SCIENTEENS LAB
DE LABO FIR JONKER

Outreach for Photovoltaics

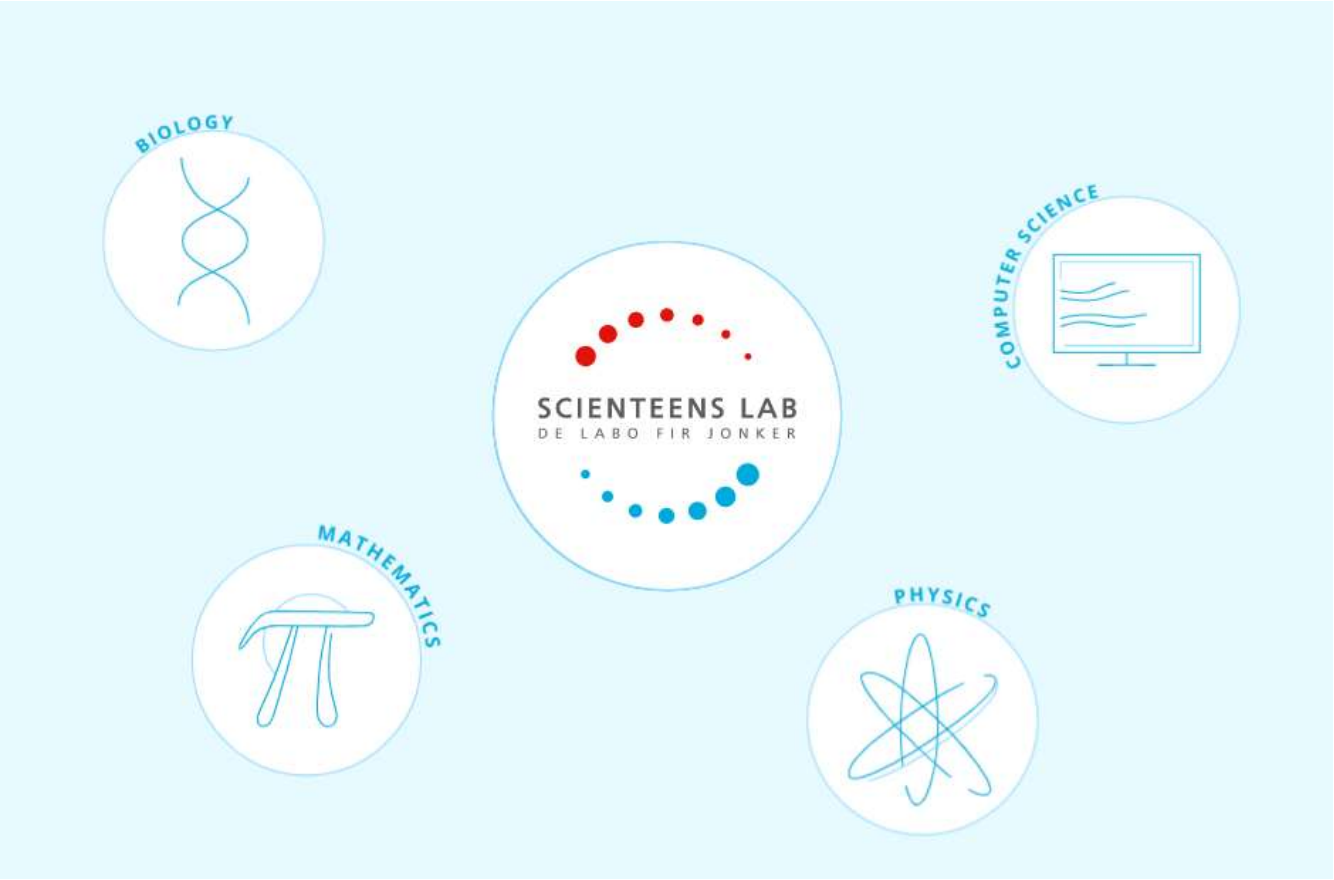
Feb. 10th 2025

UNIVERSITÉ DU LUXEMBOURG

andrē losch FONDATION

PHYMS | PHYSICS AND MATERIAL SCIENCES RESEARCH UNIT

Scienteens Lab: Workshops for Schools



"Tell me and I forget,
Teach me and I may remember,
Involve me and I learn."

Confucius

phillip.dale@uni.lu

Is it possible for Luxembourg to go 100% renewable?

phillip.dale@uni.lu

Is it possible for Luxembourg to go 100% renewable?

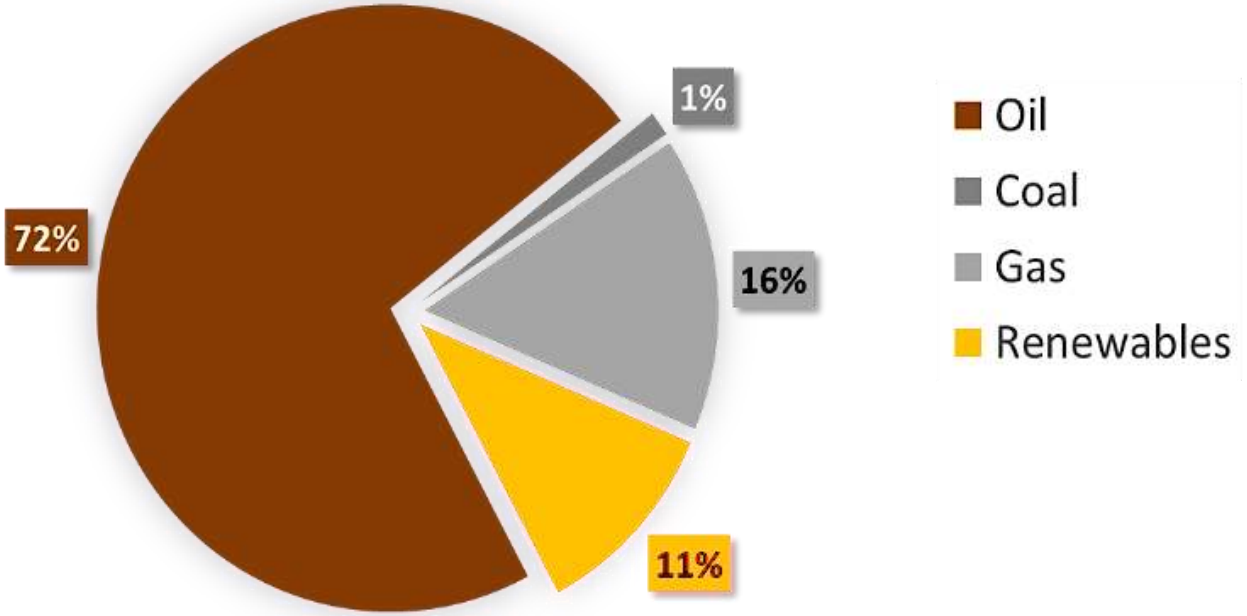
http://luxembourg.public.lu/en/cartes-du-luxembourg/06-reseau-fluvial/index.html

phillip.dale@uni.lu

Goals for the day

- ❑ Know your own energy footprint
- ❑ Evaluate the advantages and disadvantages of different types of renewable energy
- ❑ Calculate the amount of renewables necessary to cover own life choices

