Innovation in Advanced Materials & Nanotechnologies at CEA Liten.

Perspectives in Horizon Europe

Karim Sidi-Ali-Chérif

Marina Urbina

FIT-4-NMP event in EuroNanoForum 2021 5th May 2021

About CEA

CEA is the French Alternative Energies and Atomic Energy Commission

Defense & Security	Nuclear Energy	Fundamental Science	Technological Research




- 19,925 staff
- 5.3 b€ annual budget
- 700+ patent applications per year
- 600+ industrial partners
- 200+ startup created since 1972
- 400+ ongoing European projects

About CEA-Liten

CEA-Liten develops innovative technologies for the clean energy transition

- renewable energy (solar photovoltaics, solar thermal energy)
- energy storage and conversion (batteries, hydrogen, heat storage and conversion)
- closing the carbon cycle (power-to-X, biomass-to-X)
- energy systems (energy-efficient buildings, power grids, heating networks)
- advanced materials and circular economy

975 staff

200+ patent applications per year

138 M€ annual budget

200+ industrial partners
100+ ongoing European projects

Grenoble campus

Chambéry campus

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STRATEGIC RESEARCH AREAS at LITEN

#1

LOW-CARBON POWER GENERATION

Decentralized Renewable Energy

- Utility Scale Production (PV)
- High added-value PV Solutions (BIPV, autonomous systems)

#2

MANAGEMENT OF ENERGY GRIDS

Components & Digital Tools for a « Smart Energy Grid » with **Demand Management**

Solutions for Flexibility

- Storage (thermal, electro-chemical)
- Hydrogen Vector
- Sector Coupling

#3

IMPROVE ENERGY EFFICIENCY

Material & Energy Efficiency

- Additive Manufacturing
- Structural Electronics

Reducing the Environmental Footprint

- Life-Cycle Analysis & Tech-Eco
- Recycling

Closing the Carbon Cycle

Innovation along the full value chain

SYSTEMS

DEMONSTRATION

COMPONENTS

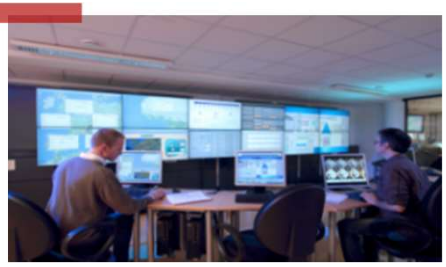
INFORMATION SYSTEMS

PROCESSES

ENERGY MANAGEMENT SYSTEMS

MATERIALS

MULTI-SCALE MODELLING



RENEWABLE ENERGY – solar photovoltaics

Materials

Silicon materials

Cells

Silicon cells
Tandem cells

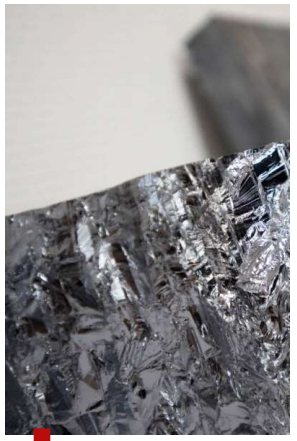
Modules

Silicon modules
Tandem modules
Integrated photovoltaics

Systems

Power electronics
Energy management

End of life



Dismantling, recycling

Characterization, test & monitoring

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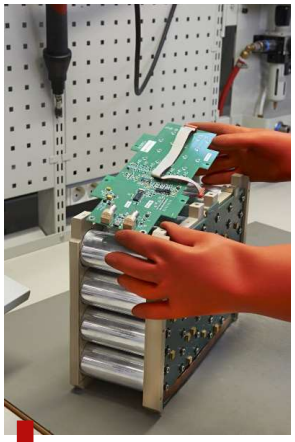
ENERGY STORAGE AND CONVERSION – batteries

