OBSERVATOIRE DE LA TRANSITION ÉNERGÉTIQUE

LNCMI

G2Elab
Grenoble Génie Electrique
Grenoble Electrical Engineering

Eco-SESA
Univ. Grenoble Alpes

A big science facility as a living-lab for energy transition: the LNCMI use case

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Sacha Hodencq, Jaume Fitó, François Debray, Benjamin Vincent, Julien Ramousse, Benoit Delinchant, Gilles Debizet, Nicolas Tixier, Sylvie Laroche

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IDEX Université Grenoble Alpes

INVESTISSEMENTS D'AVENIR

FRANCE 2030

OUTLINE

- **Energy and environnemental transition**
  - The global impact and importance of Energy Transition
  - Energy demand in cities as the focus
  - The issu of waste energy and Flexibility
- **The concept of Living-lab**
  - From the complexity of reality
  - To the concept of living-lab
  - Socio-technical approach base on living-labs from Eco-SESA to OTE
- **A research facility as a living-lab for Energy Transition**
  - **The LNCMI as a living lab for the study of flexible waste heat management and recovery for an electro-intensive industrial process through energy/exergy criteria**
    - Waste Energy At the level of the Grenoble Peninsula
    - Flexibility – Importance of LNCMI at National Level
  - **The kind of results produced**
    - The identification of actors and energy communities
    - From identification of actors with social sciences to the development of tools for design and energy management
    - Results around flexibility and energy decarbonation
    - Collaborative and participative science: the Transect

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Energy and environmental transition

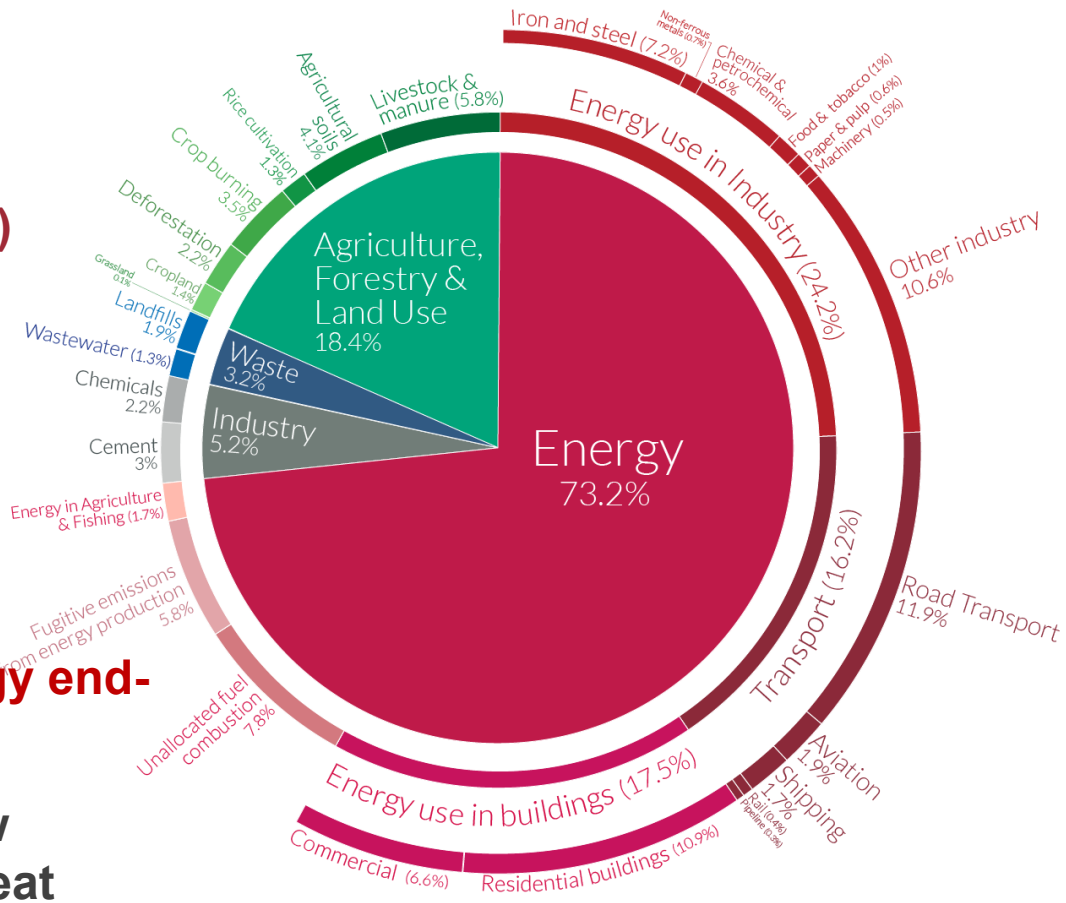
The global impact and importance of Energy Transition
Energy demand in cities as the focus
The issu of waste energy and Flexibility

THE GLOBAL IMPACT AND IMPORTANCE OF ENERGY FOR ENVIRONMENTAL TRANSITION

- **Energy consumption of human activities account for more than 70% of GHG emissions worldwide**

Global Greenhouse Gases (GHG) emissions per sector

2016
49.4 billion tonnes CO_2eq.



