Tallinn University of Technology, May 2025

Estonian Doctoral School

“Research activities @ L2EP, Univ. Lille, France & EMR formalism”

.....

Prof. Betty LEMAIRE-SEMAIL, Prof. Alain BOUSCAYROL

L2EP Laboratoire d'électrotechnique et d'électronique de puissance de Lille

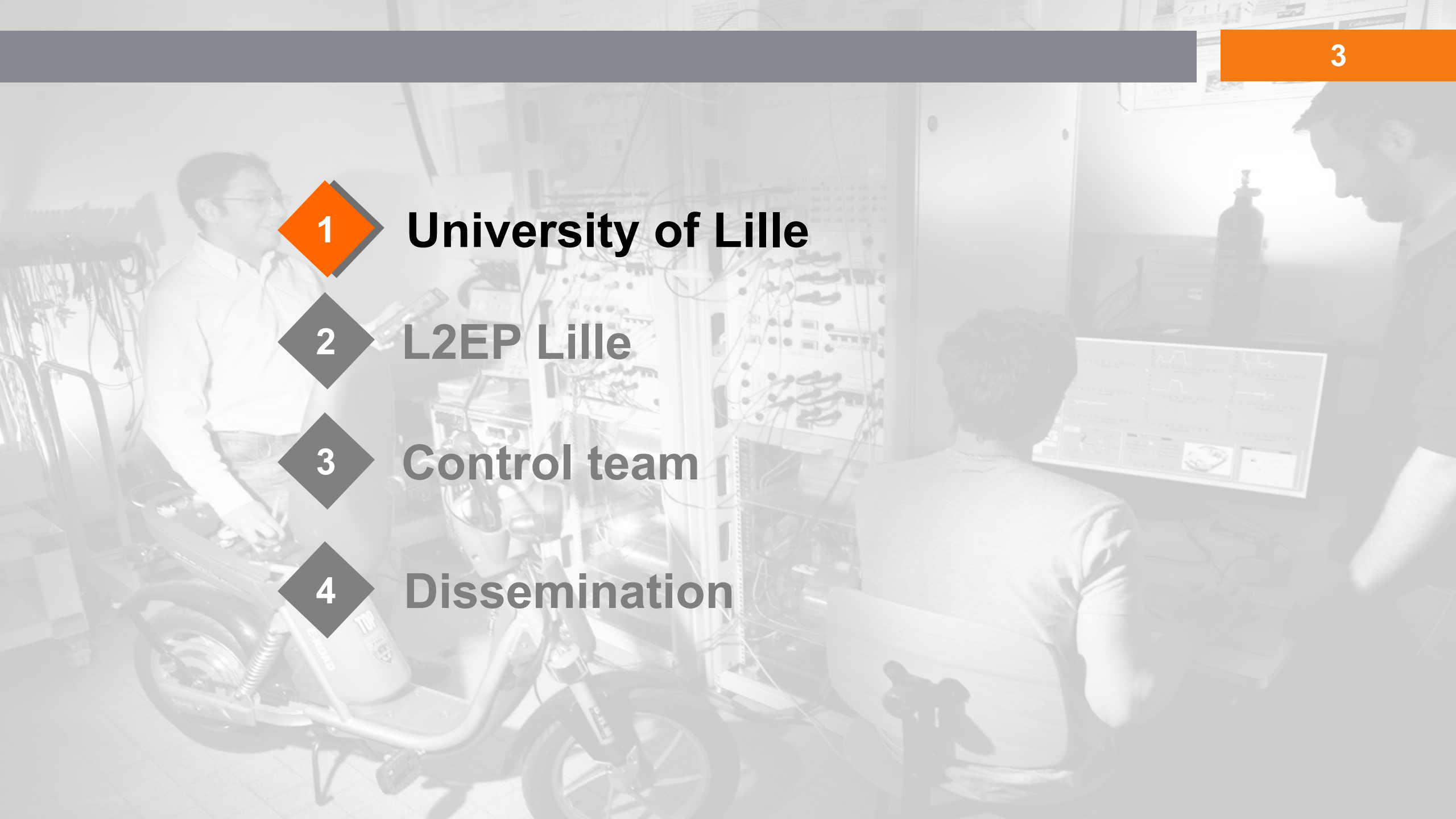
Université de Lille — Arts et Métiers Sciences et Technologies — centralelille — JUNIA Grande école d'ingénieurs

1 University of Lille

2 L2EP Lille

3 Control team

4 Dissemination



1. **University of Lille**
2. L2EP Lille
3. Control team
4. Dissemination

at the crossroad of Paris, London and Brussels

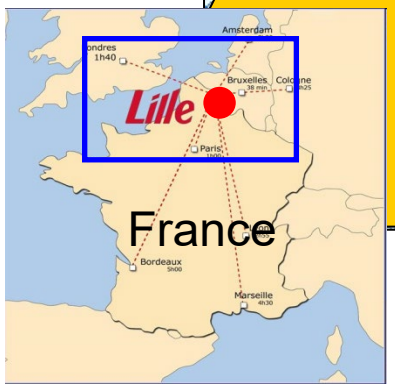
Lille and suburbs more than 1.5 million inhabitants

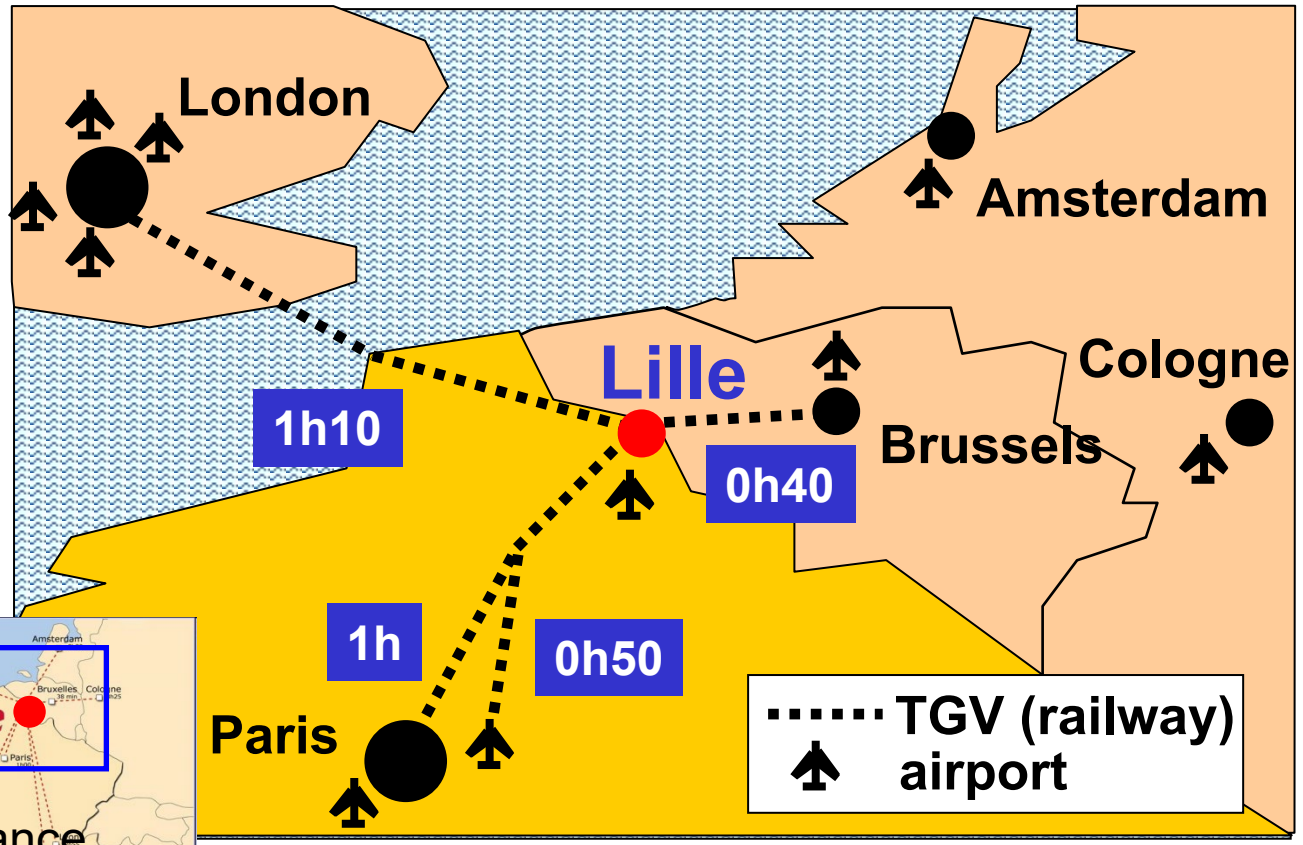
University of Lille in 2020

- 80,000 students (12% foreign students)
- 8,000 staff
- 64 research Labs
- About 400 PhD/year