Materials → **Cells** → **Packs & BMS** → **End-of-life**

From g to kg

1000m² dry room
From 1mAh
to 70Ah



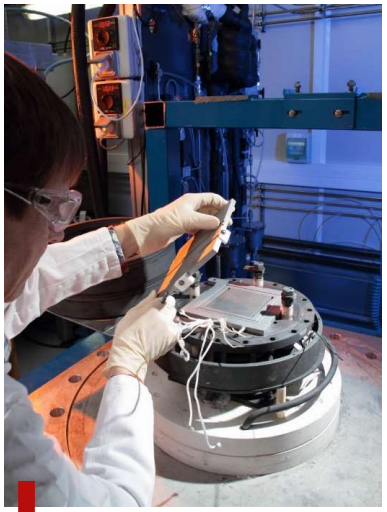
From 100Wh to
100kWh

Second life,
dismantling,
recycling

Multi-scale modelling & characterization

ENERGY STORAGE AND CONVERSION – hydrogen

H_2 production | **H_2 storage** | **H_2 use**



Solid-oxide steam electrolysis

Compressed storage
Liquid organic hydrogen carriers

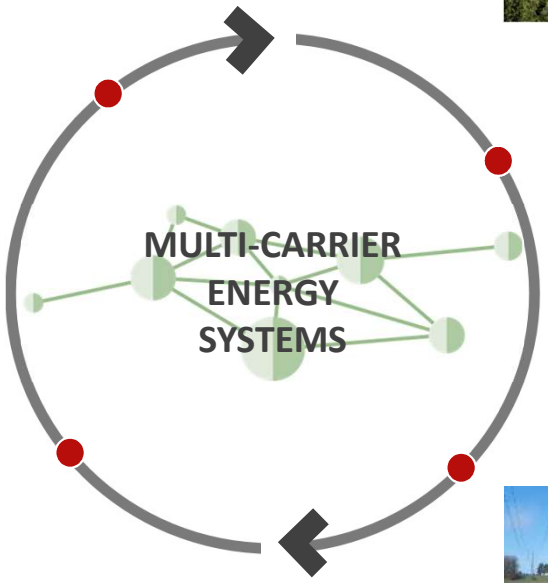
PEM and solid-oxide fuel cells
CO_2 conversion into fuels and chemicals

Modelling, characterization and techno-economic assessments

ENERGY SYSTEMS – tools and methods

Modelling & simulation
- Multi-criteria analysis
- Optimal sizing
- EMS development

Validation at pilot scales
- Experimental buildings
- Electric smart grid platform
- Thermal smart grid platform