- **Heat is one of the largest energy end-use**
  - **Need to find and exploit low greenhouse gas-emitting heat production**

Energy demand in cities as the focus point

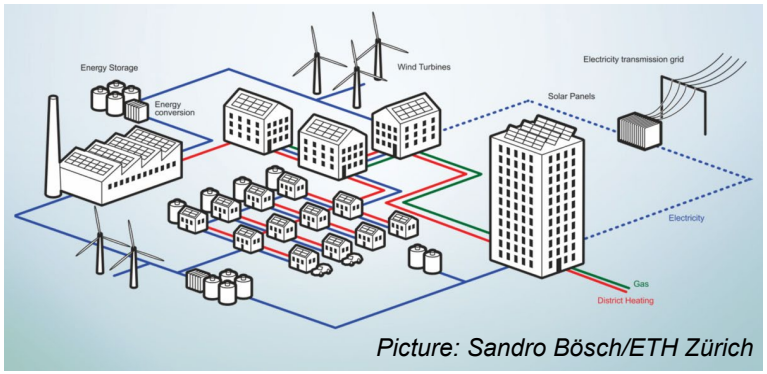
- **Cities dominate the global energy demand…**
  - Urban areas accounted for about **64%** of the global primary energy use [IEA]

- **… but they can also be the next place for energy production**
  - Decentralised renewable energies
  - Energy recovery potential

Electricity

Heat

Gas



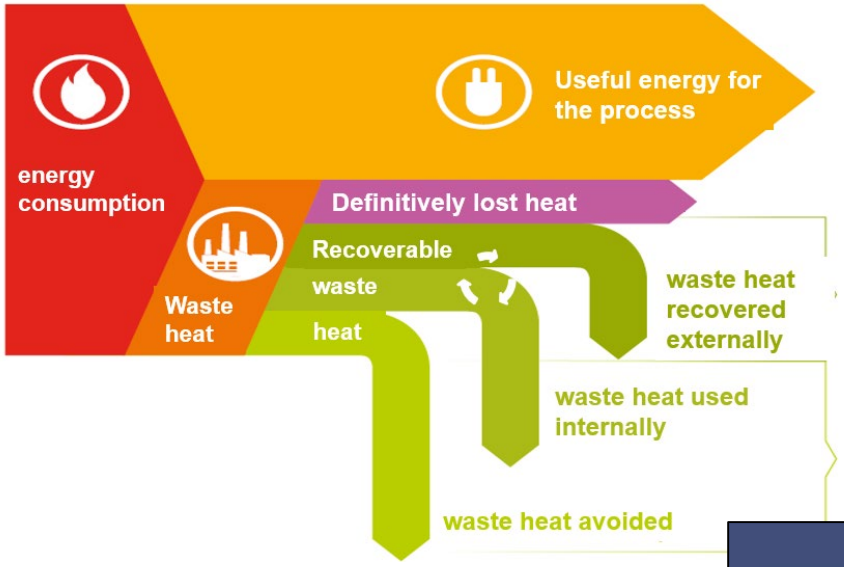
Picture: Sandro Bösch/ETH Zürich

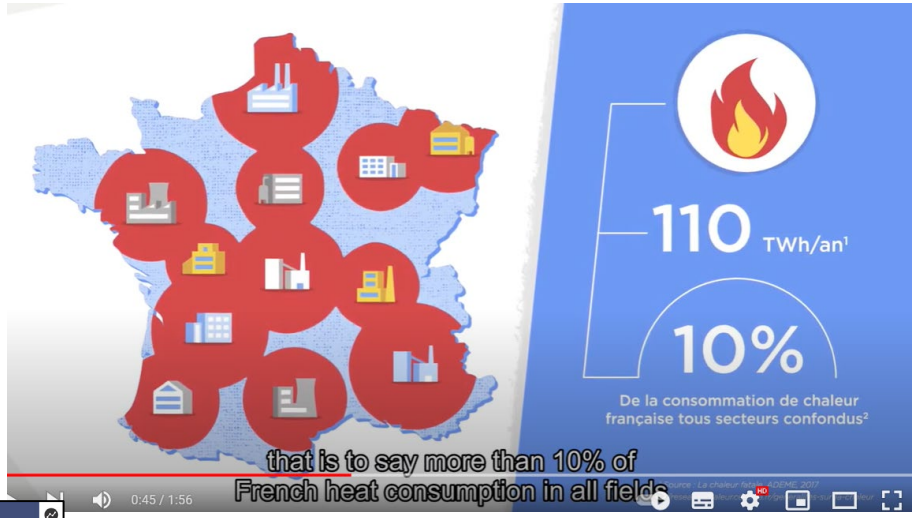
- **New challenges & solutions for the new energy sources**
  - **Intermittence**: flexibility, multi-carrier energy systems, storage
  - **Distributed**: well designed and operated energy networks
  - **New actors**: prosumers, local authorities, energy communities

→ Complex system with the need of a new socio-technical approach

THE ISSUE OF WASTE ENERGY

- **Waste heat:** heat generated in a process which is not its first end and that is not used by the process.





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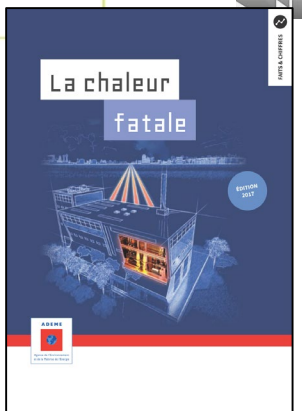
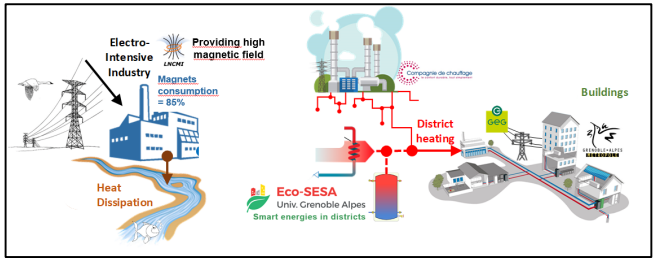
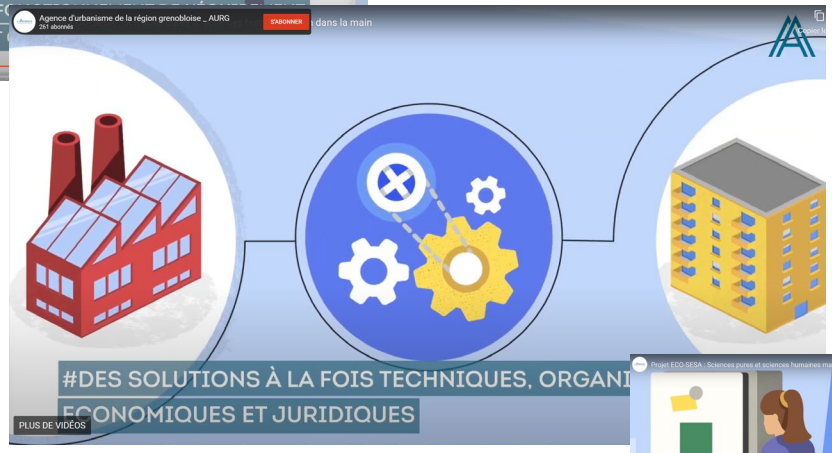