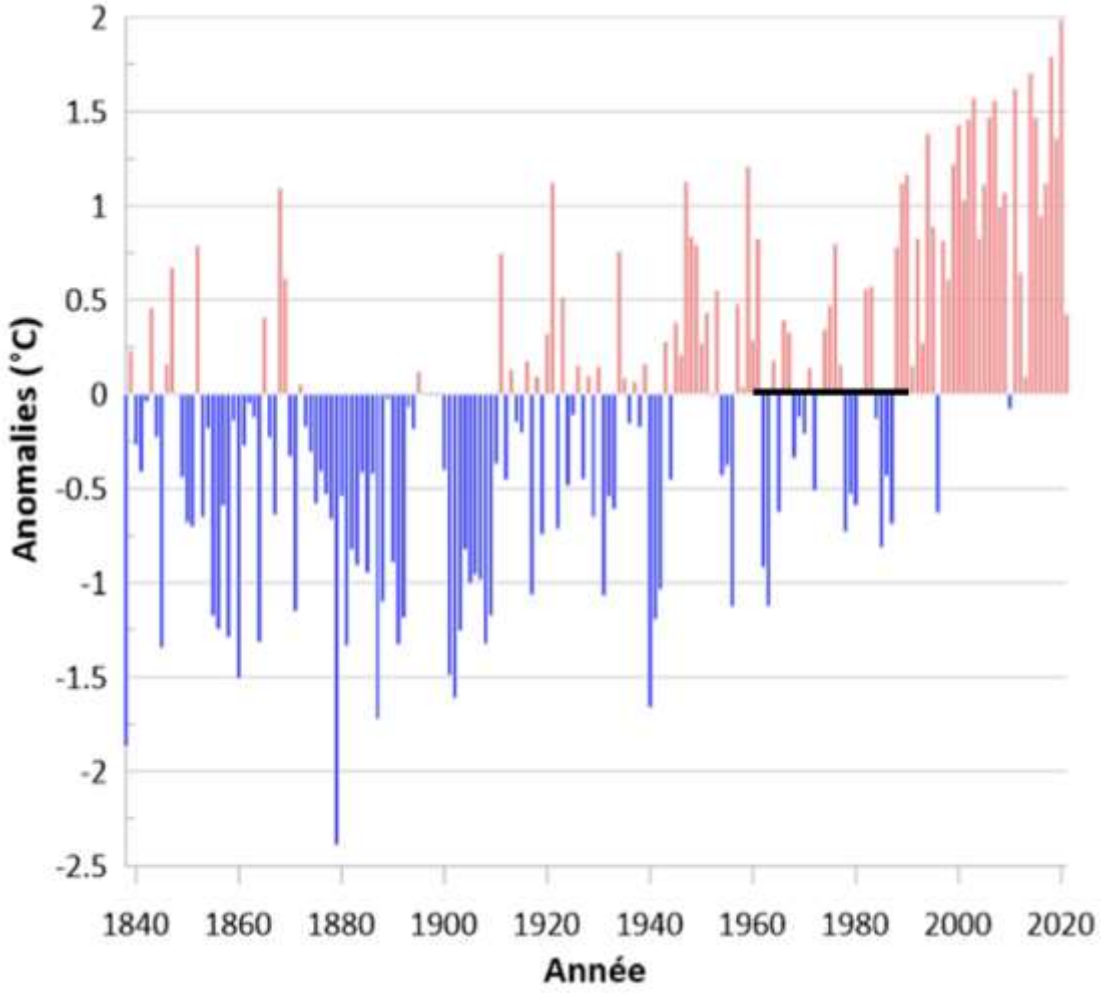
phillip.dale@uni.lu



- **Transport dominates our emissions.**

phillip.dale@uni.lu

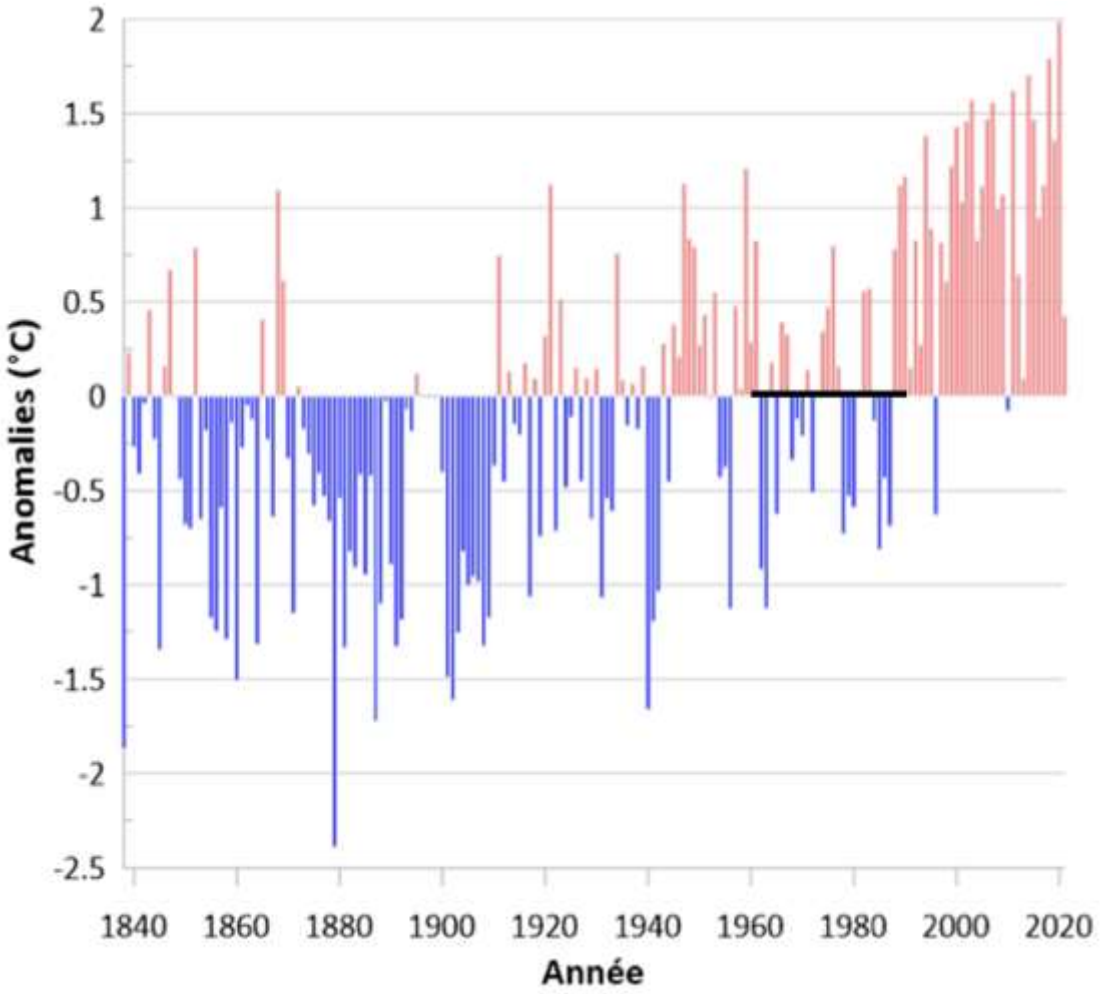
Anomalous temperatures compared to the average of 1961 - 1990