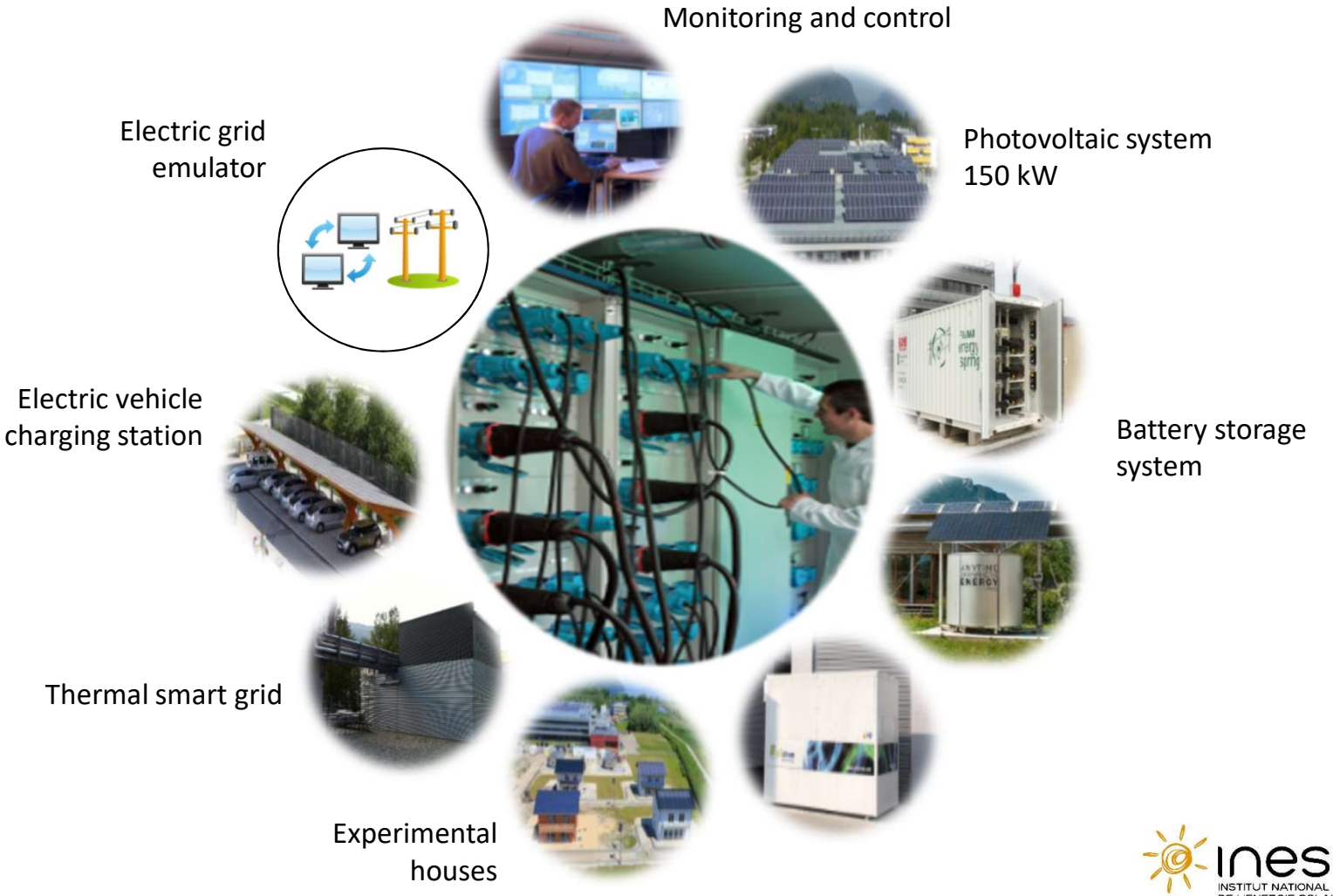
Monitoring

Field deployment

ENERGY SYSTEMS – experimental building platform

- 4 instrumented full-size experimental houses (‘INCAS’, 100 m² each)
- 10 rooftop component test benches (35 m² each)
- 4 quasi-adiabatic cells (‘PASSYS’, 3×3×5 m³ each)