Source: La chaleur fatale, Ademe, 2017
https://www.ademe.fr/chaleur-fatale

THE ISSUE OF FLEXIBILITY

- **Between production and demand of energy**





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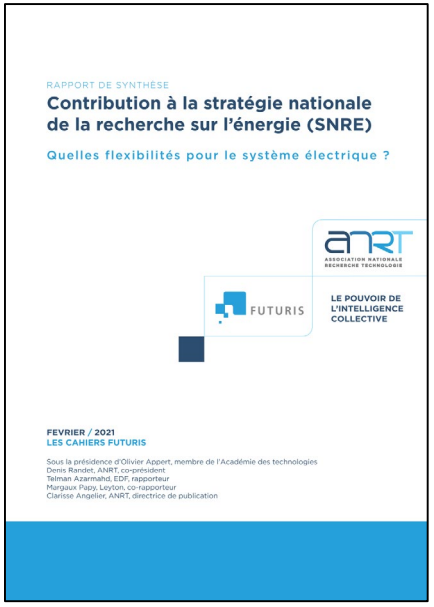

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The concept of Living-lab

- The need of a socio-technic approach with humans in the loop
- From the complexity of energy system seen as socio-technic systems
- To the concept of living-lab
- Socio-technical programs from Eco-SESA to OTE based on living-labs

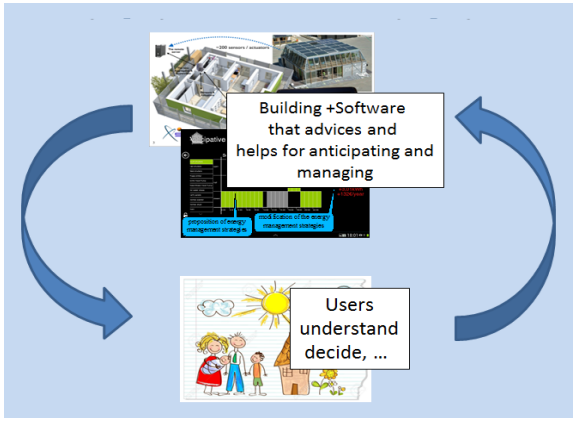
THE NEED OF A SOCIO-TECHNIC APPROACH WITH THE HUMAN/COMMUNITIES IN THE LOOP

- **Fort Smart Management of energy from local district level to national level**
  - **Individuals / Communities are key actors**
  - **Need of a socio-technical approach**
  - **Toward more involvement & appropriation**

Nudges

Dynamic prices

Environmental Signals



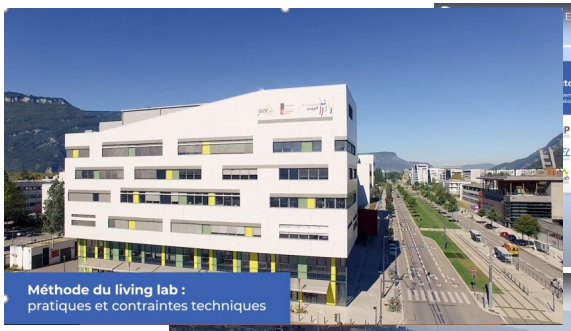
Consumption of Energy

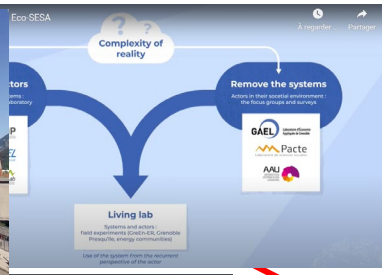
Demand Response And Flexibility

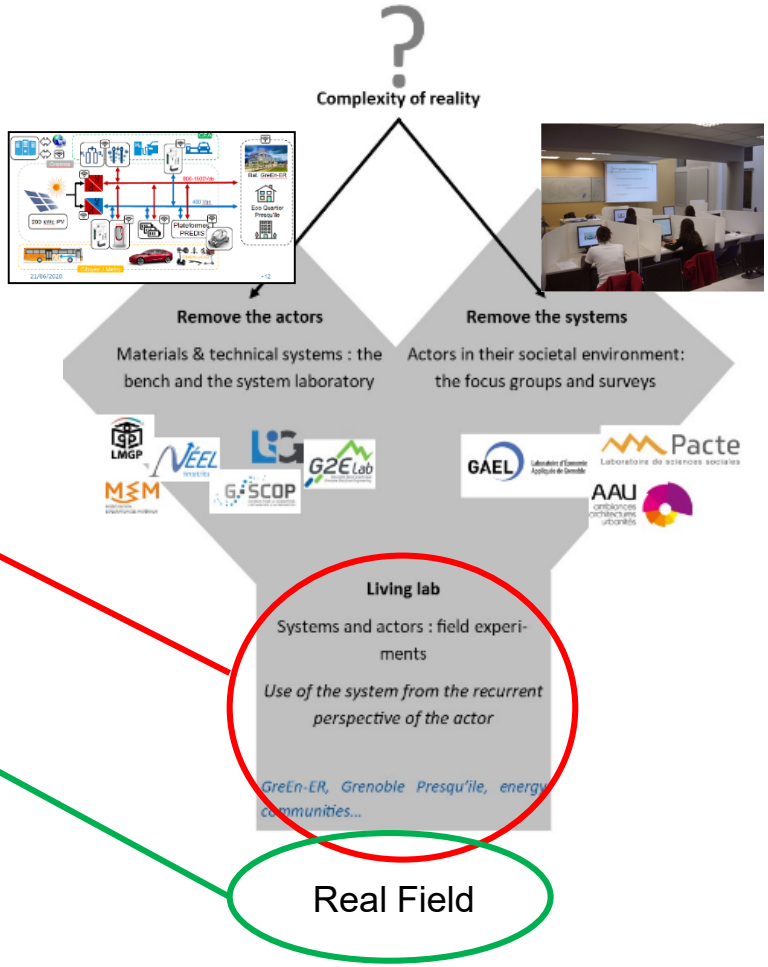
Sell/exchange of energie: From Local to Global Market