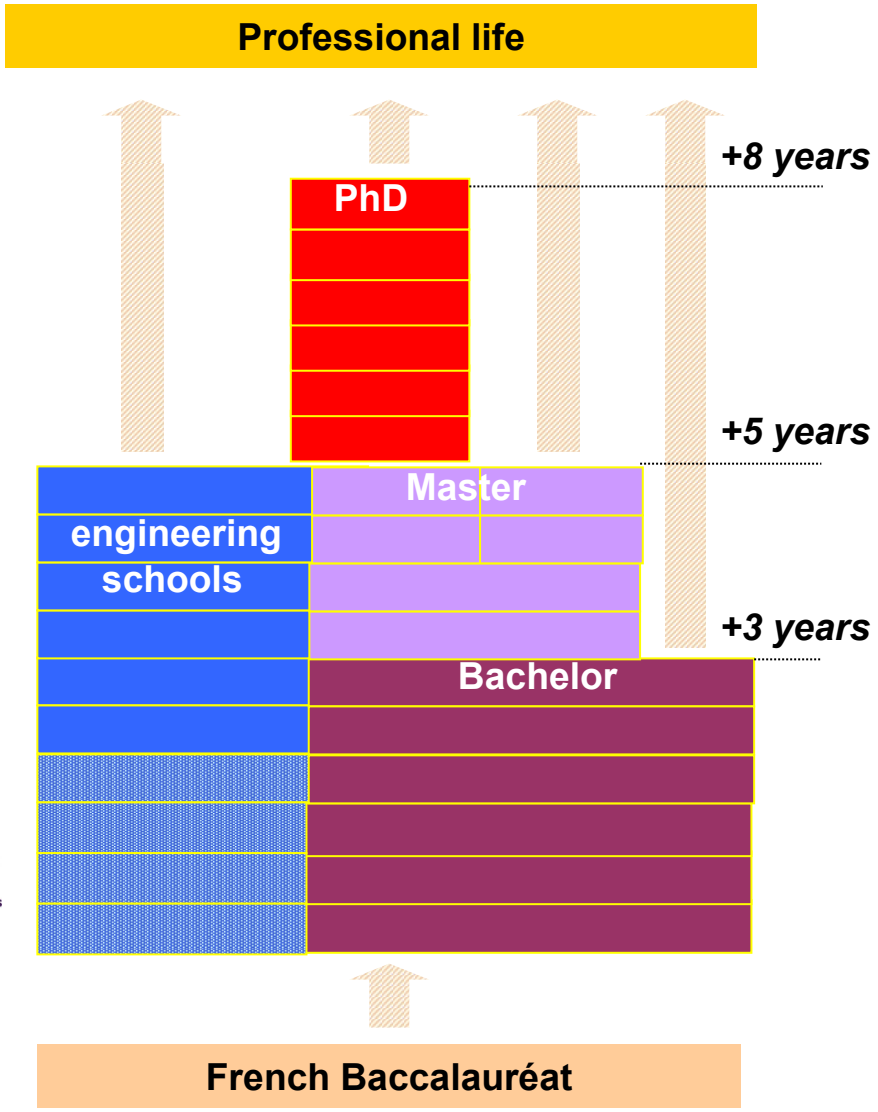
Université de Lille

https://www.univ-lille.fr/en/





Education in France



centralelille

Arts et Métiers

JUNIA Grande école d'ingénieurs

Université de Lille

Fields of study at Univ. Lille

- Arts, literature, language
- Laws, economy, management
- Social and human sciences
- Health and Sport
- Sciences and technologies
  - ~ computer sciences
  - ~ control engineering
  - ~ **electrical engineering**
  - ~ mechanics engineering
  - ~ telecommunications…

Master « Electrical Systems & Automatic Control »

4 specialties including

"**Electrical Engineering for Sustainable development**"

1 University of Lille

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Laboratory of Electrical Energy and Power electronics (L2EP)

http://l2ep.univ-lille1.fr/

More than 120 members:

- 40 professors and associate professors,
- 45 PhD students,
- 17 lab's staff,
- 25 Post-doctoral and Engineers
- Master degree students

L2EP Laboratoire d'électrotechnique et d'électronique de puissance de Lille

Université de Lille · Arts et Métiers Sciences et Technologies · centralelille · JUNIA Grande école d'ingénieurs

L2EP organization

Arts et Métiers Sciences et Technologies

centralelille

JUNIA Grande école d'ingénieurs

Université de Lille

L2EP Laboratoire d'électrotechnique et d'électronique de puissance de Lille

Prof. Betty LEMAIRE-SEMAIL

Control

Prof. Alain BOUSCAYROL

Power Electronics

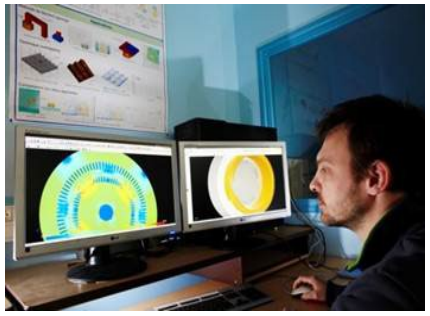
Prof. Nadir IDIR

Numerical tools & Methods

Prof. Abdelmounaim TOUNZI

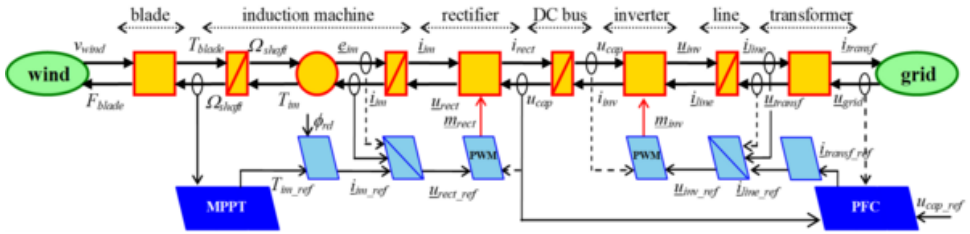
Power Grids

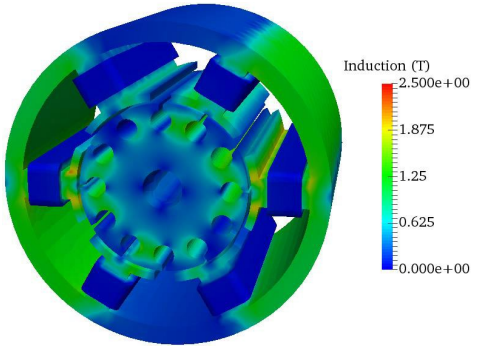
Prof. Benoit ROBYNS



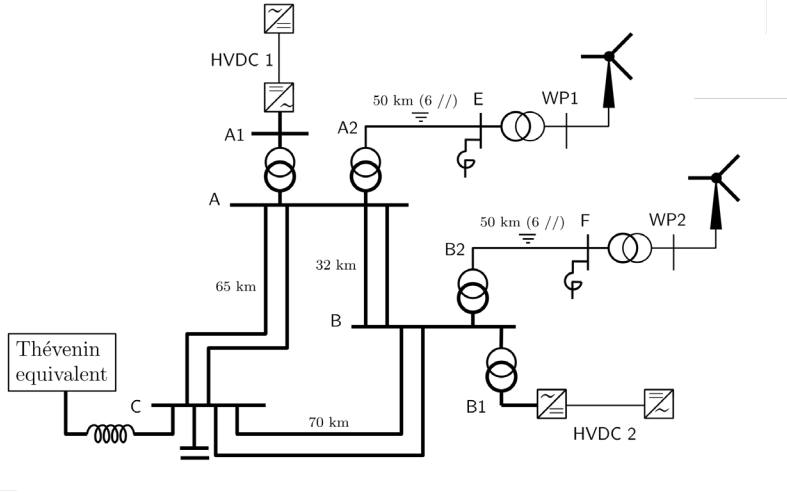
Key words

- Research fields:
  - ✓Energy management strategies of dynamic systems
  - ✓Numerical modelling and optimization
  - ✓Energy conversion systems: electrical, electromagnetic, piezoelectric
  - ✓Characterization of components and materials