- 1 versatile facility (‘FACT’, 8-meter-high twofloor building)

ENERGY SYSTEMS – electric smart grid platform



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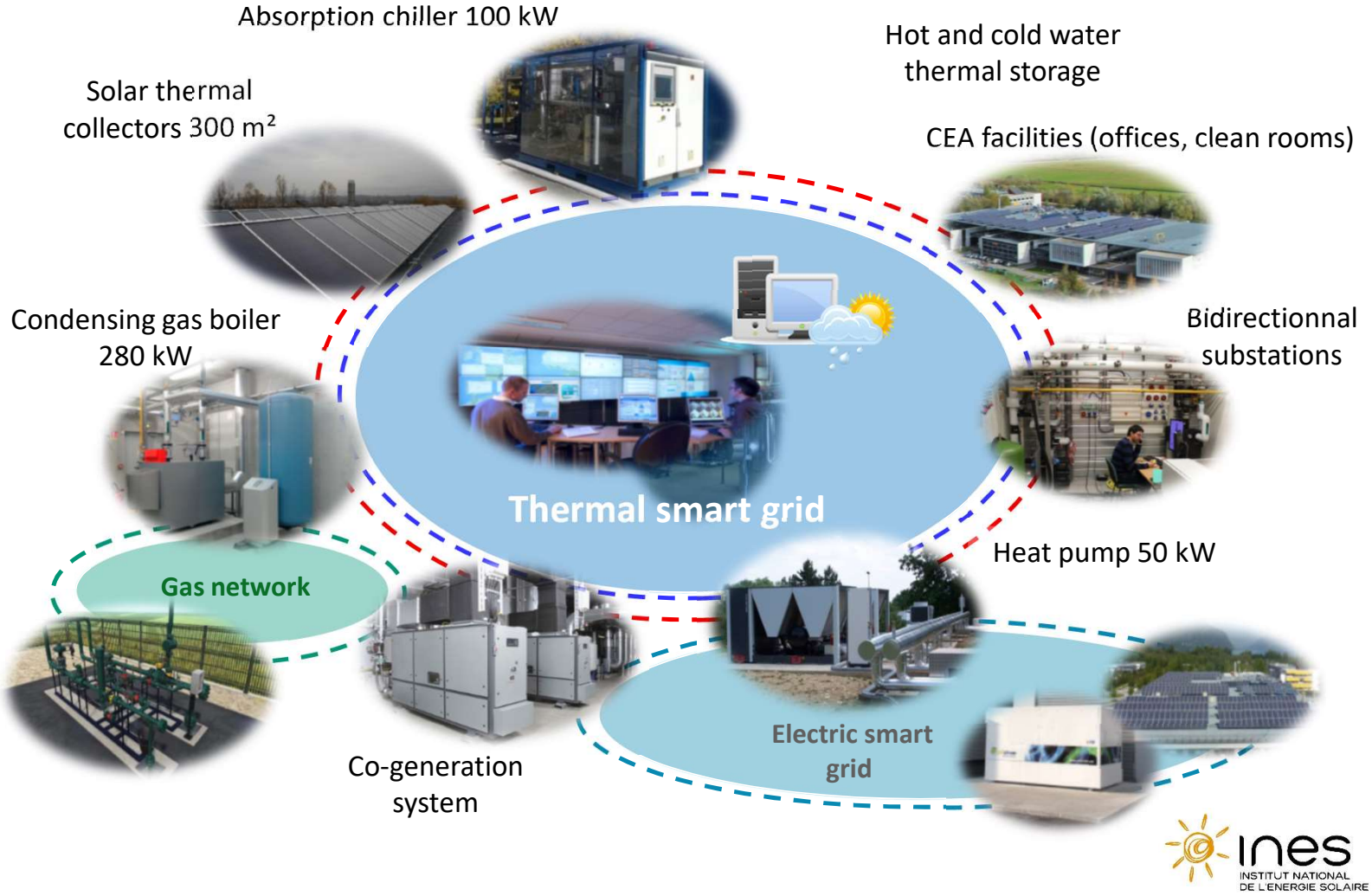
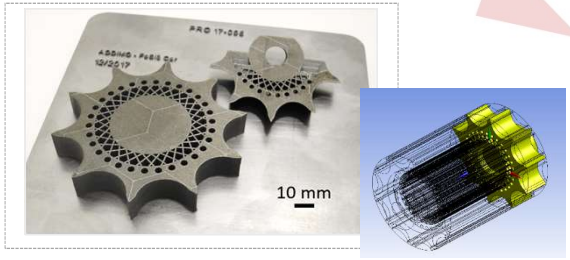
ENERGY SYSTEMS – thermal smart grid platform