FROM THE COMPLEXITY OF ENERGY SEEN AS SOCIO-TECHNICAL SYSTEMS

- **The Y strategy for a socio-technical research for energy transition**







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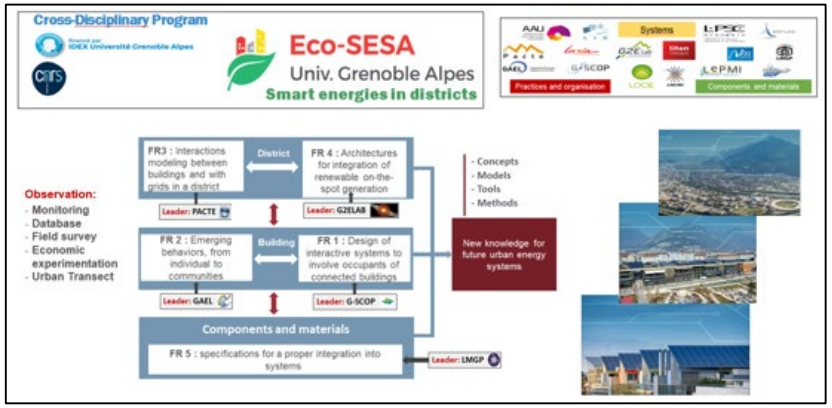
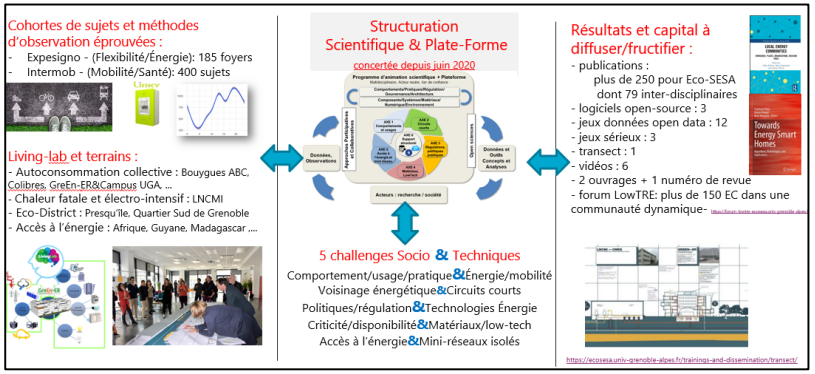
SOCIO-TECHNICAL PROGRAMS BASED ON LIVING-LABS: FROM ECO-SESA TO OTE

- **The need of a socio-technic approach with the community of users « in the loop » based on living-lab**

From eco-SESA



To OTE: Observatory of Transition for Energy



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https://ecosesa.univ-grenoble-alpes.fr/

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The LNCMI: A research facility as living-lab for Energy Transition

- Issue of waste energy: At the level of the Grenoble Peninsula
- Flexibility – Importance of LNCMI at National Level
- The kind of results produced with the living-lab approach
    - The identification of actors and energy communities
    - From identification of actors with social sciences to the developpement of tools for design and energy management
    - Results around flexibility and energy decarbonation
    - Collaborative and participative science: the Transect

ISSUE OF WASTE ENERGY: AT THE LEVEL OF THE GRENOBLE PENINSULA

- **Valorisation of waste energy from LNCMI**

Plusieurs acteurs :

A fabulous source of energy to exploit

Energy: ~15 GWh/an
- 3000 equivalent electrical dwellings
- compared to the 21 GWh of eat energy consumed in the entire peninsula

Power: 24 MW
- 45 000 dwellings

FLEXIBILITY – IMPORTANCE OF LNCMI AT NATIONAL LEVEL

- **Importance of industrial flexibility at french level**
  - **See the presentation of F. Debray, « Energy management at at High Magnetic Field Facilities"**
    - Operations from december 2020 : LNCMI has participated to the balance of the electrical grid though :
      - **"NEBEF", load shedding mechanisms, capacity to shift an energy block**
      - **PP2" , capacity mechanism, capacity to withdraw from the grid**
  - **RTE and Energy Pool Presentation**
- **Especially with the winter to come with the Energy Crises**
- **If combination of:**
  - **Low availibility of French nuclear plants**
  - **Cold temperatures:**
    - Electro-sensibility of France: 2.4 GW/°C under 15° C
  - **No gas in europe -> Limitation of electricity importations for France**
- **Expect a flexibility of 3 to 5 GW of electro-intensive industry**
- **LNCMI -> 30 MW -> Roughly 1%, not neglectible**

