Tallinn University of Technology, May 2025

TAL TECH

Estonian Doctoral School

“Sustainable development & energy transition using EMR formalism”

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Prof. Alain BOUSCAYROL, Prof. Betty LEMAIRE-SEMAIL

with the support of

Université de Lille

France 2030

Transitions énergétiques

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

Speakers

Prof. Alain BOUSCAYROL, University of Lille, L2EP,
Head of the Master “Automatic control & Electrical Systems”
Coordinator of the CUMIN interdisciplinary programme
Coordinator of the PANDA European project
Chair of the steering committee of IEEE-VPP Conference of IEEE-VTS
PhD in Electrical Engineering at University of Toulouse (1995)
Research topics: EMR formalism, HIL testing, control & electric and hybrid vehicles

Prof. Betty LEMAIRE-SEMAIL, University of Lille, L2EP,
Head of the Lab of Electrical Energy & Power Electronics
Coordinator of the GdR TACT national programme
Chair of the Energy Transition SDG group of Univ. Lille
Involved in the STINTS and MULTITOUCH European projects
PhD in Electrical Engineering at University Paris VI (1990)
Research topics: piezoelectric actuators and applications using EMR

INTRODUCTION TO SUSTAINABLE DEVELOPMENT

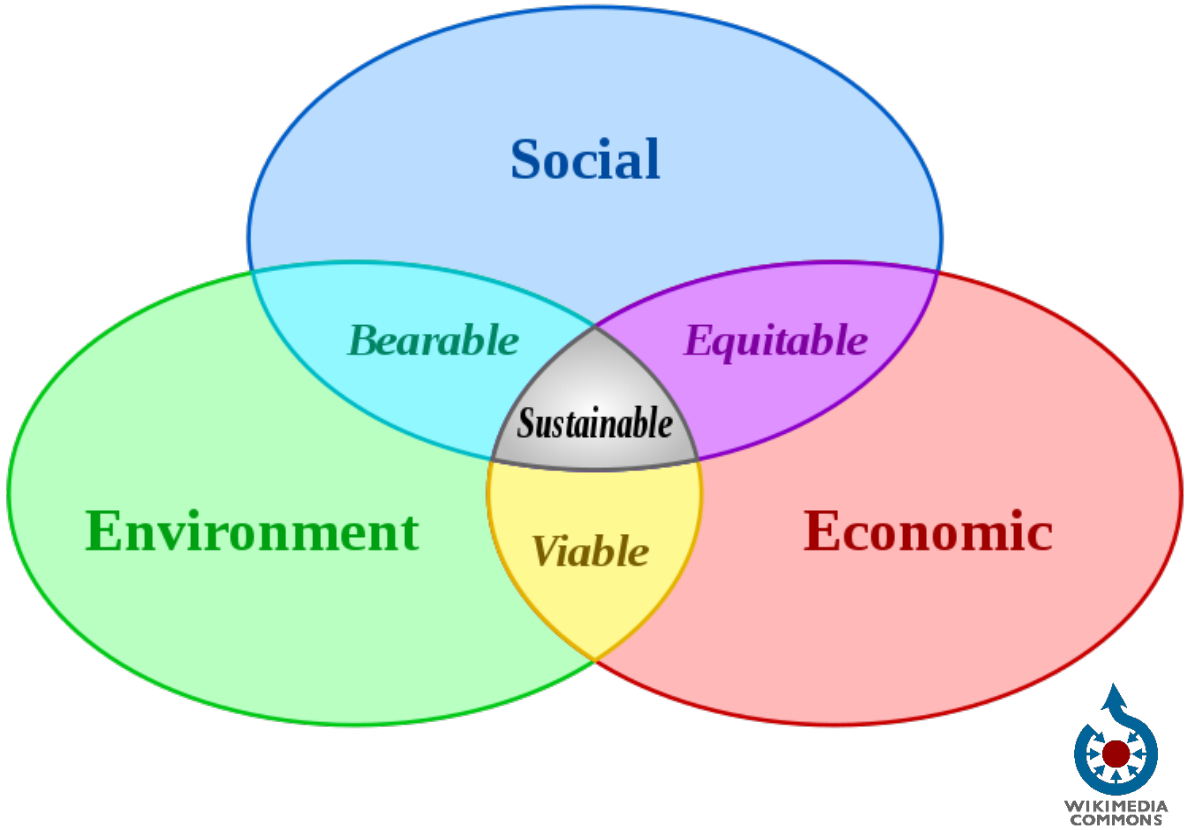
Based from presentation of Master “Electrical Engineering and Sustainable Development”, University of Lille