- Applications:
  - ✓ Power grids and smart grids
  - ✓Traction systems and electro-mobility
  - ✓Harvesting and haptic systems,
  - ✓Circular economy



→ Energy Transition

Environment

INTERACTIONS

Society

End of Life

materials

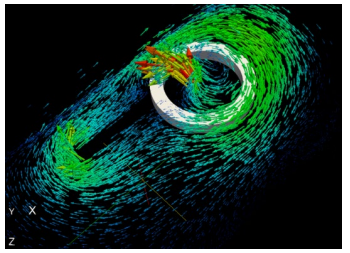
Components

Systems

Usages

Innovative Electrical Systems

EXTENSIONS



tools & methods

L2EP Laboratoire d'électrotechnique et d'électronique de puissance de Lille

System Approach

Experimental Set-ups

Key Figures of L2EP – 2018-2025

> 55 publications in international journals/year

9 Europeans projects

3 in coordination: PANDA (e-mobility),
MultiTouch (Piezzo actuators)
Maxima (e-machine)

1 joint industrial Lab (LAMEL)
with EDF, numerical modelling for electrical systems

Budget > 3M€/year excluding permanent salaries

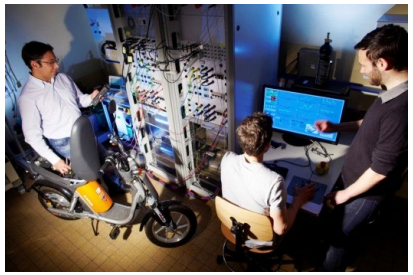
Coordination of key regional projects:

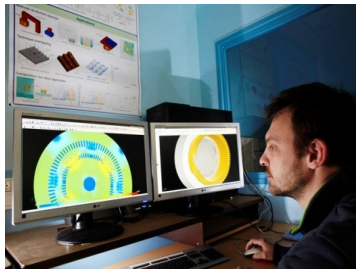
- CE2I (2015-22, 7M€)
- EE4.0 (2021-27)

(innovative electrical systems)

Coordination of TACT
(national CNRS network on tactile devices)

Coordination of eCAMPUS
(international Lab on e-mobility with UQTR - Canada)

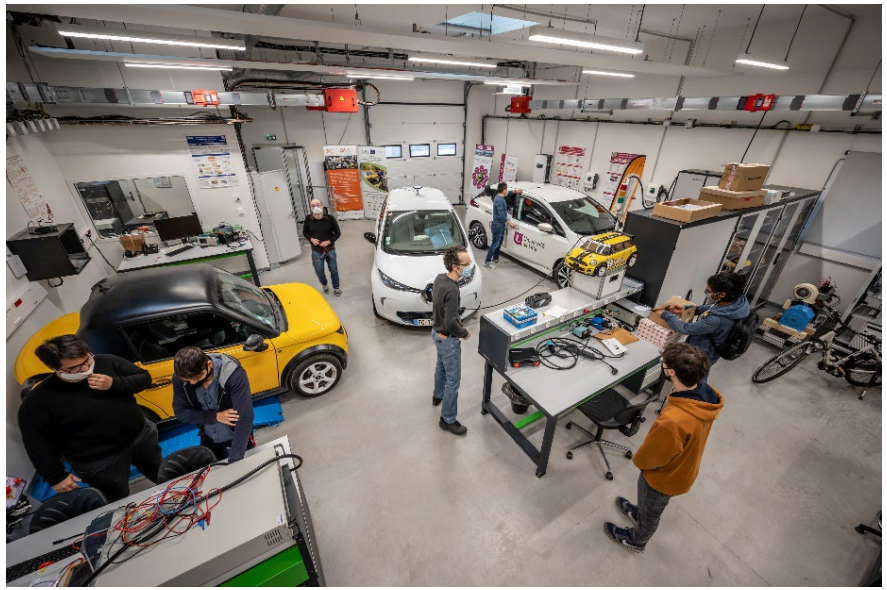




- **electricity & Vehicle platform (eV)**

Energy management and control on new electrified vehicles, power HIL

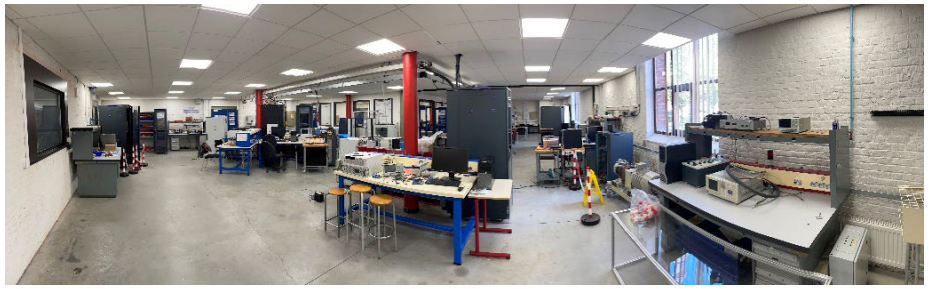
200m²



https://lt360.site/l2ep/ev-ulille.php

- **Electrical Power management platform (EPM-Lab)**

Real time simulation of power and smart grids, power HIL

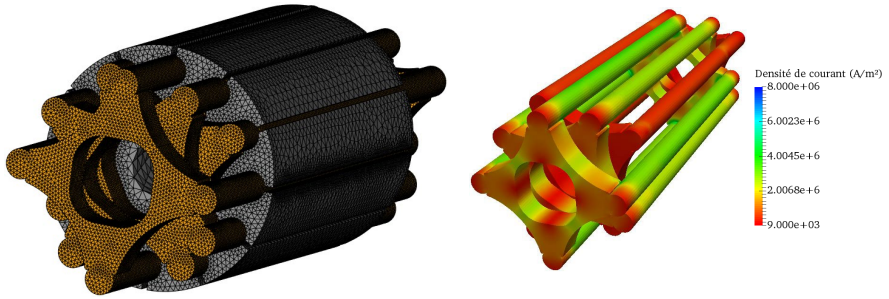


370m²

https://lt360.site/l2ep/epm-ensam.php

- **Code_CARMEL numerical platform**

3D finite element code for low frequency electromagnetic systems (co-developed with EDF)



1 University of Lille

2 L2EP Lille

3 **Control team**

4 Dissemination

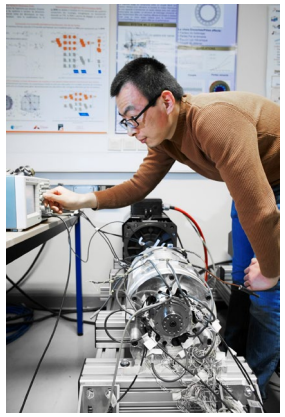
Objective

Control of more efficient / more performant « electrical systems »

Key aspects

- Unified methodology
- Experimental validations

Top Down ↓↑ Bottom Up



Piezoelectric actuators (F. Giraud)

Formalisms for modelling and control

Multiphase electric drives (E. Semail)

Electrified vehicles (A. Bouscayrol)

Technical facilities « piezo »