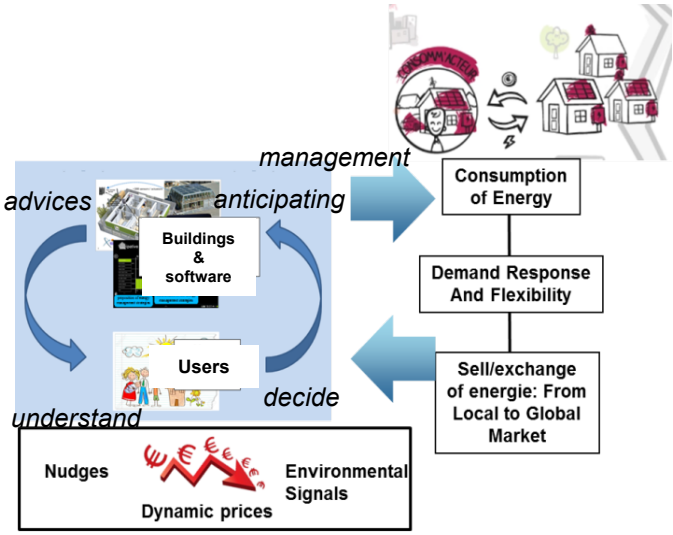
THE KIND OF RESULTS PRODUCED

THE IDENTIFICATION OF ACTORS AND ENERGY COMMUNITIES

- **Citizen energy communities defined in the EU regulation** [EU1]
  - **Collective self-consumption**
  - **Arrange the sharing of renewable energies**

DIRECTIVE (EU) 2019/944 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
of 5 June 2019
on common rules for the internal market for electricity and amending Directive 2012/27/EU

- **New concepts**
  - Enernet [COL]= internet of the energy = decentralised low-carbon energy production + information & energy networks + prosumers
  - Human in the loop approaches [WUR]



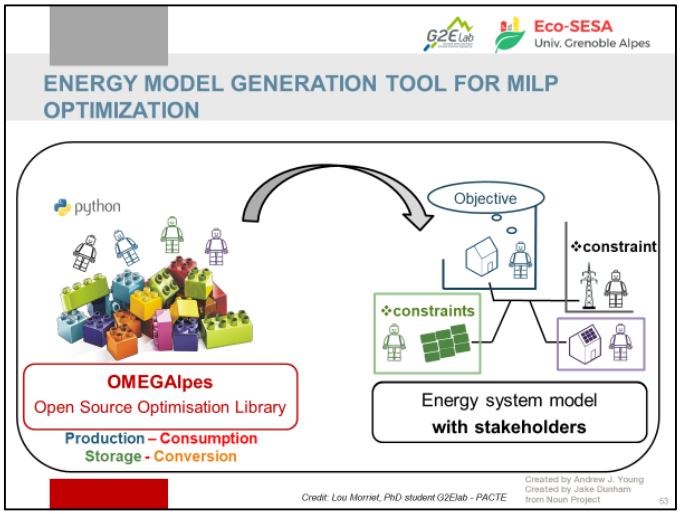
- **The identification of communities and actors around LNCMI**
  - **Through eco-SESA and OTE Programs**
  - **With social Science labs**
    - PACTE (Social Science), GAEL (Economy Science), CRESSON (Urban Science, …)

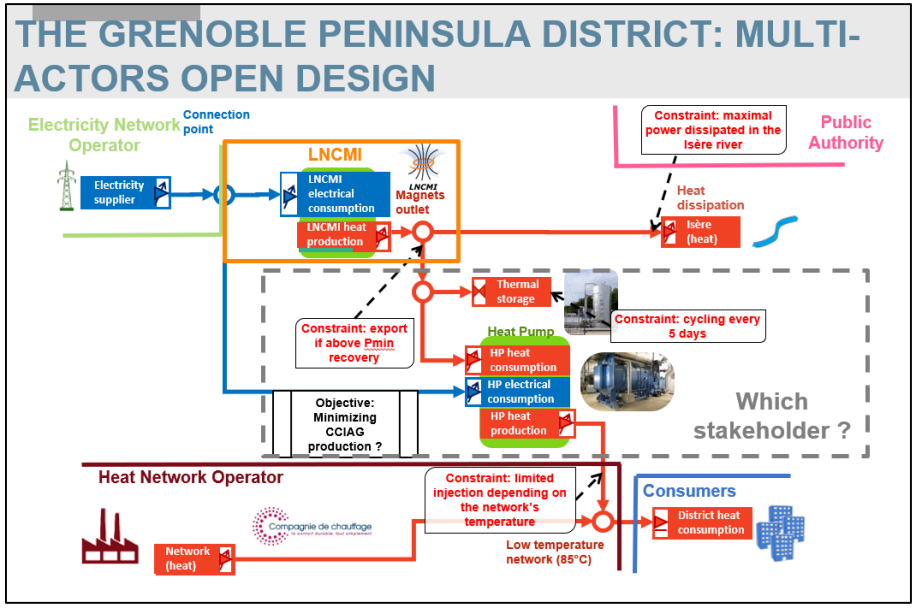
THE KIND OF RESULTS PRODUCED

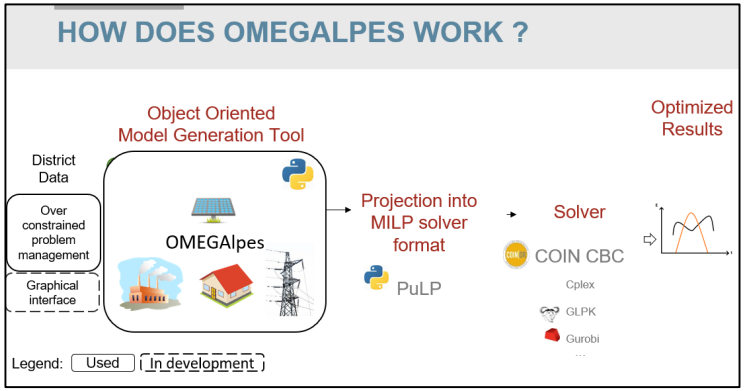
- **From identification of actors with social sciences to the development of Tools for Design and Energy management and socio technic modelisation**