Sustainable Development

One definition:

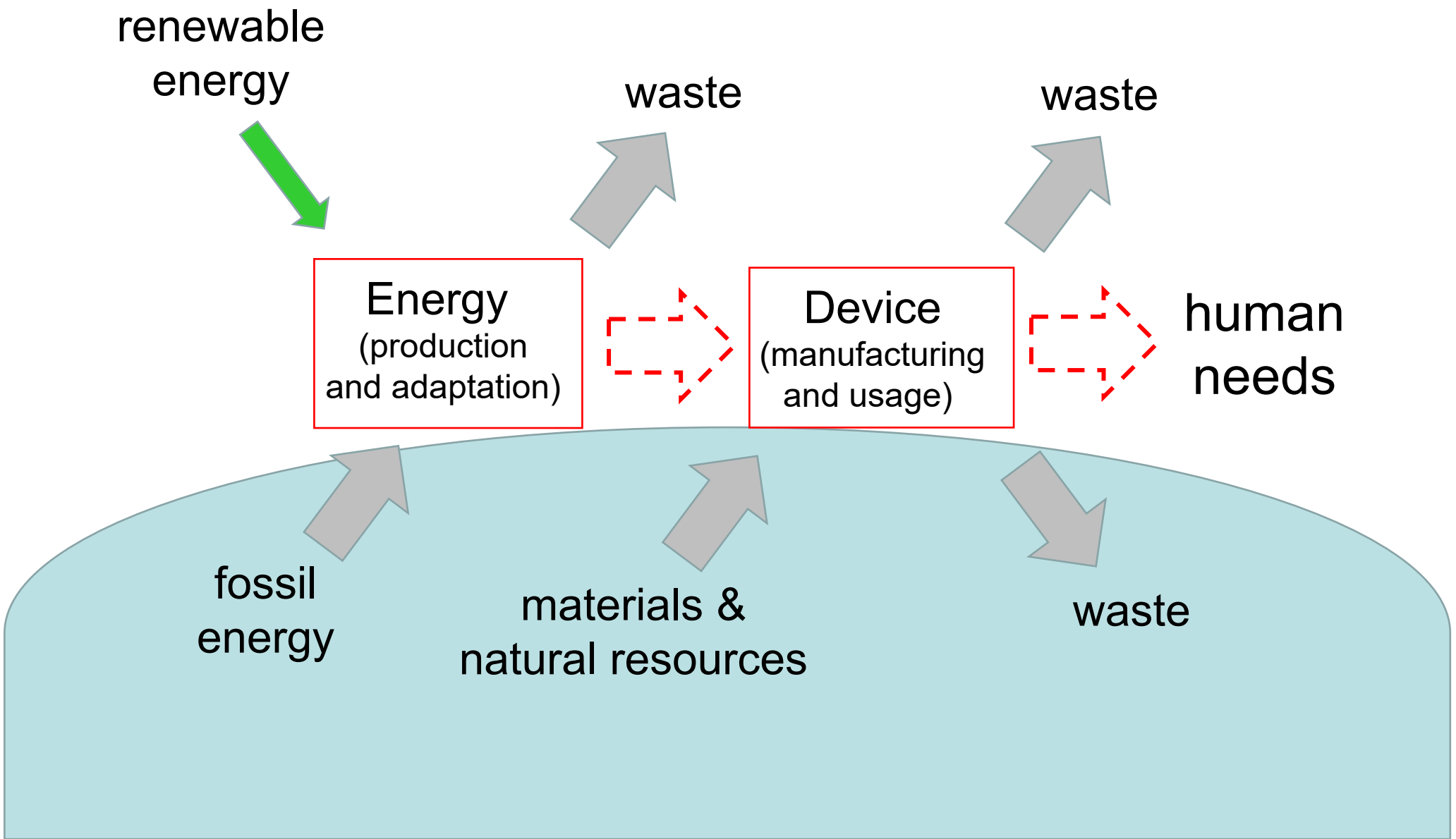
meeting human goals while preserving

natural resources for future generation



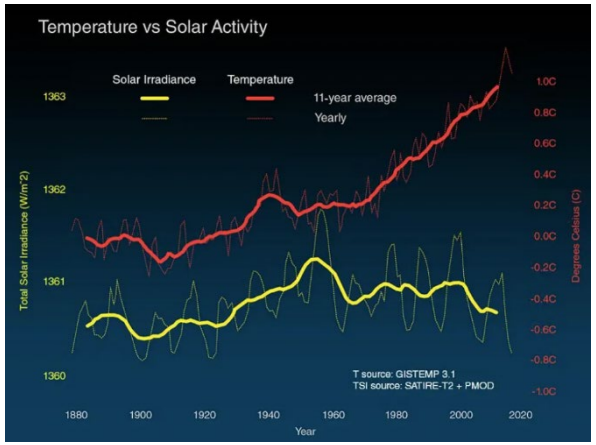
No sustainable development without

combining social / economics / environment