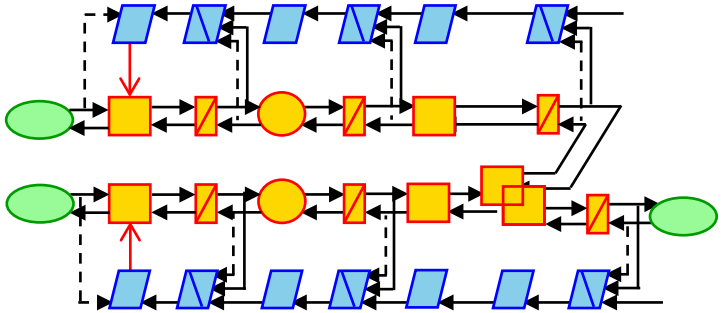
platform « eV » (electricity & Vehicle)

April 2025

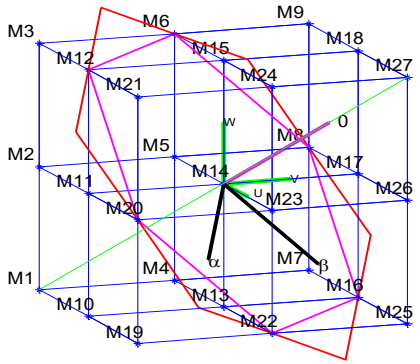
4 Professors
5 Associate Prof.
4 Engineers & 1Technician
5 Post-Doc
13 PhD students
6 Master students

Specificity of the team: **FORMALISMS** for control of electrical systems…

Energetic Macroscopic Representation (EMR)

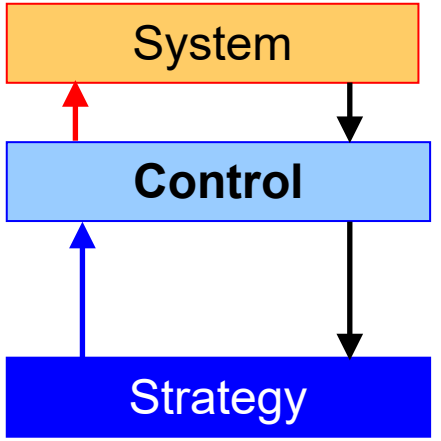


2000 2005 2010 2015 2020 2025



Generalized Vectorial Formalism (GVF)

model reduction strategies organization

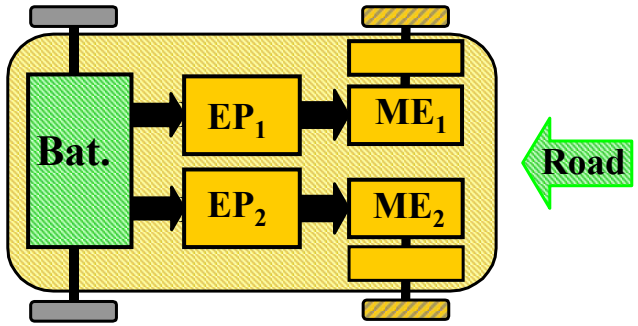


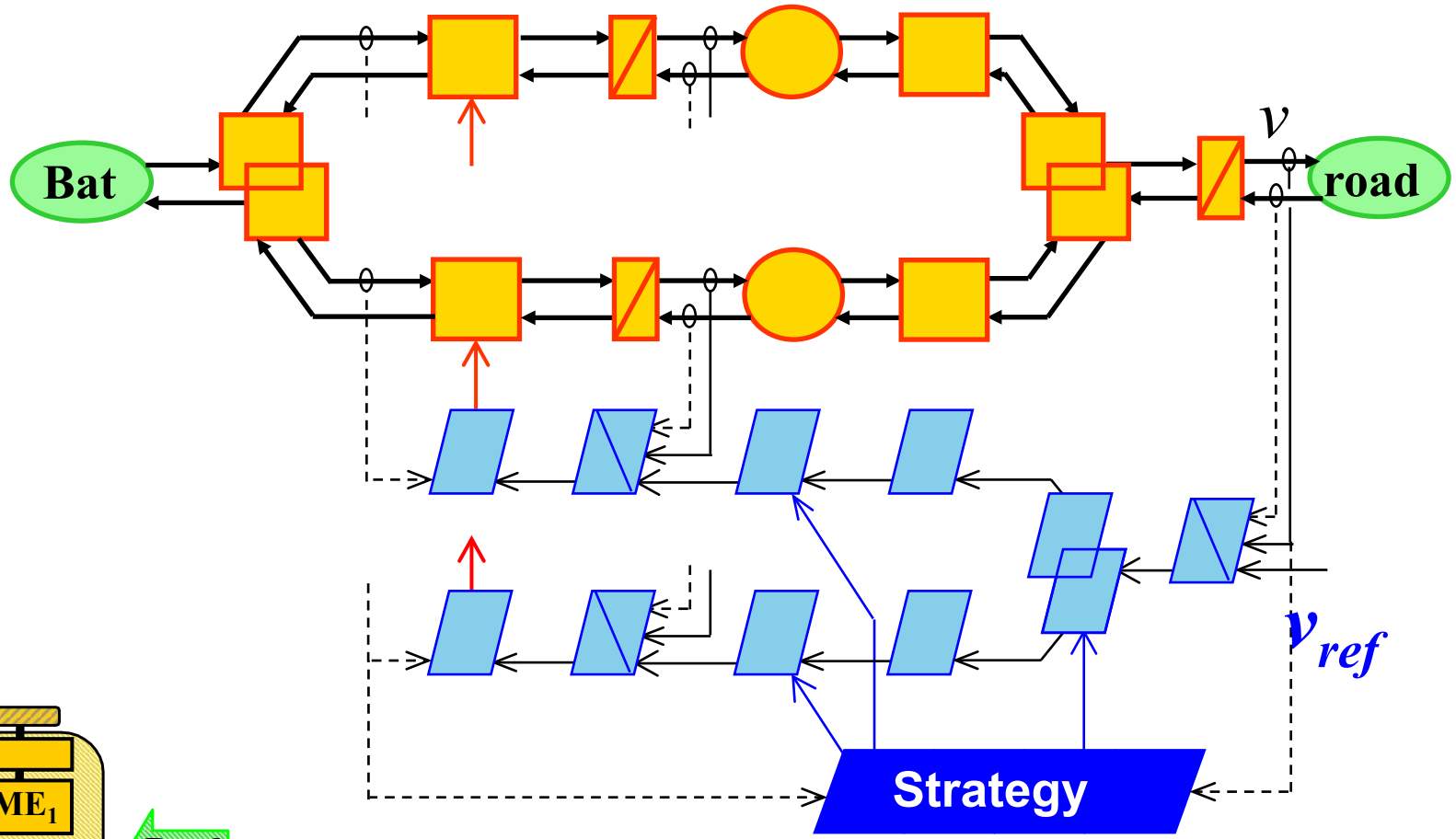
Strategy: generation of global references / coordination of subsystems

EMR
(graphical description)
=
organization
of models of
complex systems

⇩

Systematic deduction
of organization of
control schemes

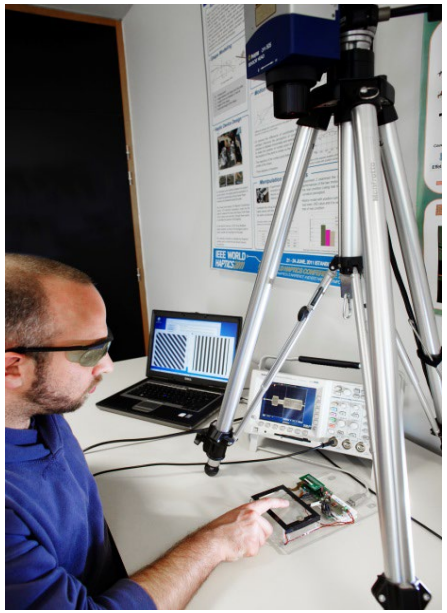




[Bouscayrol 2012] [Bouscayrol 2023]

Strong experimental valdiation

Experimental expertise for validation of the developed formalisms and applications



Piezo actuators

Multi-phase drives

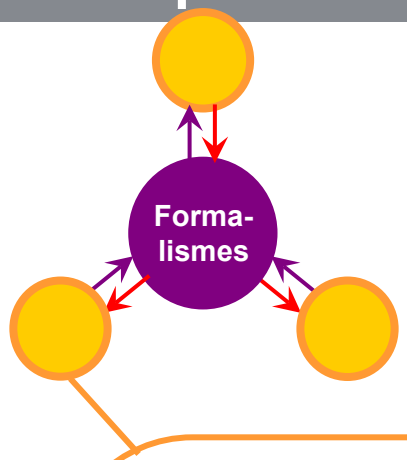
Experimental facilities « eV »

