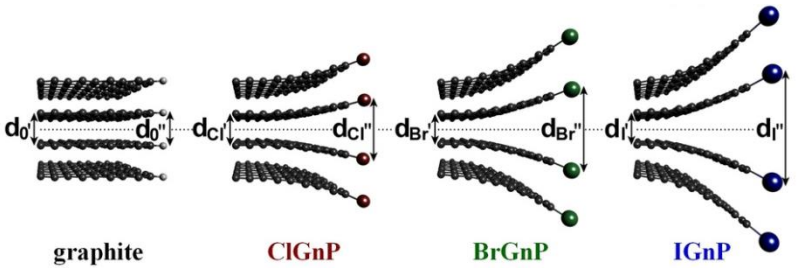


Energy storage



Solar electricity production

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



Jeon *et al. Scientific Reports* **3**, 1810, 2013

Energy conversion (catalysis).

Operational needs

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.

© EOLANE

Take away message – A willing End-User

- 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 a end-user and is willing to develop the right network of partners in order to develop the right solution for energy business.

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