renewable energy
waste
waste
Energy (production and adaptation)
Device (manufacturing and usage)
human needs
fossil energy
materials & natural resources
waste

renewable energy

waste



Energy (production and adaptation)

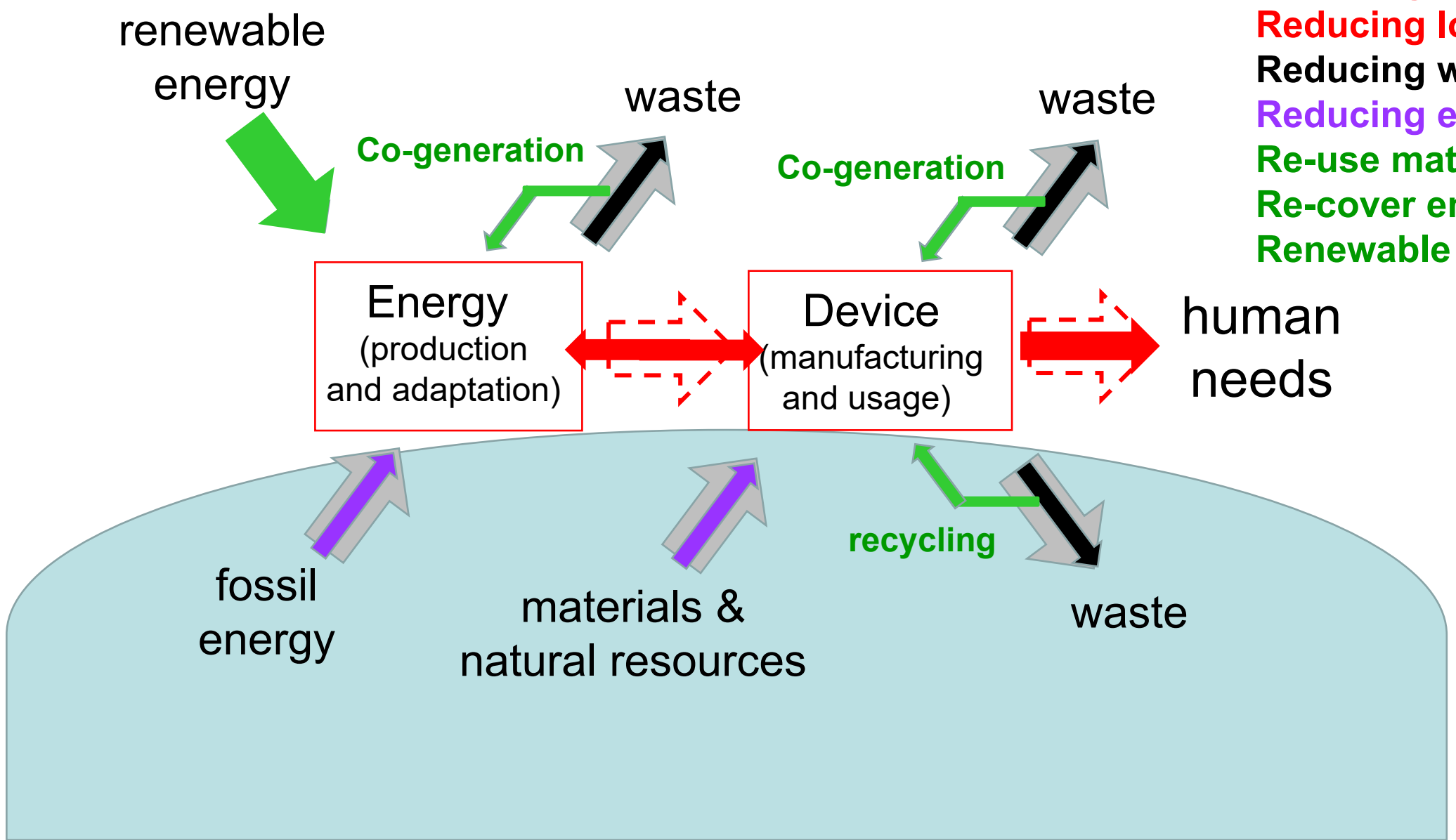
Device (manufacturing and usage)