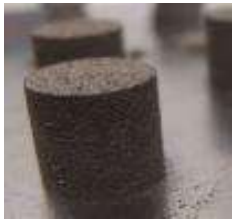


ADVANCED MATERIALS AND CIRCULAR ECONOMY

Additive manufacturing and **powder metallurgy**



Reduction or **substitution** of **critical raw materials** (photovoltaics, batteries, fuel cells, magnets, etc.)



REDUCE

REUSE

RECYCLE

Second life (batteries)

Dismantling and **recycling** (photovoltaics, batteries, magnets)

CURRENT ENVIRONNEMENTAL ISSUES

INNOVATION OPPORTUNITIES FOR MATERIALS & PROCESSES WITH CIRCULAR ECONOMY FOCUS

Collective awareness

Raw materials limitation

Impact of environnemental degradation on health

Climate change

Environnemental regulations

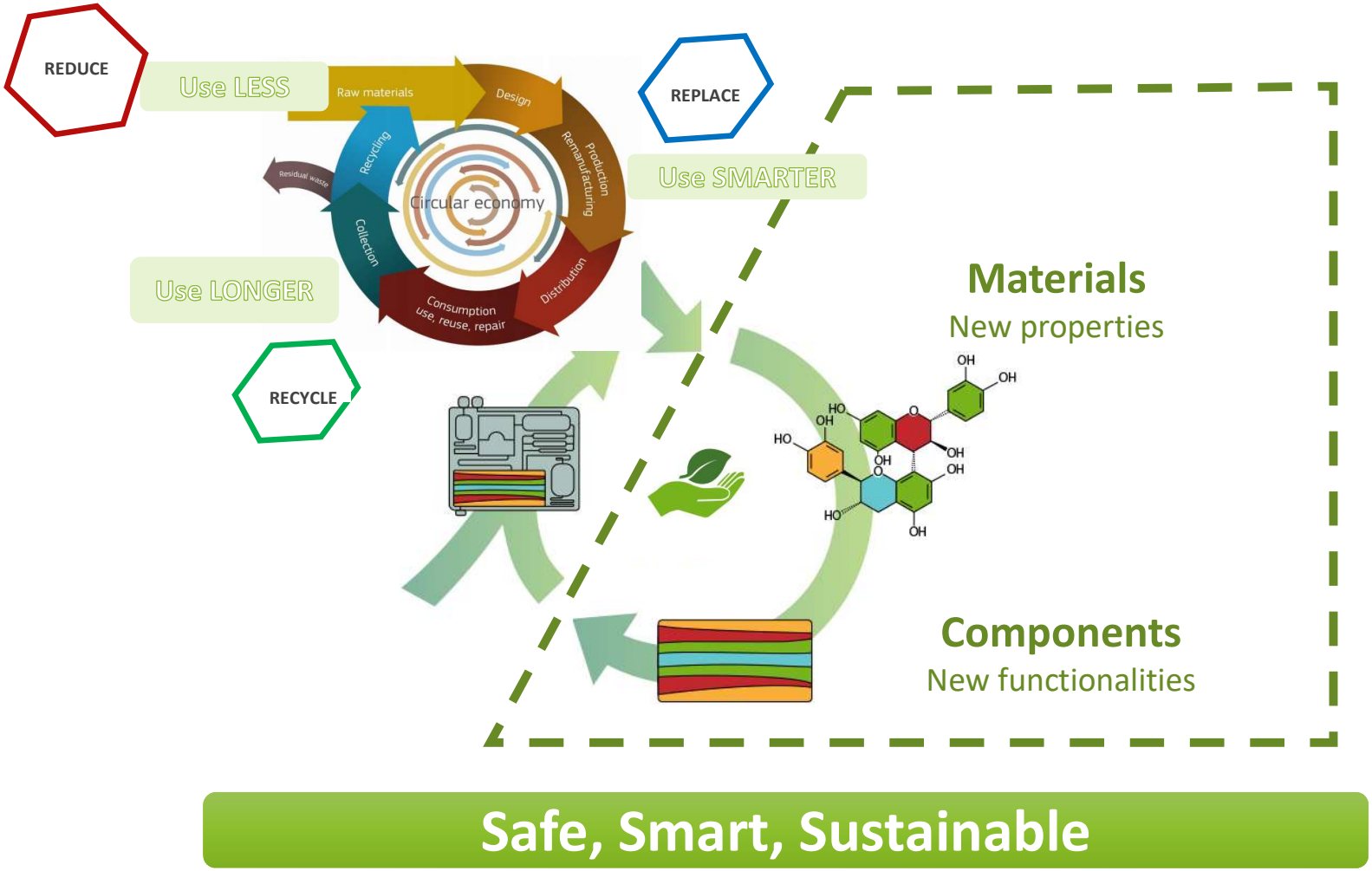
FROM MATERIAL TO COMPONENTS

to anticipate / sustain the energy transition

OUR MISSION :

Develop high-performance **materials, processes and components** for industry in accordance with the concept of **material and energy savings**