Social Science

Pacte
Laboratoire de sciences sociales





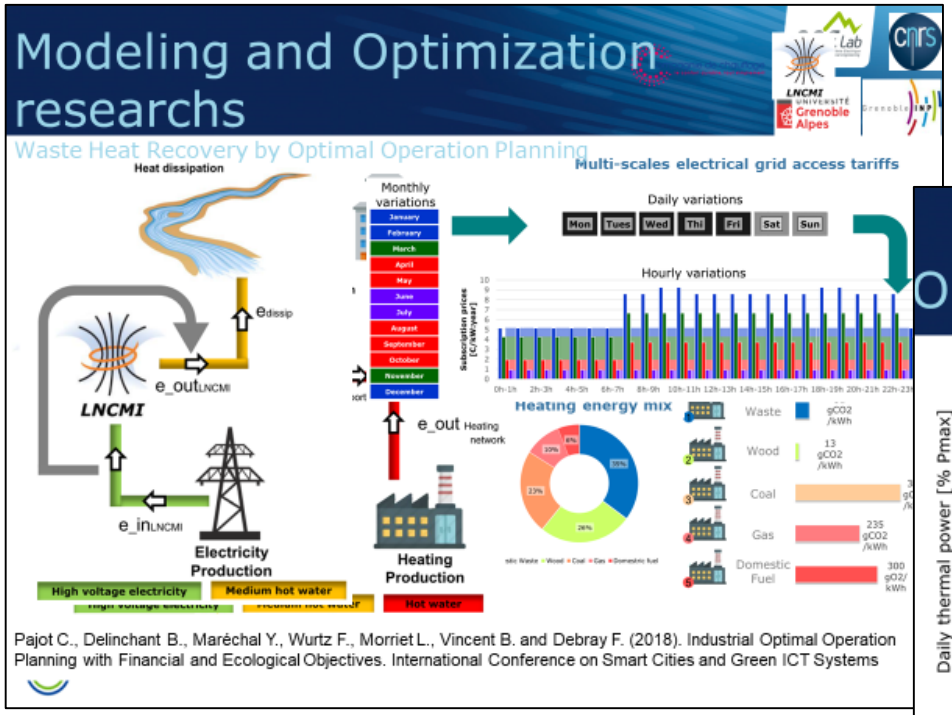


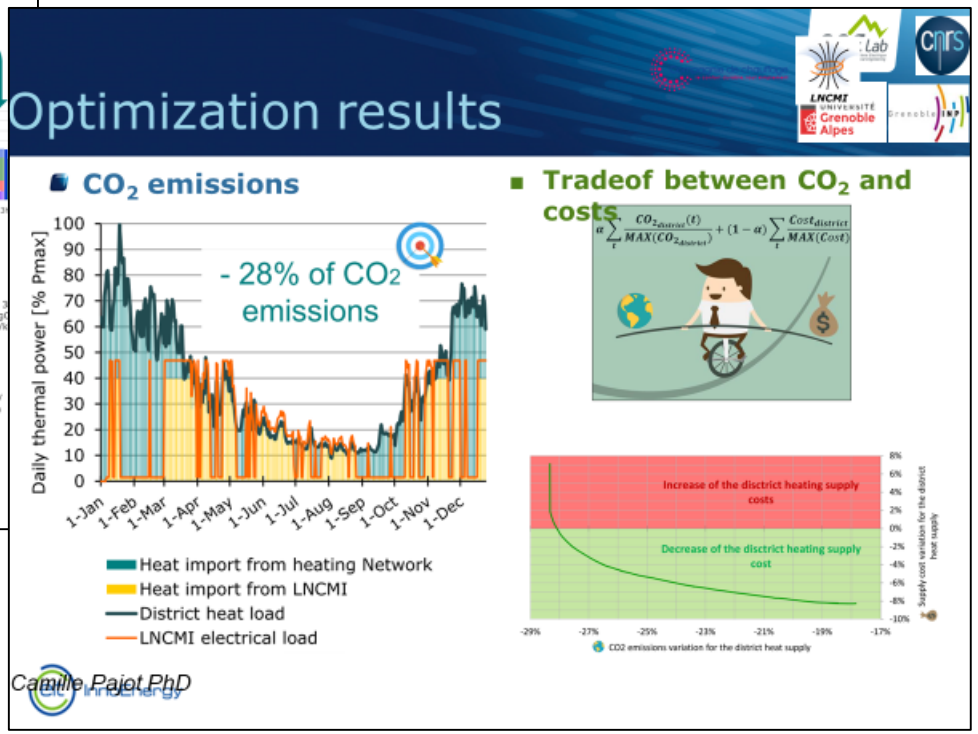
La thèse de Lou Morriet: « Conception multiacteur de systèmes énergétiques locaux bas-carbone : outils, modèles et analyses qualitatives », thèse de l'Université Grenoble Alpes Soutenue le 8 mars 2021, https://hal.archives-ouvertes.fr/tel-03285666v1

OMEGAlpes code: gricad-gitlab.univ-grenoble-alpes.fr/omegalpes
OMEGAlpes documentation: omegalpes.readthedocs.io