human needs

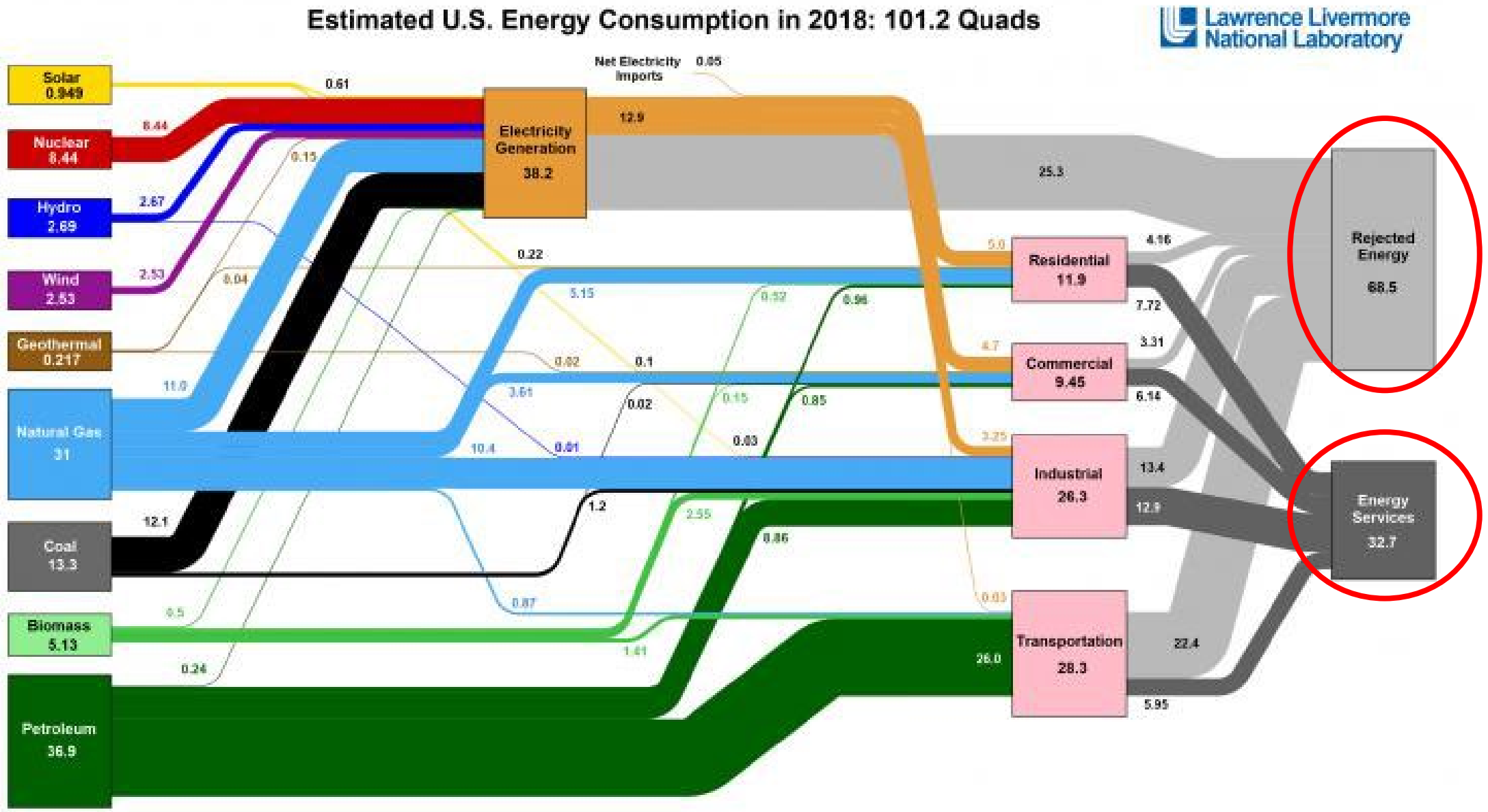
fossil energy

waste

Reducing needs
Reducing losses
Reducing waste
Reducing extractions
Re-use materials
Re-cover energy
Renewable energy



Energy and waste, e.g. USA 2018

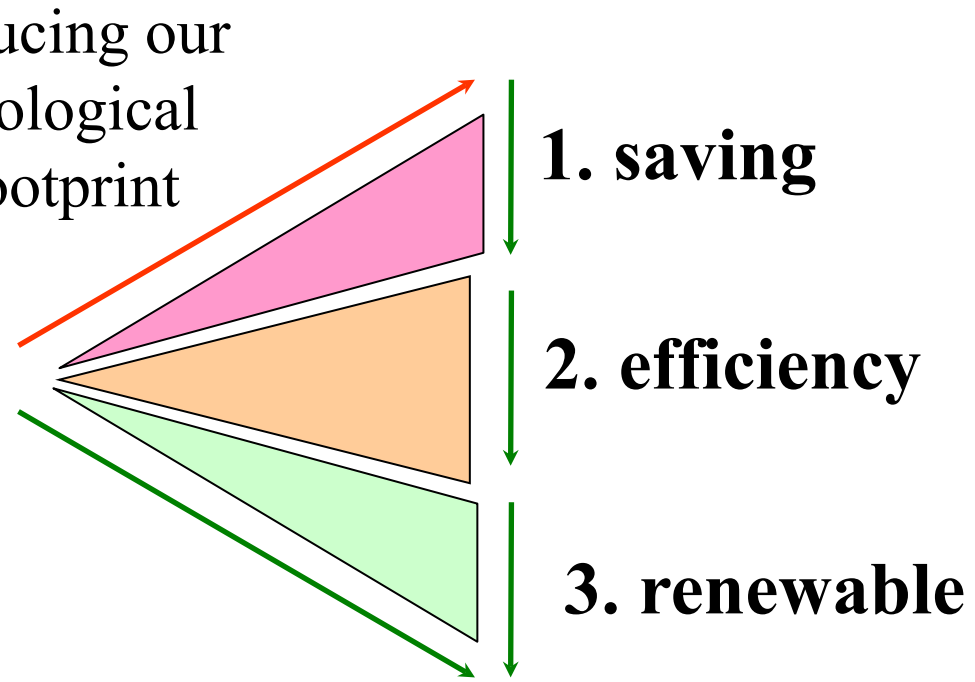


Waste (66%)

real use (33%)

For environmental concerns and resource depletions, a sustainable development is required by:

- reducing our energy consumption
- increasing efficiency of products
- producing energy from renewable sources



Development of new efficient systems (design, building, control)