CIRCULAR ECONOMY FOR SUSTAINABLE GROWTH

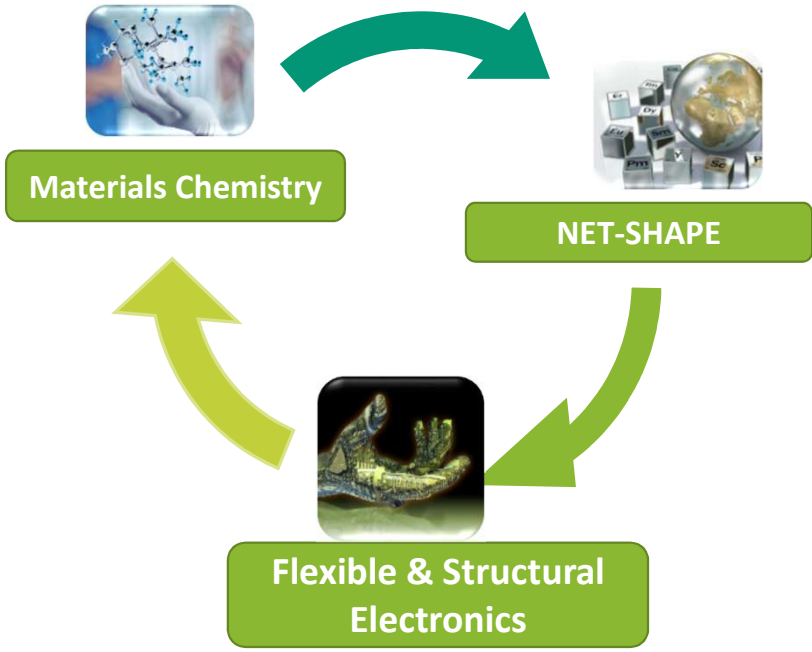


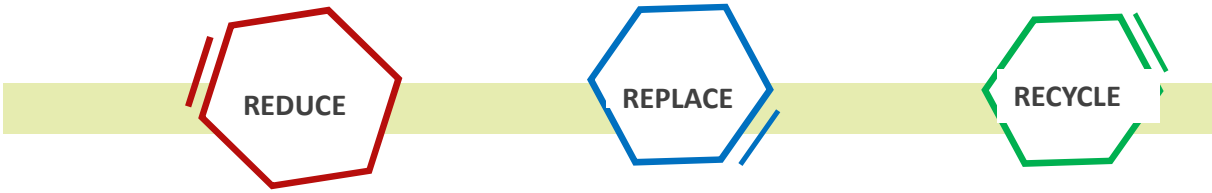
Safe, Smart, Sustainable

3 STRATEGIC AXES & 3 PILLARS

Innovation on Materials and Processes driven by:

- **Safe**
  - Smart Materials « Safe by Design »
  - Environmental and societal concern: Air treatment, catalysts development, nanoparticles release, VOC
- **Smart**
  - Materials Modelling
  - Novel smart materials with new properties and improved functionalities
  - New components, Energy and resources efficiency: net shape Processes, substitution, recycling
  - Embedded electronics
- **Sustainable**
  - Higher life time products
  - Validation of recycled raw materials
  - Fundamental understanding of materials, structure and their properties
  - Eco-design - Recyclable by Design





IMPROVE ENERGY EFFICIENCY

Finding the Economic and Environmental Optimum of the Energy Transition

CIRCULAR ECONOMY

Resource Efficiency & Environmental Sustainability

Material & Energy Efficiency

- Additive Manufacturing
- Structural Electronics

Raw Materials Limitation

- Rare earth magnets

Reducing the Environmental Footprint

- Life-cycle analysis & Tech-eco
- Recycling
- Closing the Carbon Cycle

SUSTAINABLE TECNOLOGIES FOR THE MATERIALS LIFE CYCLE

Materials Chemistry

Chemistry and processes for materials life cycle and environment

#1

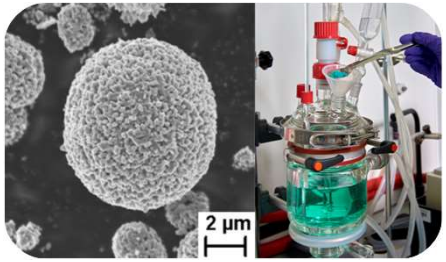
RECYCLING OF LOW CARBON ENERGY SYSTEMS COMPONENTS

- New Energies Technologies: : Batteries, PV, Components for H_2, Magnets and RE
- PGMs & medical radionucleids

#2

VALORISATION OF RECYCLED MATERIALS

- Valorisation of bio-based materials: wood, biomass, microalguae
- Re-manufacturing of catalytic systems
- Materials and processes for H_2 storage and CO2 cycle



#3

MATERIALS AND PROCESSES FOR THE ENVIRONMENT

- Depolution of waters, air and soils
- Nanomaterials safety
- NRBC risks

Eco-design / LCA

Advanced characterisation

SUSTAINABLE CHEMISTRY: OPTIMISED Li-ion BATTERY RECYCLING

Materials Chemistry

RECYCLE: Development of a process for extracting the valuable metals (Ni, Co, Mn, Li) from a black mass of Li-ion (NMC) batteries

- Recovery efficiency Co, Ni and Mn beyond European regulation (> 50%)
- Purity of metal salts Co, Ni and Mn recycled> 95%

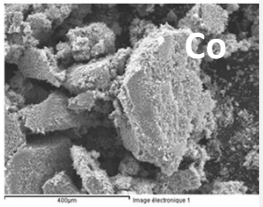
REDUCE: 40% less effluent, **35%** less steps and **40%** less chemical reagents

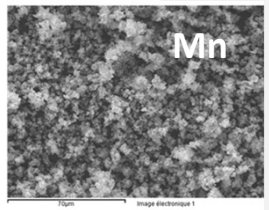
➔ Lithium-ion battery recycling process optimized to dissolve and separate critical metals

TROPHÉES INNOVATION RECYCLAGE

REPLACE: Pyrometallurgy technologies by mechanical approaches and safe openning procedures for safe deactivation

- Higher recovery efficiency and purity



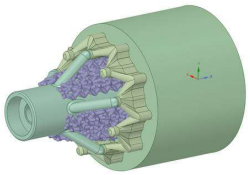


3D Architecture technologies for sustainable development

NET-SHAPE

#1 ECO-DESIGN STRATEGIES IN PERMANENT MAGNET MOTORS FOR ELECTRO-MOBILITY

- Hard permanent magnets (NdFeB, SmCo)
- Soft Ferrite (MFe2O4)
- Plasto-magnet
- Electrical Generators
- Power Electronics
- Recycling and reduction of critical metals in permanent magnets
- Mould design under field and magnetic systems