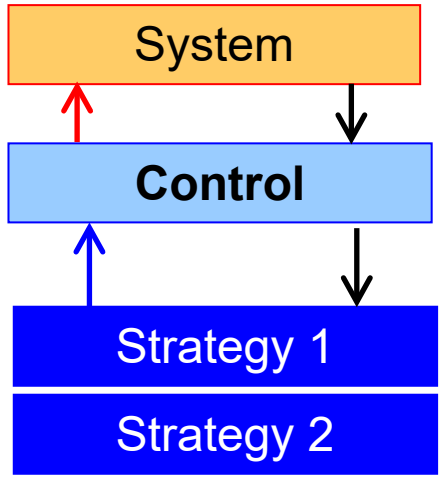
COMASUS Continuum de l'énergie

MEGEVH French network on HEV's

Comin

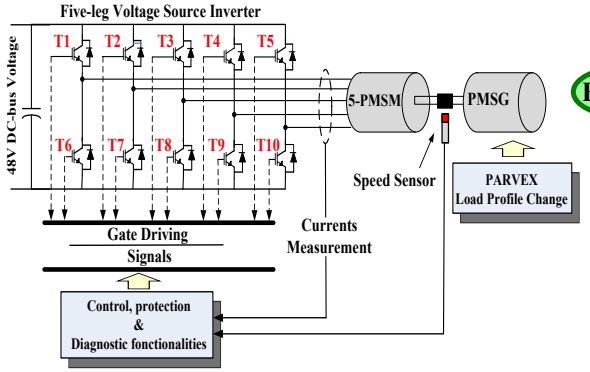
Example of control of multi-phase drive

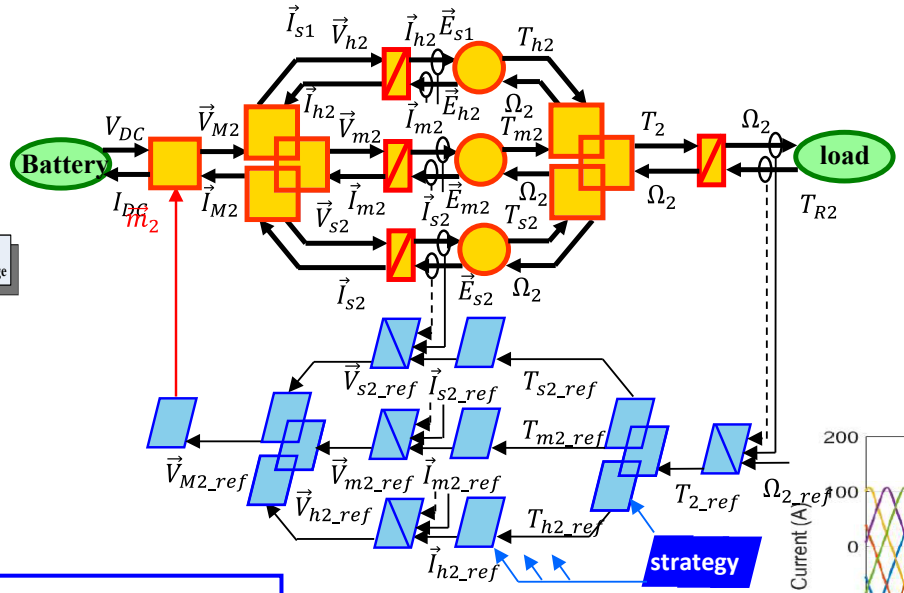


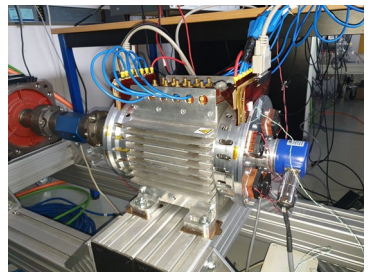


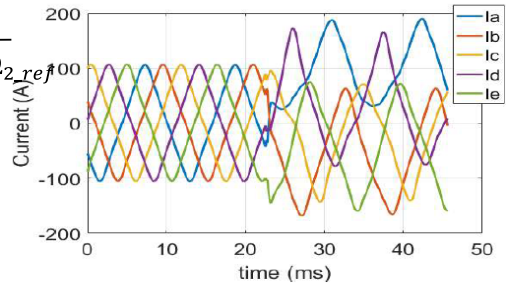
Same control organization for
Managing several operation modes

From normal to fault operations of a 5-phase electric drive







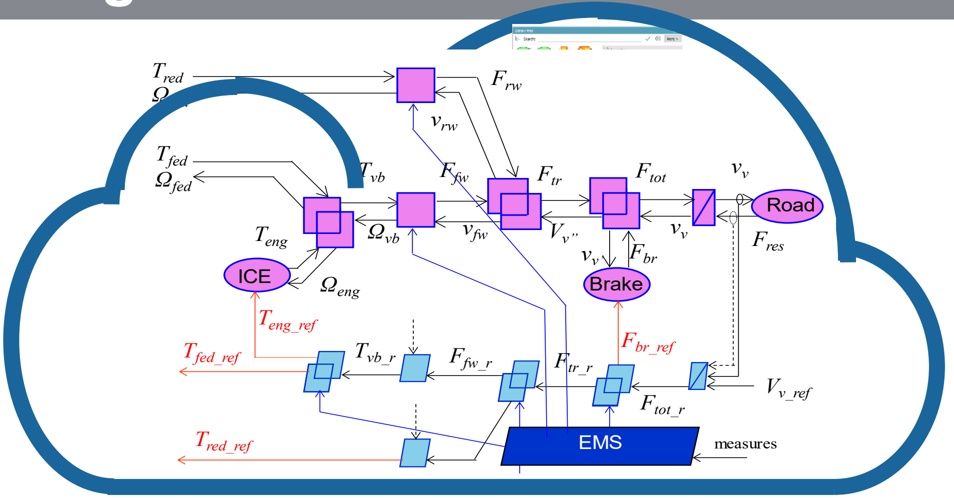


Strategy 1: normal mode
Strategy 2 : fault mode

[Vu 2022]

« Hardware-In-the-Loop » testing for e-vehicles

HIL testing of
new components



PARIS

aws

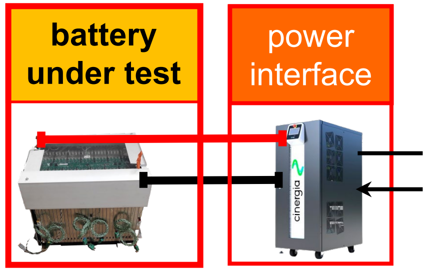
GA 824256

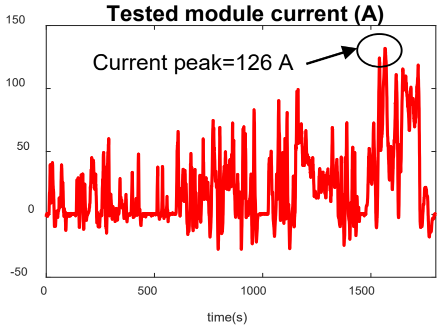
[German 2024]