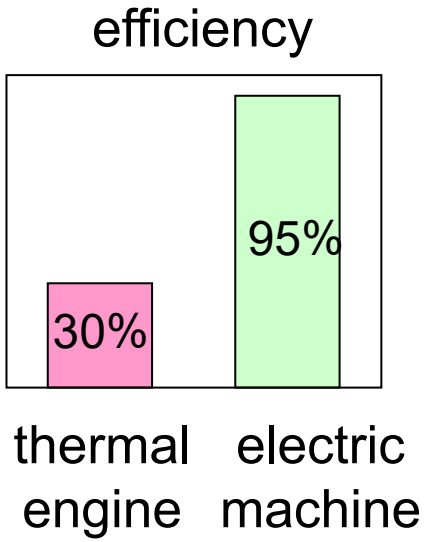
Don’t confuse Sustainable Development and Renewable Energy

NEEDS OF RELEVANT METHODS AND TOOLS

Based from presentation of Master “Electrical Engineering and Sustainable Development”, University of Lille

New efficient systems are developed including:

- **more renewable energy conversion systems** (high availability)
- **more electrical subsystems** (high efficiency)
- **energy storage subsystems** (energy smoothing and recovery)
- **more multi-physical subsystems** (complementary operations)
- **more efficient control** (for same/higher performances)



How to design the different subsystem?
How to control the entire system?

a trans-disciplinary methodology is required!

independent of the physical fields

systematic procedures and testing

In order to face the complexity… “divide and conquer” !

Prof. C.C. Chan (Univ. of Hong-Kong)

That’s the Engineer challenge !

complex system → subsystems in interactions

decomposition is a key and **sensitive** issue!

SYSTEMICS approach

system analysis

adapted models are a key and sensitive issue!

MODEL-BASED approach

system design

system control

EMR
(graphical description)
=
Organization of models of energy conversion systems

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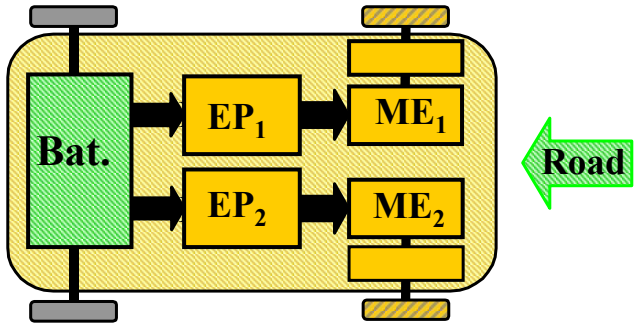
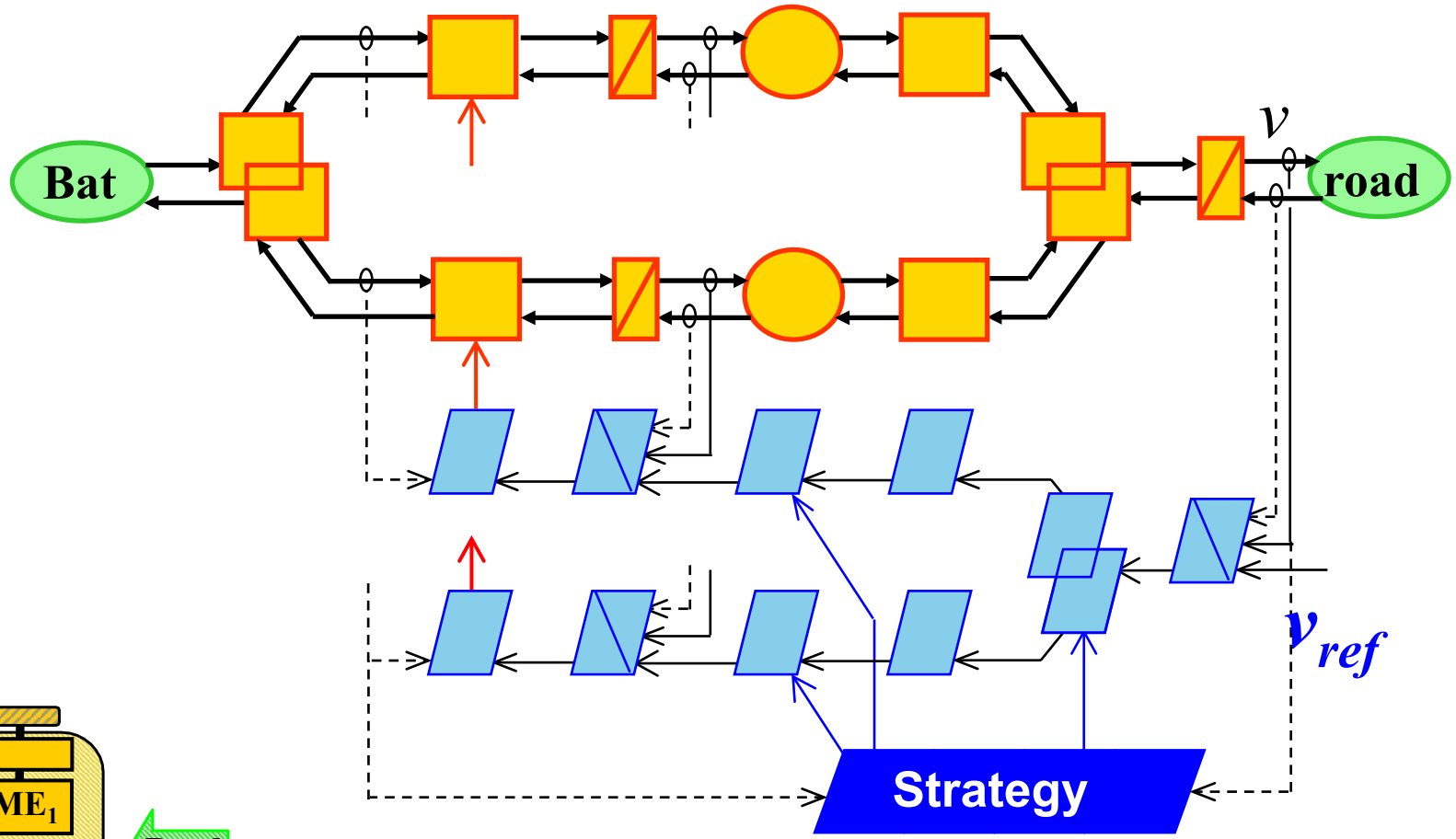
Systematic deduction of organization of control schemes and energy management