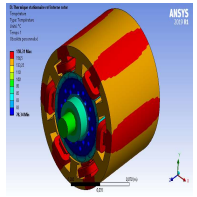


#2 MATERIALS ENGINEERING AND PROCESSES FOR SUSTAINABLE DEVELOPMENT

- Sintered materials , coatings
- Thermoplastic materials with low env. Impact (bio-based and secondary)
- Formulation (powder and feedstock)
- Injection moulding and PIM
- Additive manufacturing (FFF, DLP, MJF, BJ)

#3 DESIGN AND SIMULATION FOR ADDITIVE MANUFACTURING

- Metals (main alloy classes) & composites (MMC)
- Metal additive manufacturing
- Functionalisation of powders
- Development of new materials/microstructures
- Advanced design
- Digital Simulation
- Thermoelectric devices



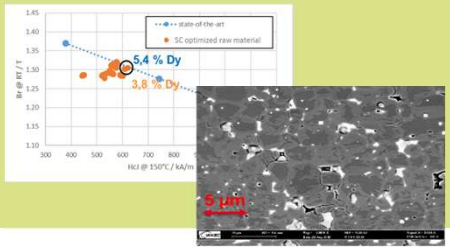
A **Technology Plarform 1500 m² dedicated to**

Fabrication of near net shape parts
Development of materials
Design of components
Characterisation and multi-physical simulation

RAW MATERIAL OPTIMIZATION : RARE-EARTH MAGNETS

NET-SHAPE

“3 R” strategy: how do we optimize REE in permanent magnets?

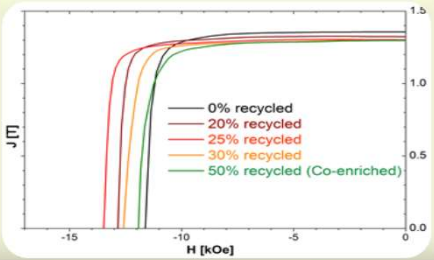


REDUCE

- Control of microstructure, phases's nature and stability
- REE (Dy) location optimization in grain boundaries
- Less material thanks to additive manufacturing

REPLACE

- Use new phases to reduce/replace REE



RECYCLE

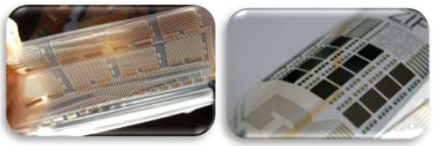
- Magnets recycling (by chemical treatment, powder, fusion)

FLEXIBLE & STRUCTURAL ELECTRONICS

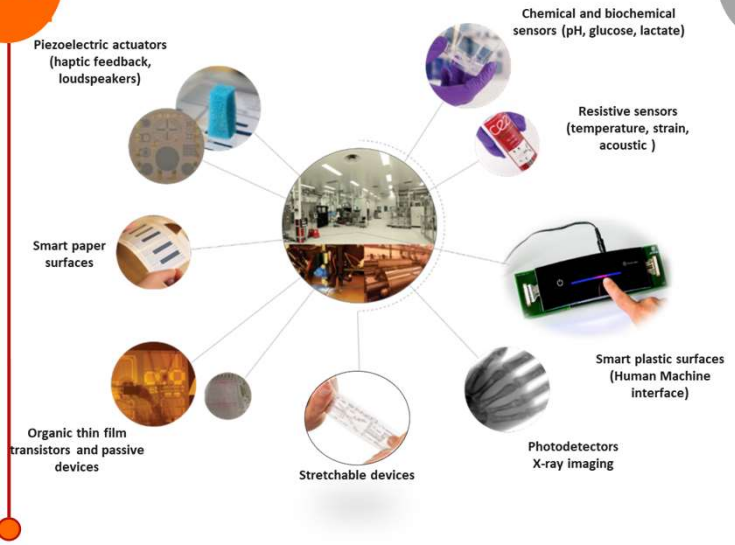
Flexible & structural Electronics

#1 DEVELOPMENT AND CHARACTERIZATION OF SMART SURFACES/OBJECTS EMBEDDING ELECTRONIC FUNCTIONALITIES

- Process : low capex, short cycle time, easy customisation and fast prototyping
- Flexible/Stretchable substrates : lightweight, conformable, thin, transparent
- Large area circuits with sensors and actuators co-integration
- Heterogeneous Integration, easy customization