Managing complexity

BRUSSELS

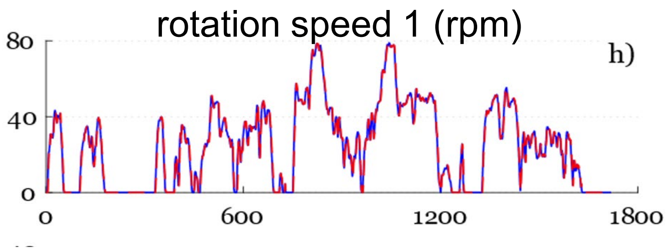
VRIJE UNIVERSITEIT BRUSSEL

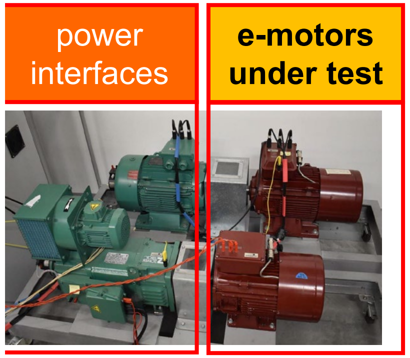




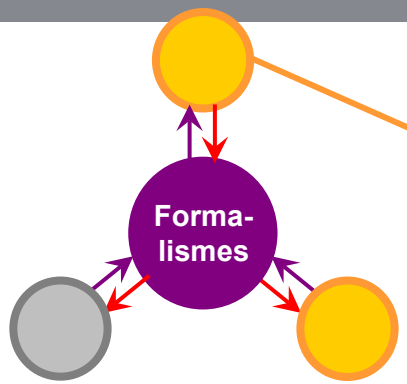
LILLE

L2EP
Université de Lille



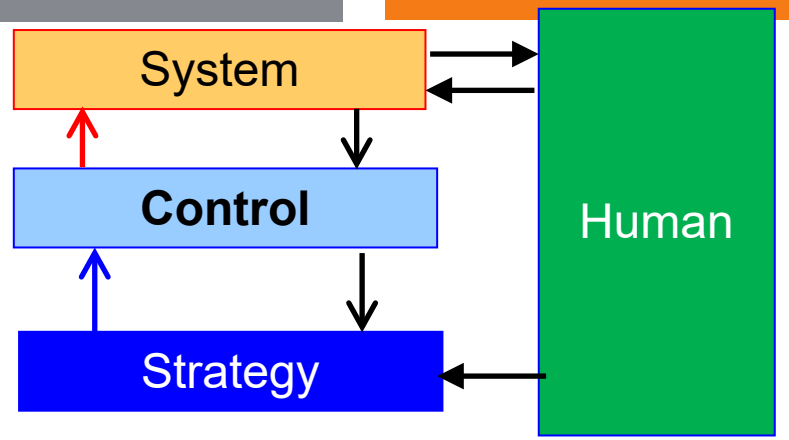


« Human-In-the-Loop » with piezoelectric actuators

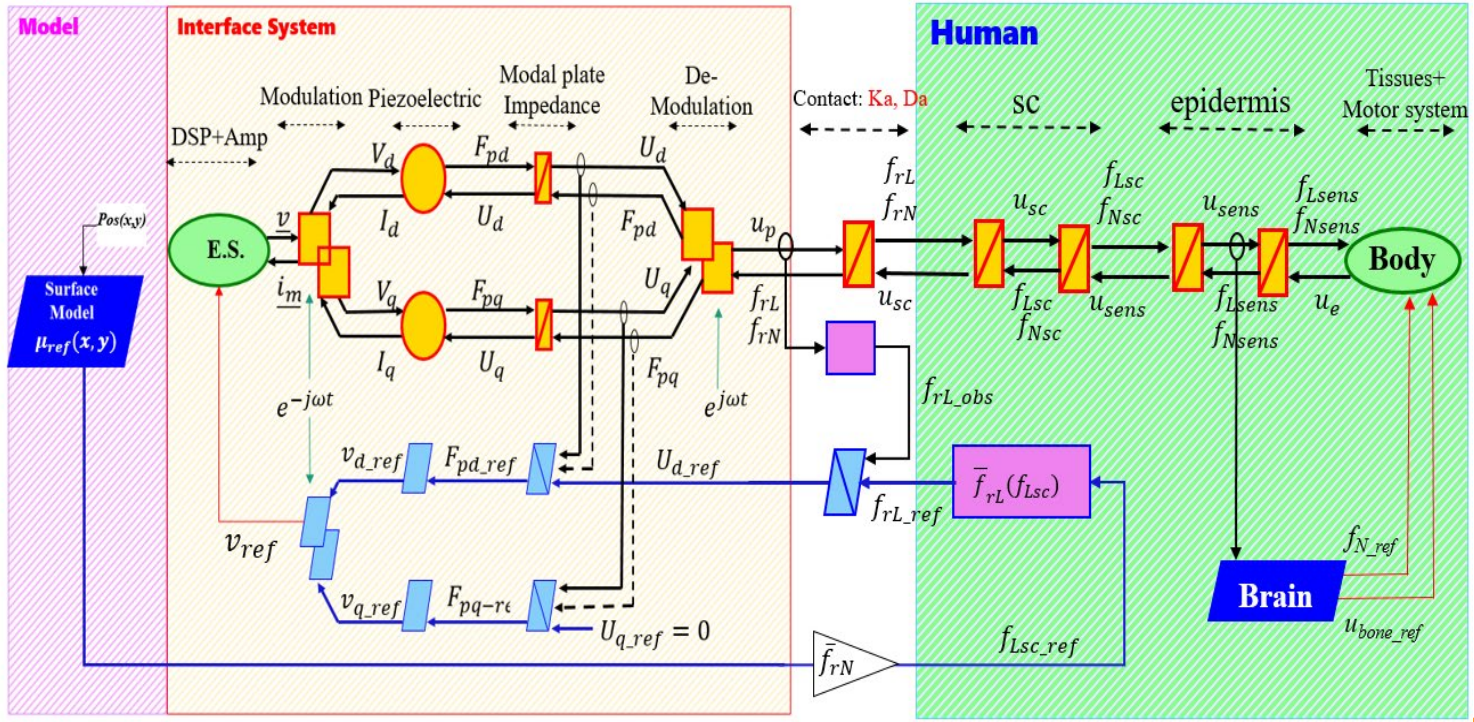


Considering interactions with human

- characterization
- analyses of impacts
- Adaptation strategies



Example: improvement of the control of tactile devices



[Torres 2021]