https://gouvernement.lu/fr/actualites/toutes_actualites/communiques/2022/12-decembre/27-agrimeteo.html

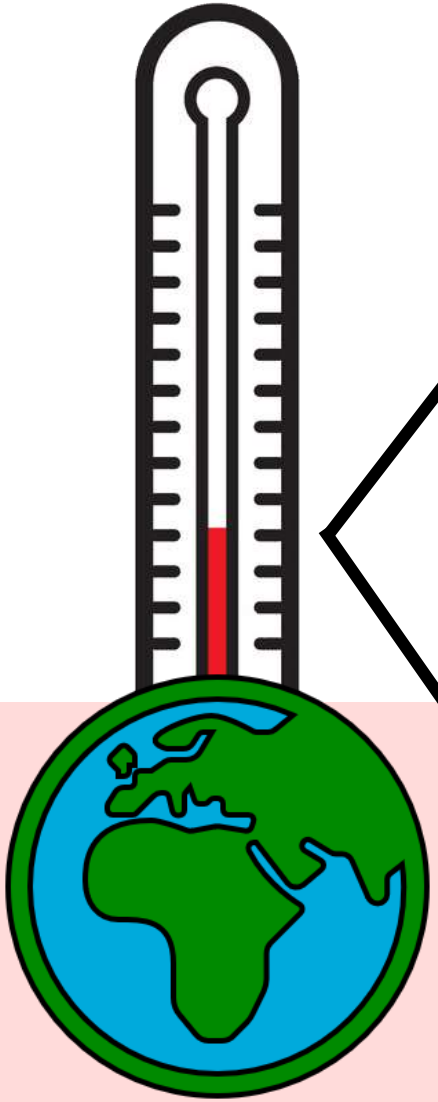
phillip.dale@uni.lu

Anomalous temperatures compared to the average of 1961 - 1990



https://eau.gouvernement.lu/dam-assets/actualites/2024/rap-no3-2020-2023-lu.pdf
https://gouvernement.lu/fr/actualites/toutes_actualites/communiques/2022/12-decembre/27-agrimeteo.html

phillip.dale@uni.lu



4 °C

x39

Current promises

2 °C

x14

Today

1 °C

x5

0 °C

x1

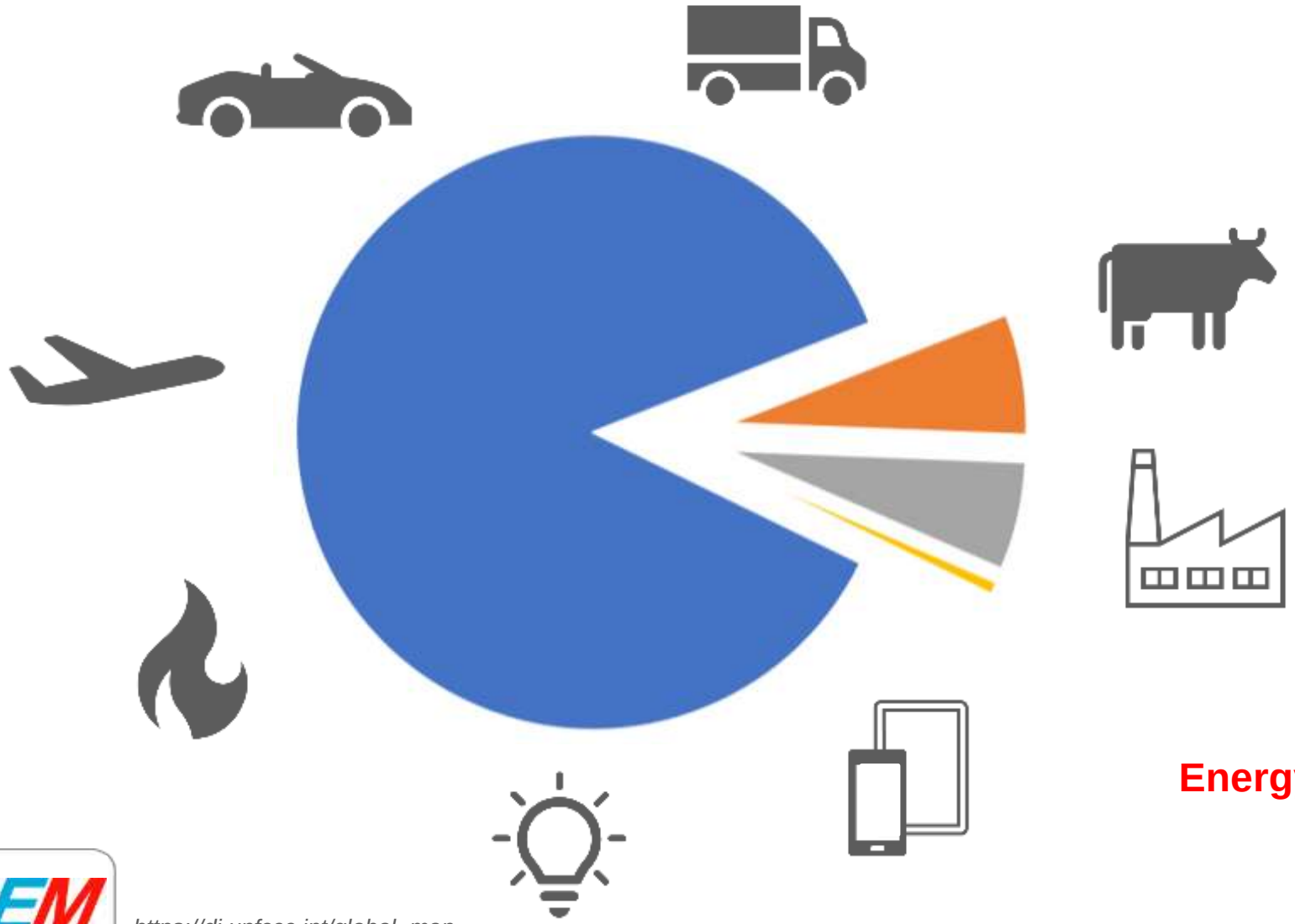
Greenhouse gas footprint

Luxembourg green house gas per capita is double that of Europe

Data taken from the national GHG emission inventory: https://di.unfccc.int/global_map