[Bouscayrol 2012] [Bouscayrol 2023]

Université de Lille

FRANCE 2030

7 Sustainable Development Goals

Energy Transition SDG group

Campus of University with Mobility
Based on Innovation and carbon Neutrality

https://cumin.univ-lille.fr/

Continuum of energy
from matetials to systems

https://comasys.univ-lille.fr/

EMR formalism
as common tool

EMR TRAINING PROGRAMME @ TALTECH

Training outline

Wednesday 14 May 2025			
		Lecture session / NRG 422	
09:30	10:00	Introduction on Energy conversion	Both
10:00	11:00	Energy & Systems	A. Bouscyarol
11:00	12:00	Energetic Macroscopic Representation	B. Lemaire Semail
12:00	12:30	Open discussion on modelling	Both
		Simulation session / NRG 223	
13:45	17:00	Simulation of an electric vehicle part 1. EMR of the vehicle	Both
Thursday 15 May 2025			
		Lecture session / NRG 422	
09:30	10:00	Inversion-based control	B. Lemaire Semail
10:00	11:00	Wind energy conversion system	B. Lemaire Semail
11:00	12:00	Photovoltaic conversion system	B. Lemaire Semail
12:00	12:30	Open discussion on control	Both
		Simulation session / NRG 223	
13:45	17:00	Simulation of an electric vehicle part 2. Control of the vehicle	Both
Friday 16 May 2025			
		Lecture session / NRG 422	
09:30	10:00	Energy management strategy	A. Bouscayrol
10:00	11:00	Hybrid Electric Vehicles	A. Bouscayrol
11:00	12:00	Subway supply system	A. Bouscayrol
12:00	12:30	Open discussion on energy management	Both
		Simulation session / NRG 223	
13:45	17:00	Simulation of an electric vehicle part 3. Energy management of the vehicle	Both

Global schedule that **will be adapted** in function of the attendance

Lectures on concepts
(EMR formalism)

Lectures on applications
(energy conversion systems)

Practice using simulation
(MATLAB-Simulink ©)

Open discussions