#2 EXAMPLES OF DEVICES



#3 EXAMPLE OF DISRUPTIVE APPLICATIONS

- Structural Health Monitoring (SHM)
- Internet of things
- Stretchable electronics (well-being, sport, robotics)
- Human machine interface (Automotive, Home appliance…)

PictiC

Virtual tour
http://pictic.cea.atwl.fr/

Facility dedicated to smart surfaces/objects embedding electronic functionalities offering:

- **front-end processing**: screen printing, gravure, slot-die, vacuum drying, surface and plasma treatment, laser ablation,…physical vapor deposition, chemical vapor deposition and atomic layer deposition
- **back-end processing:** encapsulation, lamination, laser dicing, packaging, assembly
- **thermoforming post processing,**
- **opto-electrical and electrical characterization tools**, connectable with ageing and climatic controlled test benches.

GREEN FLEXIBLE & STRUCTURAL ELECTRONICS

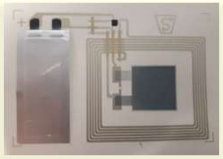
Flexible & structural Electronics

How do we make future electronics greener and/or at the service of circular economy thanks to flexible and structural electronics ?

REDUCE:
- The use of raw materials and resources thanks to efficient 2D additive manufacturing processes
- Electronics weight/volume in smart objects

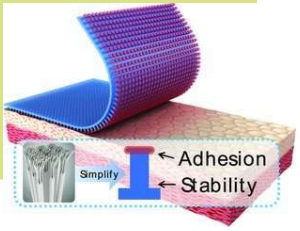
Example of the Gravure printing tool offering an efficient utilization of materials (additive manufacturing)

REPLACE:
- Conventional raw materials with bio-based inks and substrates
- Standard ACF (Anisotropic Conductive Film) by green adhesives



Smart paper-based label including printed sensors, antenna and conductive tracks

RECYCLE & REUSE:
- Recycle waste from Electrical and Electronic Equipment (WEEE)
- Reuse/replace high value components in smart devices thanks to reversible functional adhesives



Enhanced Skin Adhesive Patch with Modulus-Tunable Composite Micropillars. Won Gyu Bae et al. 2013

H2020 NMBP PROJECTS PORTFOLIO @ CEA LITEN's Materials division

PERSPECTIVES IN HORIZON EUROPE : CLUSTER 4

- **HORIZON-CL4-2021-RESILIENCE-01-01: Ensuring circularity of composite materials (RIA)**
- **HORIZON-CL4-2021-RESILIENCE-01-04: Developing climate-neutral and circular raw materials (IA)**
- **HORIZON-CL4-2021-RESILIENCE-01-11: Safe- and sustainable-by-design polymeric materials (RIA)**
- **HORIZON-CL4-2021-RESILIENCE-01-14: Development of more energy efficient electrically heated catalytic reactors (IA)**
- **HORIZON-CL4-2021-RESILIENCE-01-17: Advanced materials for hydrogen storage (RIA)**
- **HORIZON-CL4-2021-DIGITAL-EMERGING-01-31: Functional electronics for green and circular economy (RIA)**
- **HORIZON-CL4-2021-TWIN-TRANSITION-01-03 Laser-based technologies for green manufacturing (RIA)**
- **HORIZON-CL4-2021-TWIN-TRANSITION-01-05 Manufacturing technologies for bio-based materials (RIA)**
- **HORIZON-CL4-2021-TWIN-TRANSITION-01-17 Plastic waste as a circular carbon feedstock for industry (IA)**
- **HORIZON-CL4-2021-HUMAN-01-14 eXtended Reality for All – Haptics (RIA)**

Thank you very much for your attention

Karim Sidi-Ali-Chérif, PhD
Adjoint au directeur, partenariats institutionnels
Deputy director, research funding programmes
T. +33 4 38 78 25 59 I M. +33 (6) 37 65 19 78
Karim.sidialicherif@cea.fr www-liten.cea.fr

Marina Urbina, PhD
European Programmes Manager, Novel Material Technology Department
T. +33 4 38 78 5395 I M. +33 643944201
Marina.urbina@cea.fr www-liten.cea.fr

Commissariat à l'énergie atomique et aux énergies alternatives
17 rue des Martyrs | 38054 Grenoble Cedex
www-liten.cea.fr

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