phillip.dale@uni.lu

Luxembourg greenhouse gas emissions

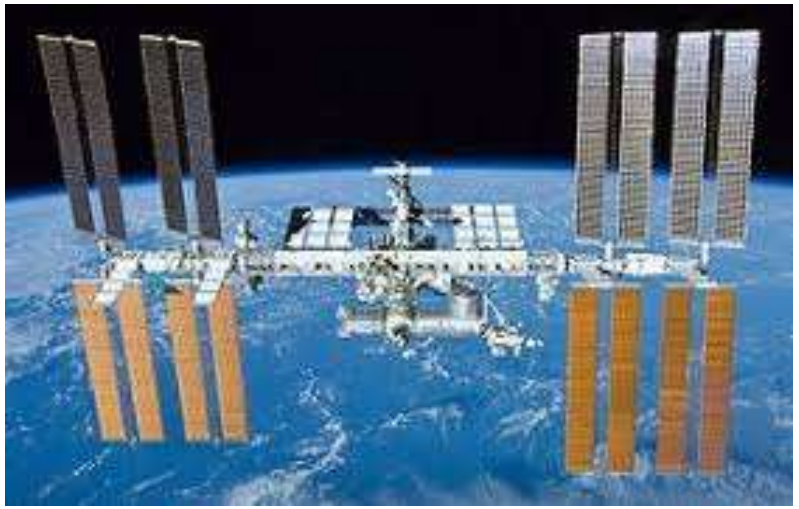


Energy dominates our emissions.

https://di.unfccc.int/global_map

phillip.dale@uni.lu

Our approach



120 kW – 8 hours per day
= 960 kWh per day

160 kWh per day
per astronaut

How much energy do we need?

How much energy is available?

https://www.nasa.gov/mission_pages/station/structure/elements/solar_arrays-about.html

phillip.dale@uni.lu

Electricity in our homes is measured in kWh

Electricity consumption per day:

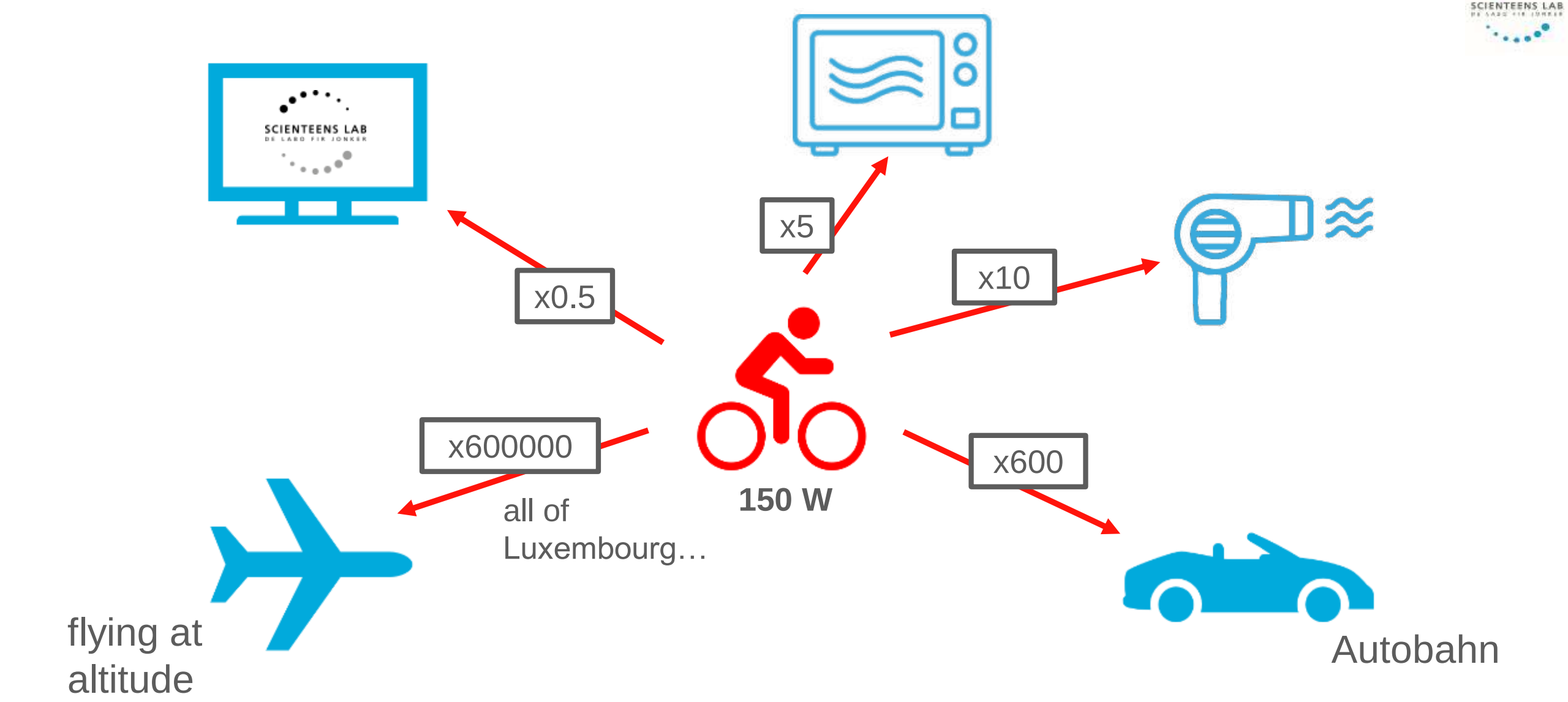
$$\frac{14\,075\ \text{kWh}}{365\ \text{d}} = 38{,}6\ \text{kWh/day}$$

Electricity consumption per day per person

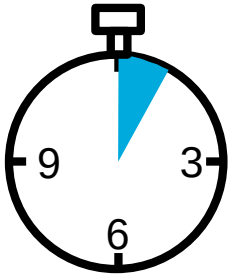
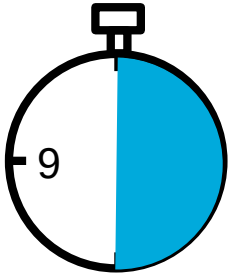
$$\frac{38{,}6\ \text{kWh/d}}{6\ \text{p}} = 6{,}4\ \text{kWh/day/person}$$

kWh/day/person is the unit we use to estimate our Energy needs

phillip.dale@uni.lu


SCIENTEENS LAB
x0.5
x5
x10
x600000
x600
150 W
all of Luxembourg…
flying at altitude
Autobahn

Energy measurements

Power [Watts (W)]	x	time [hours (h)]	=	Energy [Wh]
 150 W	x	 1h	=	150 Wh
75 W  150 W	x	 6h	=	900 Wh = 0.9 kWh

kilo Watt hours or kWh

I've got the power?