THE KIND OF RESULTS PRODUCED

- **Results around flexibility and energy decarbonation**

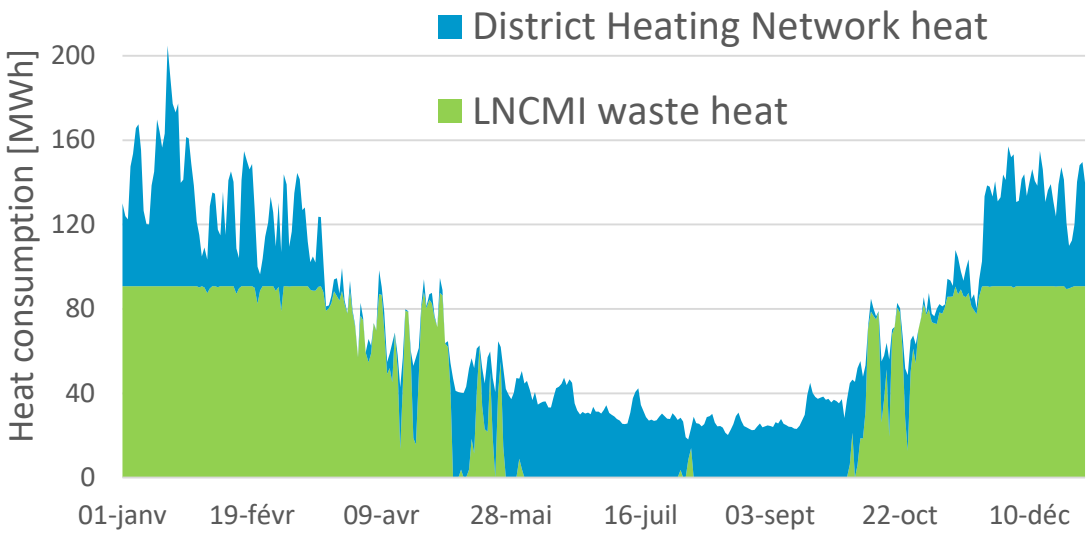




La thèse de Camille Pajot: « OMEGAlpes : outil d'aide à la décision pour une planification énergétique multi-fluides optimale à l'échelle des quartiers », thèse de l'Université Grenoble, https://hal.archives-ouvertes.fr/tel-02520569

THE KIND OF RESULTS PRODUCED

- **Results around flexibility, energy**
- **Providing the heat of the district over a year**
  - **60% of the annual needs could be covered by the LNCMI waste heat (60% reduction in CO_2 emissions)**
  - 20MWh / 6,7MW storage



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Scenarios	Heating network (GWh)	CO_2 em. (g/kWh)
Reference	28,2	144
LNCMI waste heat recovery project	10,8	57,8

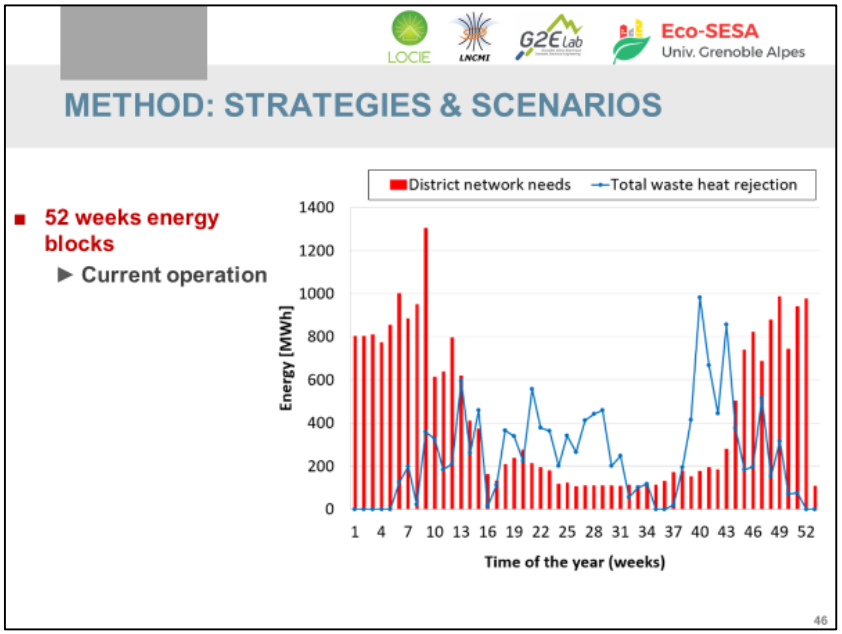
Annual study with 1 hour time step

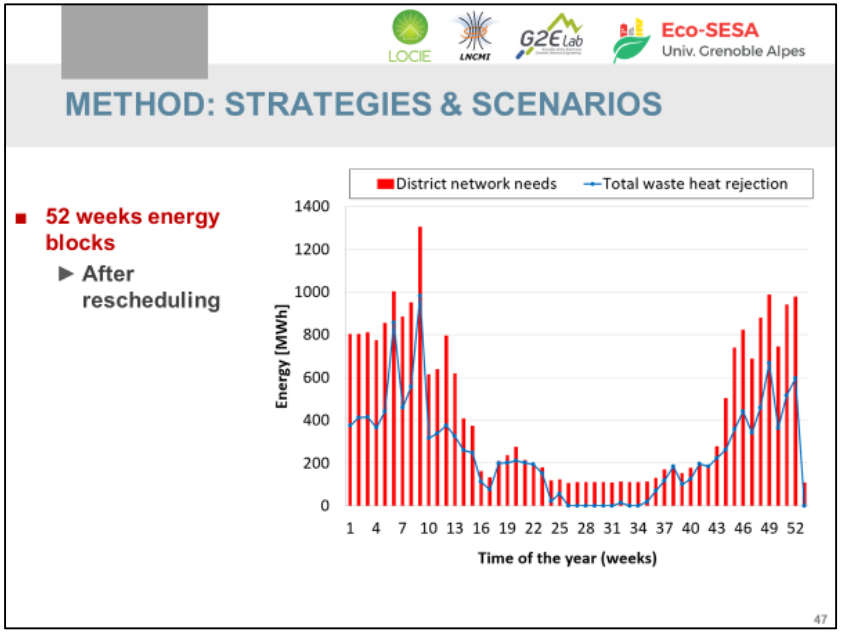
Automatic generation of the optimisation problem