From « Hardware » to « Human » In the Lopp

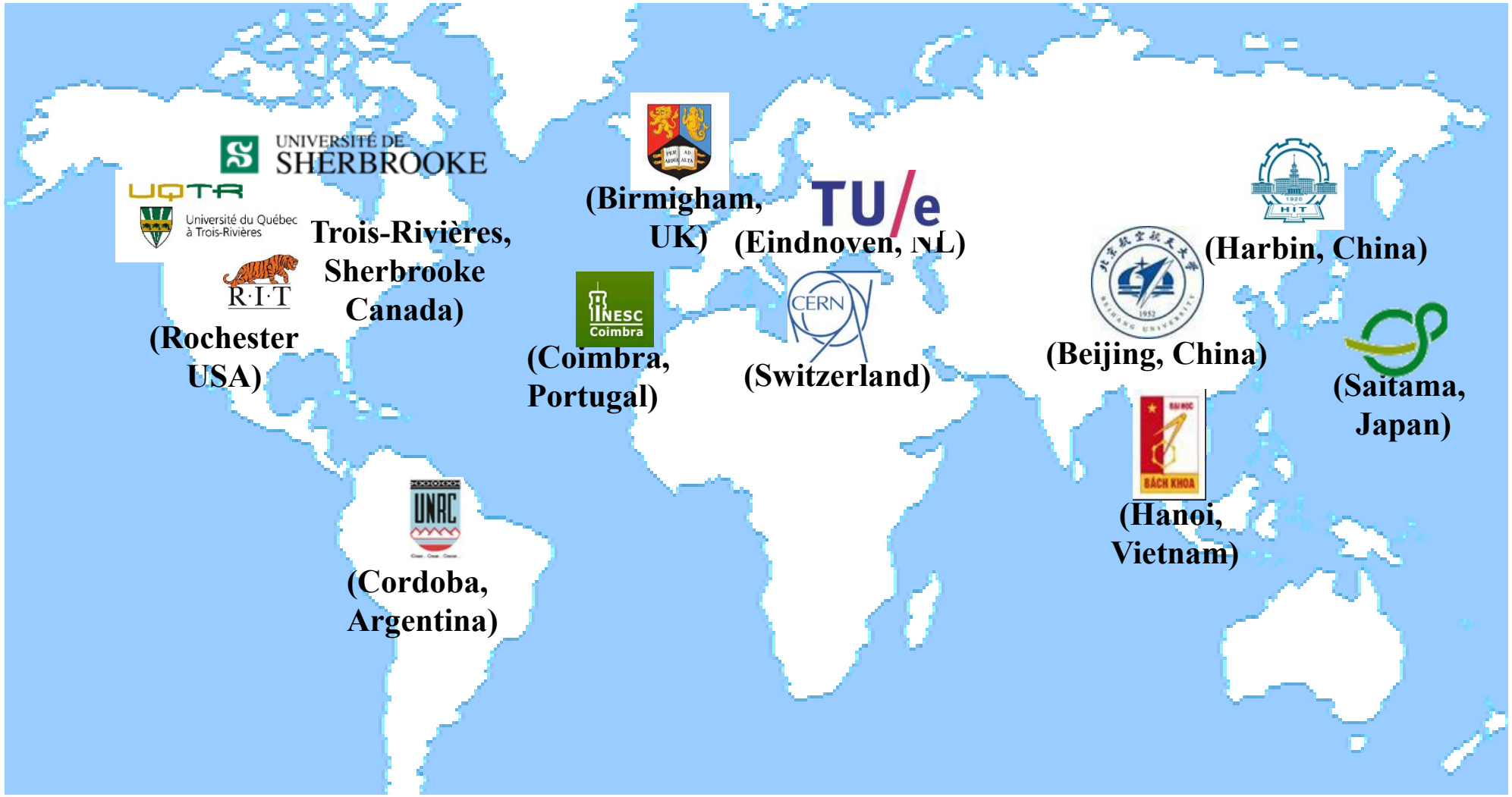
1 University of Lille

2 L2EP Lille

3 Control team

4 **Dissemination**

Main industrial and international collaborations



Industry

hap2U
MMT
SEGULA TECHNOLOGIES
SIEMENS
Typhoon HIL
INSTITUT VEDECOM
EDF R&D
GOTOUCHVR
MEL MÉTROPOLE EUROPÉENNE DE LILLE
GROUPE RENAULT
SHERPA ENGINEERING
SNCF
Valeo

- **University of Lille, Polytech Lille, Centrale Lille**
  - Master 1: EMR initiation
  - Master 2: EMR further development

Simulation session, EMR'08, Harbin

- **Other French Universities and Engineering Schools**
  - Cachan (2004) Belfort (2006), ParisTech (2010),
  - Polytech'ParisSud (2018), etc.

EMR'17, Lille, June 2017

- **Universities abroad France**
  - Canada (Trois-Rivières, 2002, Sherbrooke 2015)
  - Switzerland (EPF Lausanne, 2005, Univ. Sion, 2014)
  - Spain (Barcelona, 2010, Madrid 2013, Oviedo, 2016)
  - Portugal (Coimbra, 2014) Colombia (Santander, 2016)
  - China (Tsinghua, 2008, Harbin 2013) Vietnam (Hanoi, 2017)
  - Colombia (Santader, 2019), Romania (Cluch 2020),
  - India (Amity, 2024)…

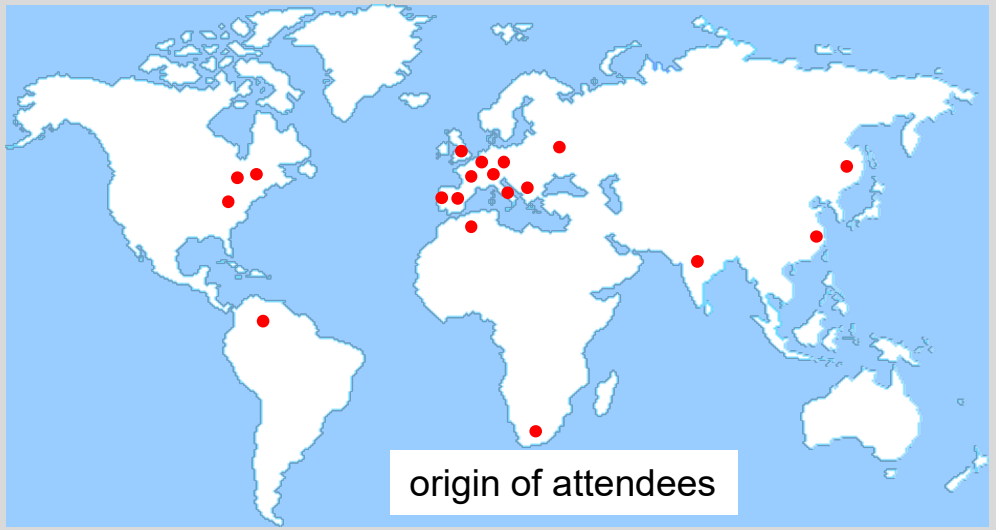
EMR Simulink library

EMR summer schools

Since 2006, even year in France, odd year abroad

2014 Coimbra (Portugal), 2016 Montreal (Canada), 2018 Hanoi (Vietnam) 2022 Sion (Switzeland) 2024 Delhi (India)

118 attendees
from 17 countries
(51 in presences, 61 on-line)
3 lectures on concepts
26 lectures on applications,
4 simulation sessions (3 on-line).



EMR'25, Lille (France), 8-11 July 2025, hybrid
http://emerwebsite.org

Pre-doctoral summer school

1-month Summer School
50% technical lectures
50% culture & language

All inclusive except travel
Scholarships from French embassy

ACES'18: 9 Chinese + 2 Brazillian students
2 now in PhD at Univ. Lille

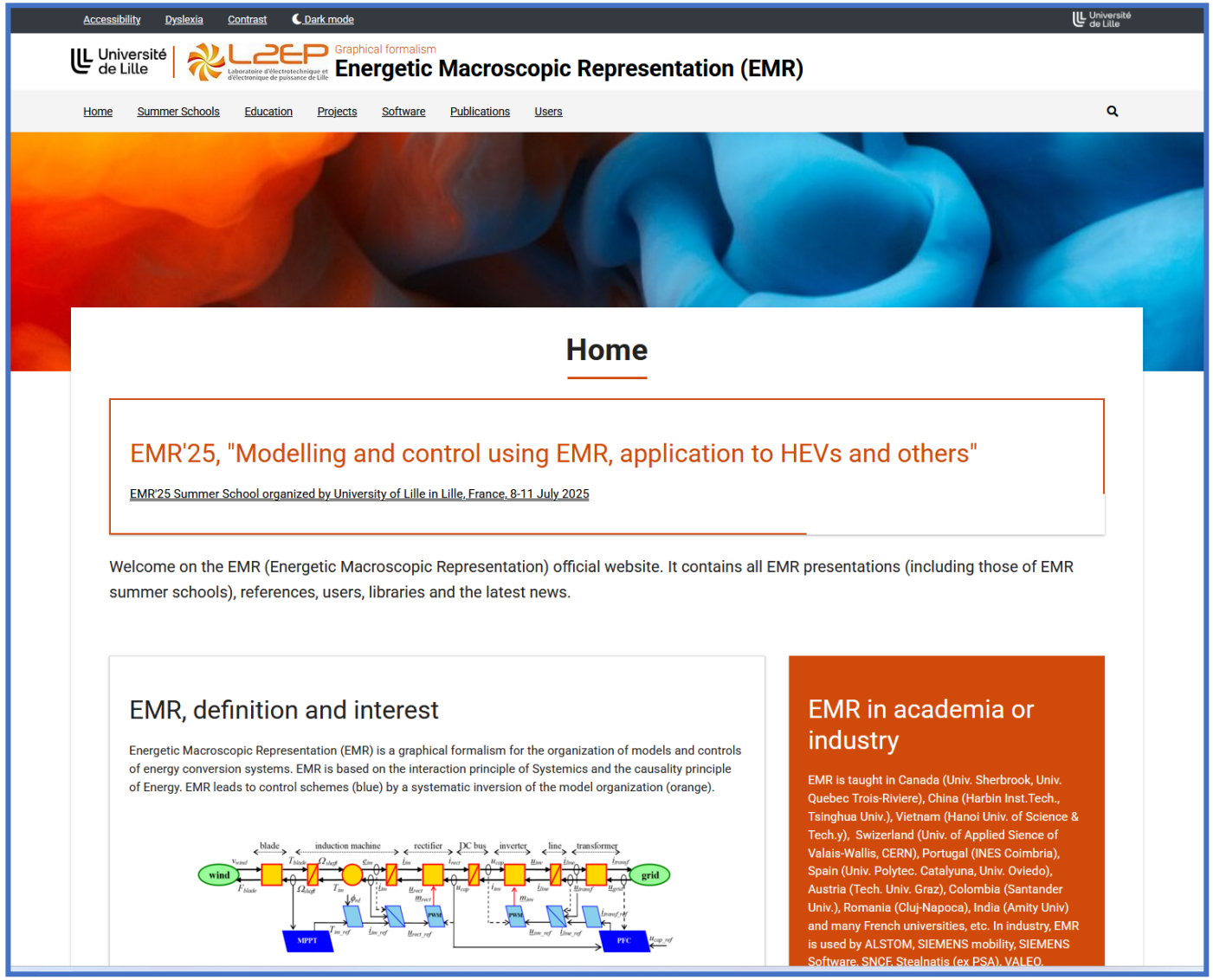
Driving test of the L2EP electric vehicle