70 kWh

Number of panels	Peak power (kWp)	Hours of full sunshine (h)	Energy produced (kWh)
1	0.35	1	0.35
1	0.35	200	70
10	3.5	20	70
30	10.5	6.7	70

Power x time = Energy

phillip.dale@uni.lu

Power x time = Energy

1000 J /s for 3600 s = 3600 kJ = 1 kilo Watt hour (kWh) ≙ 150 g

1000 kg coal ≙ 8200 kWh

1 barrel of oil ≙ 1670 kWh

1 m^3 gas ≙ 11 kWh

we burnt 1454 m^3 of gas in one year = 16000 kWh/year
= 44 kWh/day = 11 kWh/day/person

kWh/day/person is a very good unit....

phillip.dale@uni.lu

A bit of philosophy

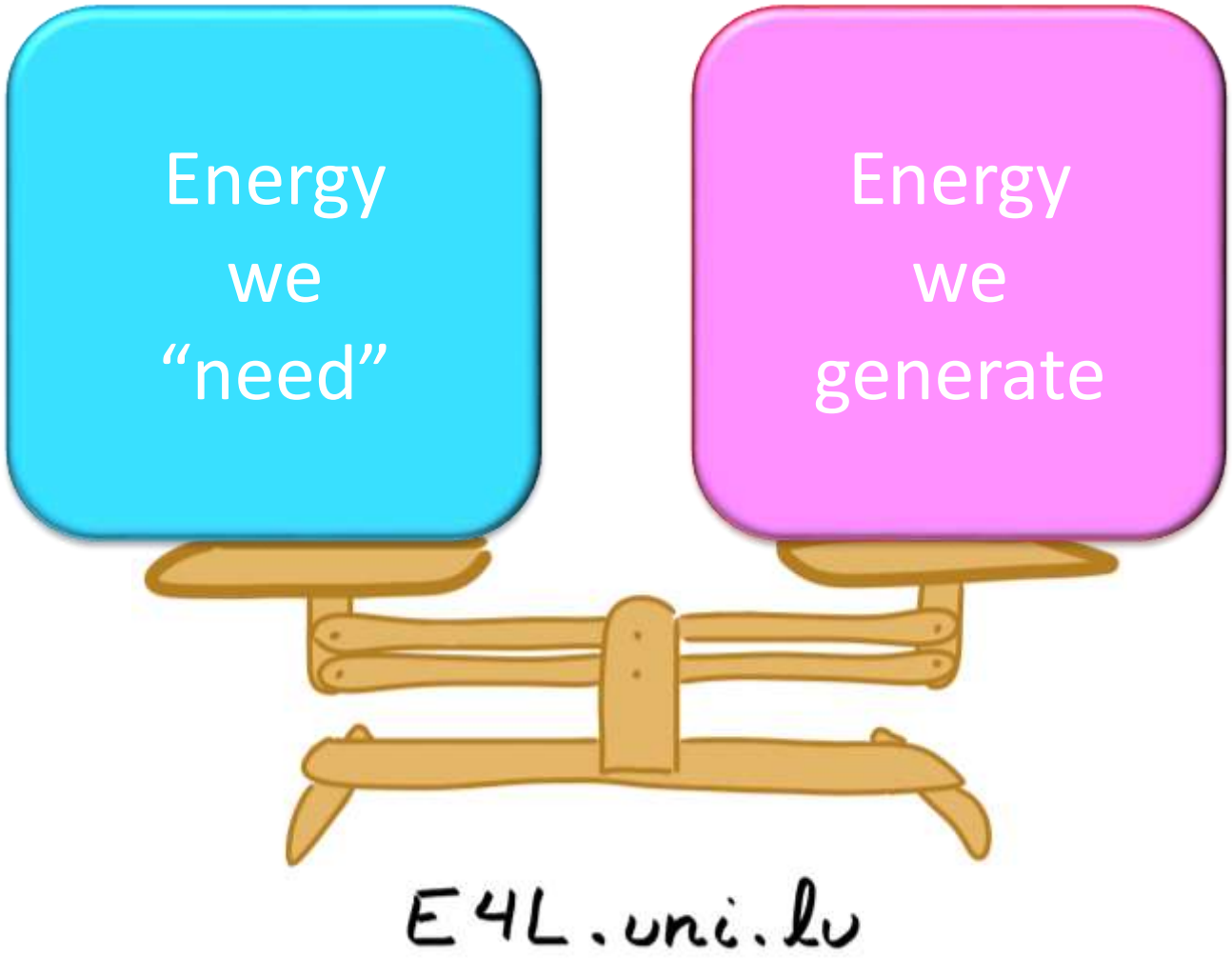
Je pense, donc je suis [1]

I am, therefore I consume

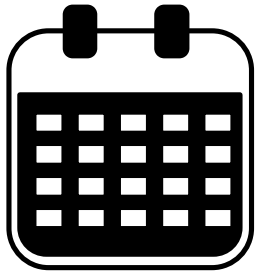
For accounting purposes, all energy you use in the day is yours