- 228k variables (158k continues et 70k binaires)
- 316k contraintes
- Résolution en 13h (Gurobi)

THE KIND OF RESULTS PRODUCED

- **Results around flexibility, energy**





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THE KIND OF RESULTS PRODUCED

- **Collaborative and participative science: the Transect**

AAU cresson ambiances architectures urbanités

Collaboration with social science and urban science

Go to the LNCMI visit Tomorrow

http://grand-a.aurg.org/ancrage-energie/parole-croisee-de-chercheurs

CONCLUSION

- **Impact and importance of big research facilities as Energy Player**
- **Big players as:**
  - Energy consumption
  - Importance of flexibility, valorisation of waste energy
  - Probably sobriety
- **Scientific interest as living-lab for:**
  - Reducing CO2 emissions of the district heating network
  - Addressing waste heat recovery challenges
  - Durability of research infrastructures
  - Open research facility
- **An added societal utility besides fundamental science**
  - Being living-labs as archetype of electro-intensive actors
- **For a socio-technic inter-disciplinary research involving**
  - Development of energy technologies
  - Study of community of users and actors:
    - **The community of researchers of the research facility**
    - **The managers of facilities**
    - **In coordination with**
      - **Network managers**
      - **Local energy consumers**

SYNTHESIS AND SCIENTIFIC ROADMAP

- **Toward the « Observatory of Transition for Energy » with the LNCMI as key Facility as « living-lab » for learning by doing at sociatel level**

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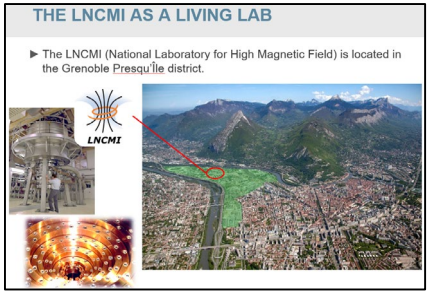
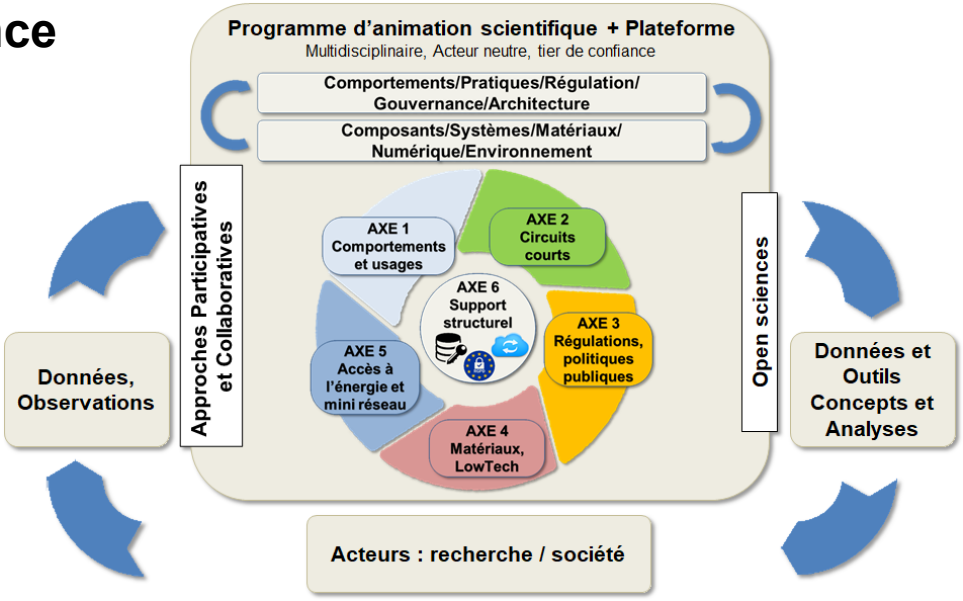
Living-lab and Participatory Science



Community of Facility Users



Societal energy impact & stakeholders

Open science

- Open access papers
- Open software and models
- Open data
- Open use cases and strudies
- Transects
- …

https://ote.univ-grenoble-alpes.fr/

SOME REFERENCES

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- [EU1]: DIRECTIVE (EU) 2019/ 944 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on common rules for the internal market for electricity and amending Directive 2012/ 27/ EU
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- See also:
- Lou Morriet, Camille Pajot, Benoît Delinchant, Yves Maréchal, Frédéric Wurtz, et al.. Optimisation multi-acteurs appliquée à la valorisation de chaleur fatale d'un acteur industriel flexible. *IBPSA 2018*, May 2018, Bordeaux, France. ⟨hal-01884585⟩
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- La thèse de Lou Morriet: « Conception multiacteur de systèmes énergétiques locaux bas-carbone : outils, modèles et analyses qualitatives », thèse de l'Université Grenoble Alpes Soutenue le 8 mars 2021, https://hal.archives-ouvertes.fr/tel-03285666v1
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- The authors are grateful to La Région Auvergne-Rhône-Alpes for their financial support through the OREBE project (Optimisation holistique des Réseaux d'Energie et des Bâtiments producteurs d'énergies dans les Eco-quartiers). They are also grateful to the ADEME (the French Agency for Environment and Energy Management) for their financial support through the RETHINE project (Réseaux Electriques et THermiques InterconNEctés).

- The authors thank the corresponding decision-makers from the French National Laboratory of High-intensity Magnetic Fields (LNCMI) for: facilitating real operational data to construct the model hourly energy profile of electricity consumption used in this study; allowing to publish that hourly profile in the articles and making data available for public use under an open data license.

- The authors thank the CCIAG's representatives for facilitating their thermal consumption profile and allowing displaying it in this article.

- The authors also thank Etienne Cuisinier (CEA, LITEN, DTBH, University of Grenoble Alpes) for his help regarding the MILP formulation.

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