Next edition
ACES'26
(in-presence event)
July 2026

ACES LILLE 2026 EXCELLENCE

http://www.international-academy.fr/aces/

EMR web site



http://emerwebsite.org

- Summer schools
- Education
- Projects
- Publications
- Users

Next Week:
All documents and photos
Available on EMR website

[Bouscayrol 12] A. Bouscayrol, J. P. Hautier, B. Lemaire-Semail, "Graphic Formalisms for the Control of Multi-Physical Energetic Systems", *Systemic Design Methodologies for Electrical Energy, tome 1, Analysis, Synthesis and Management, Chap. 3*, ISTE Willey editions, Oct. 2012, ISBN: 9781848213883.

[Bouscayrol 23] A. Bouscayrol, B. Lemaire-Semail, "Energetic Macroscopic Representation and Inversion-Based Control", *Encyclopedia of electrical and electronic power engineering*, Vol. 3, pp 365-375, Elsevier, DOI : 10.1016/B978-0-12-821204-2.00117-3, ISBN : 978-0-12-823211-8, 2023.

[Torres 21] Diana Angelica Torres Guzman, “Generation and control of tactile feedback with longitudinal ultrasonic vibration and human-in-the-Loop analysis“, PhD dissertation, University of Lille, December 2021.

[German 24] R. German, T. Kalogianis, A. Bouscayrol, J. He, F. Tournez, M. Berecibar, C. Husar, M. Ciocan, S. Costa, A. Genic, B. Lemaire-Semail, "A flexible cloud-based HIL testing of batteries for various electrified vehicles," *IEEE Transactions on Vehicular Technology*, vol. 73, no. 4, pp. 4610-4620, April 2024. (with the PANDA H2020 project)

[Wu 22] D.Y Wu, N. K. Nguye, E. Semail, "Fault-tolerant Control for Non-sinusoidal Multiphase Drives with Minimum Torque Ripple“, IEEE Transactions on Power Electronics, Vol. 37, no. 6, pp. 6290-6304, June 2022

Thanks for your attention!

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L2EP
Laboratoire d'électrotechnique et d'électronique de puissance de Lille

Université de Lille

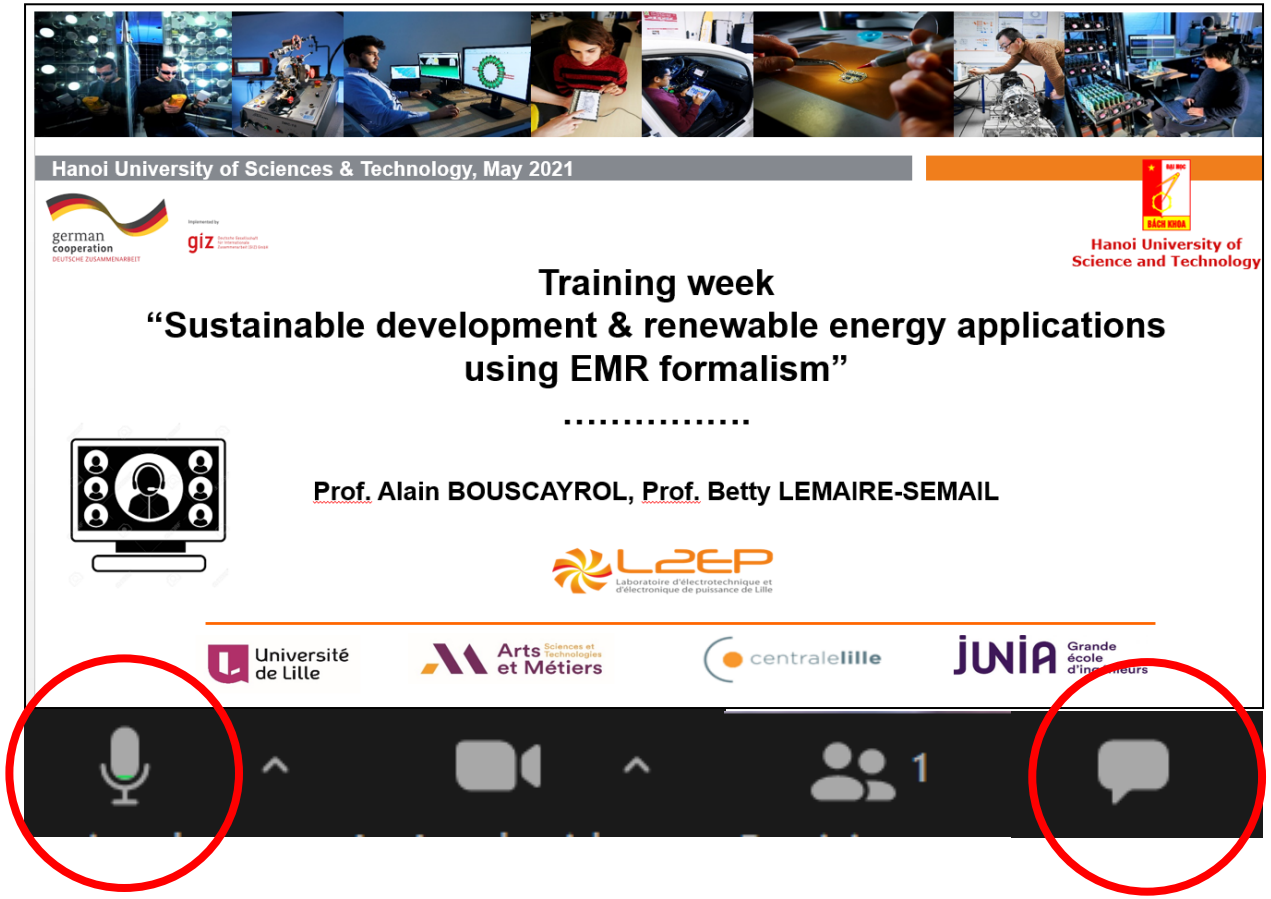
Arts et Métiers Sciences et Technologies

centralelille

JUNIA Grande école d'ingénieurs

Time for discussion

Problem with ZOOM?
Stop & Restart = 75% of solutions



microphone webcam attendees **chat**

During webinar

- turn off microphone
- turn off webcam
- open your mind!

(increase of the flow quality)

For questions

- ask your question by chat
- manager gives you the floor
- turn on your microphone and take the question

(no question = no interest)

End of lecture

- open your webcam for nice photo group!

Key figures 2018-2024

Industry:

- 1 joint industrial Lab with EDF, numerical modelling for e-systems)
- 2 framework agreements with EDF and RTE (power systems)

University:

- coordination of Interdisciplinary programs: CUMIN (e-mobility) and COMASYS (energy)

Regional:

- coordination of CPER projects : CE2I (2015-2022, smart e-drives) / EE4.0 (2021-2027, electrical energy of future)

National: coordination of GDR CNRS TACT (tactile applications)

International:

- coordination of 3 Europeans Projects: PANDA (e-vehicle, MuliTouch (piezo actuators), MAXIMA (e-drives)