[1] René Descartes – Discours de la Méthode……1637

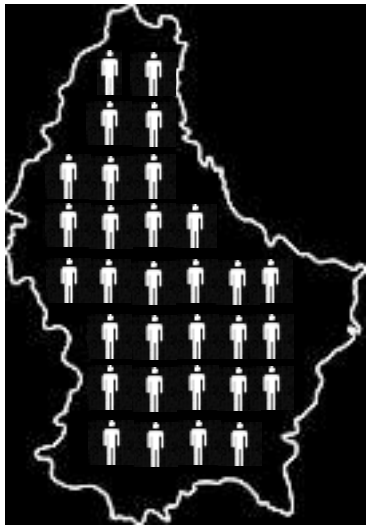
phillip.dale@uni.lu


Energy we "need"
Energy we generate
E4L.uni.lu

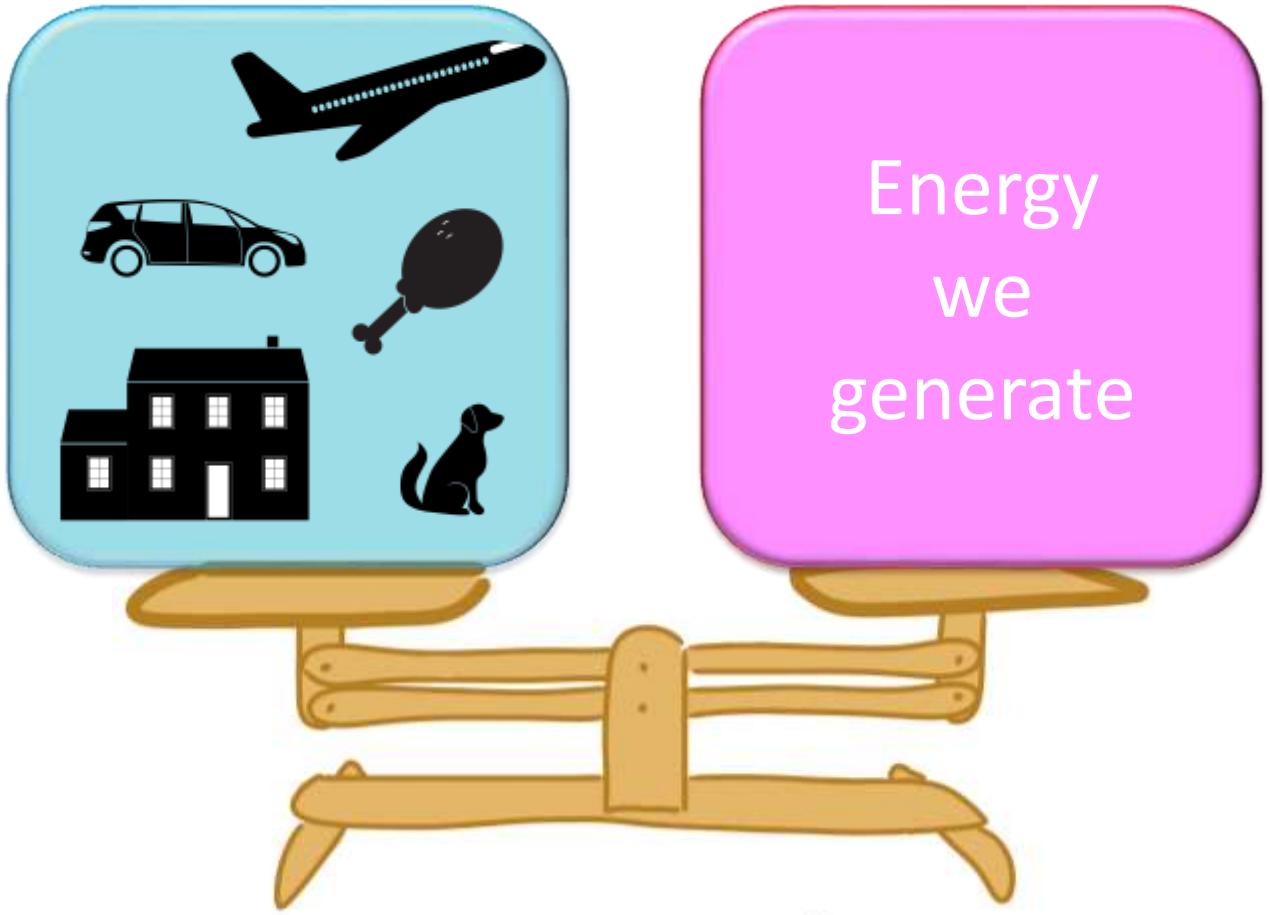
x



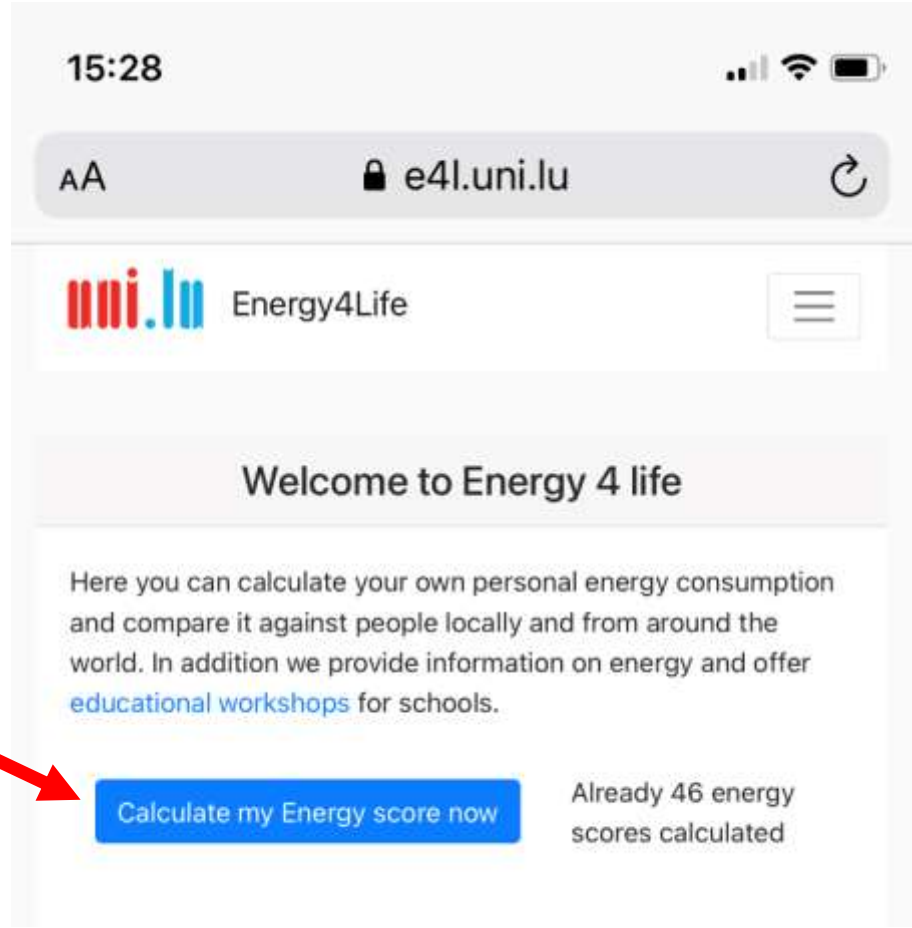
x



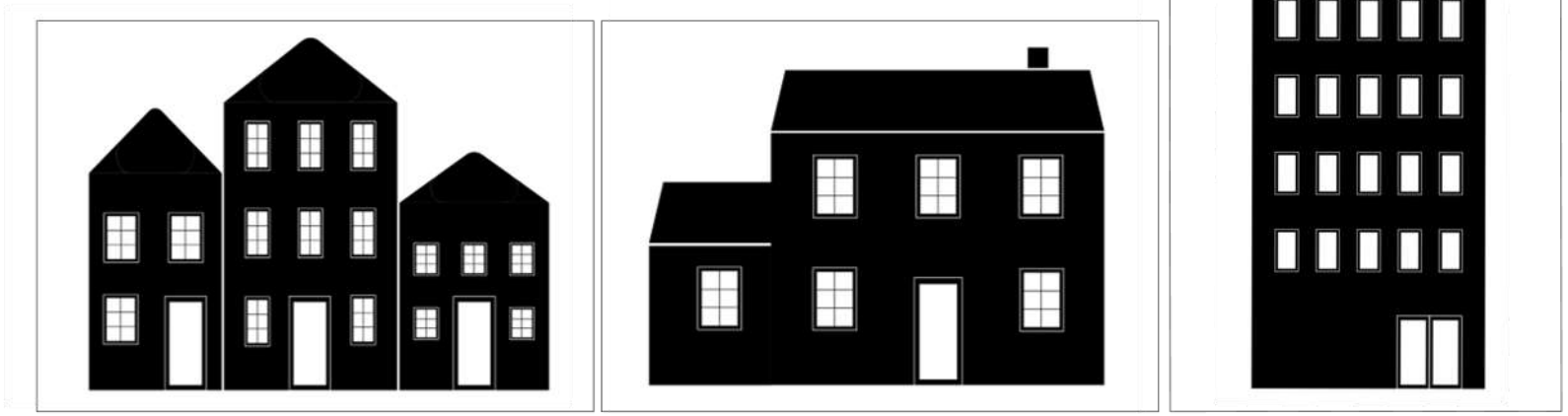
Energy we “need”


Energy
we
generate
E4L.uni.lu

e4l.uni.lu


15:28
AA
e4l.uni.lu
Energy4Life
Welcome to Energy 4 life
Here you can calculate your own personal energy consumption and compare it against people locally and from around the world. In addition we provide information on energy and offer educational workshops for schools.
Calculate my Energy score now
Already 46 energy scores calculated

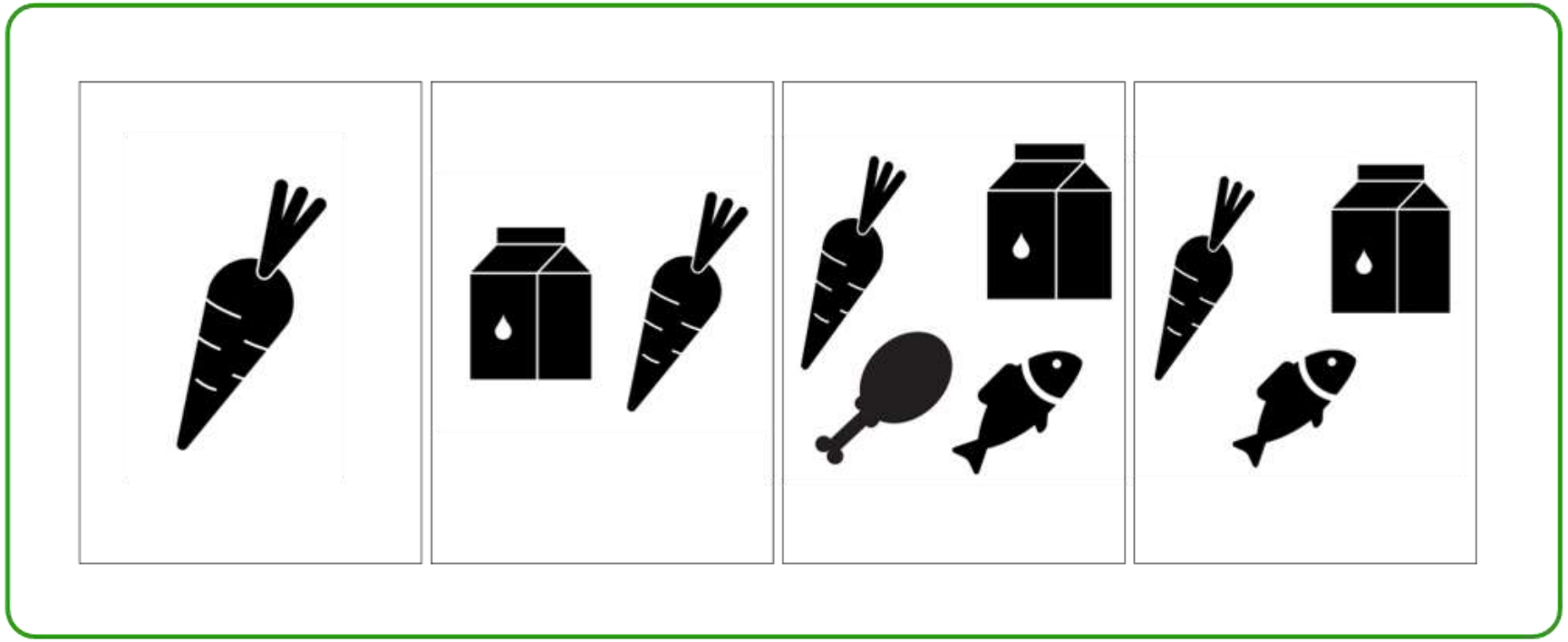
1. Where do you live ?



E4L.uni.lu

phillip.dale@uni.lu

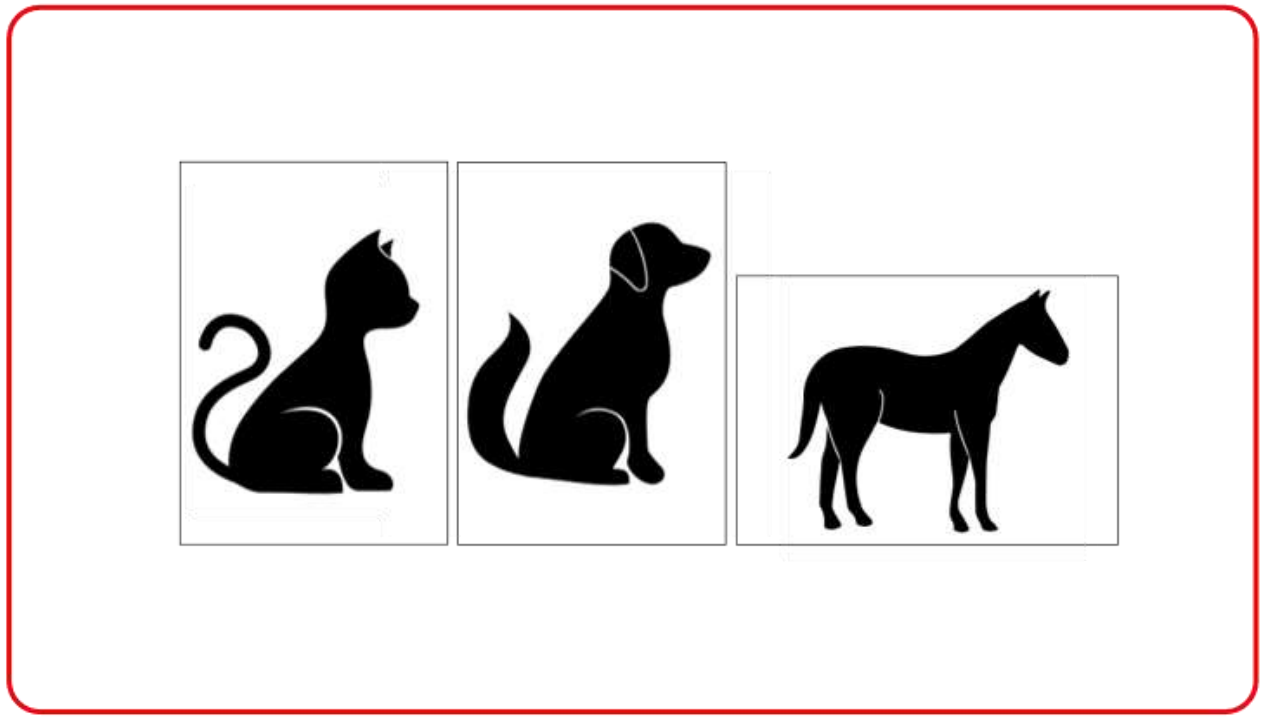
2. What do you eat ?



E4L.uni.lu

phillip.dale@uni.lu

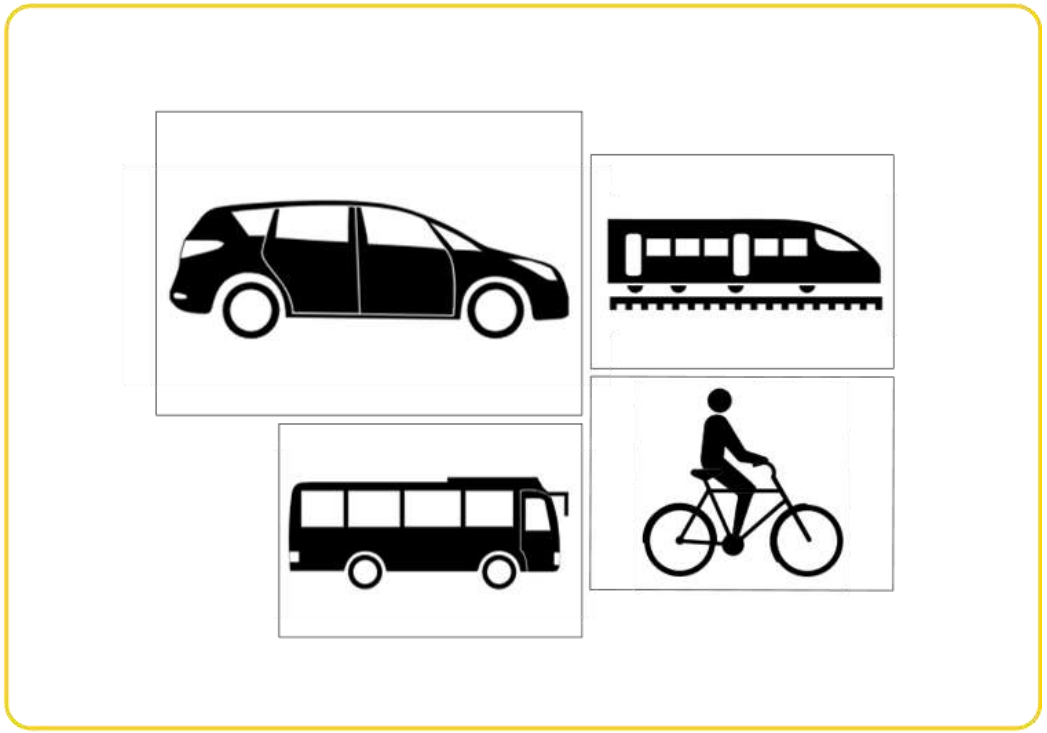
3. Do you have pets ?



E4L.uni.lu

phillip.dale@uni.lu

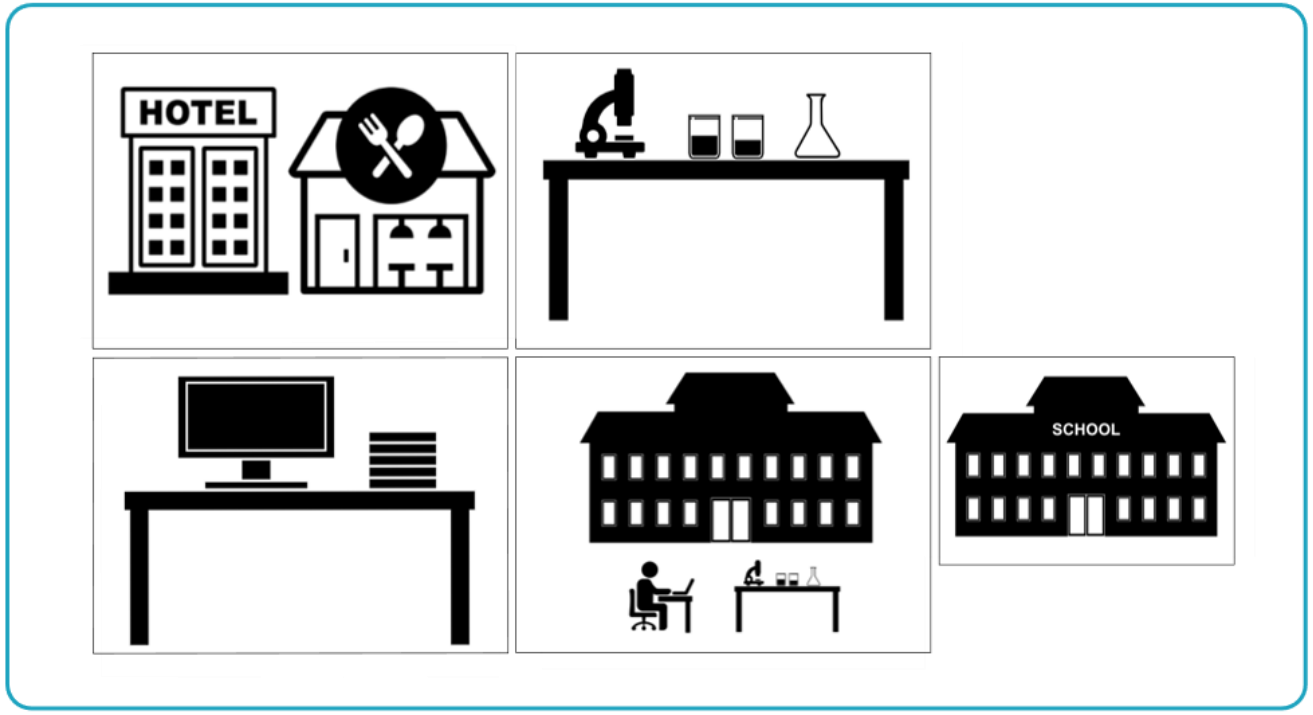
4. How do you travel to school / work ?



E4L.uni.lu

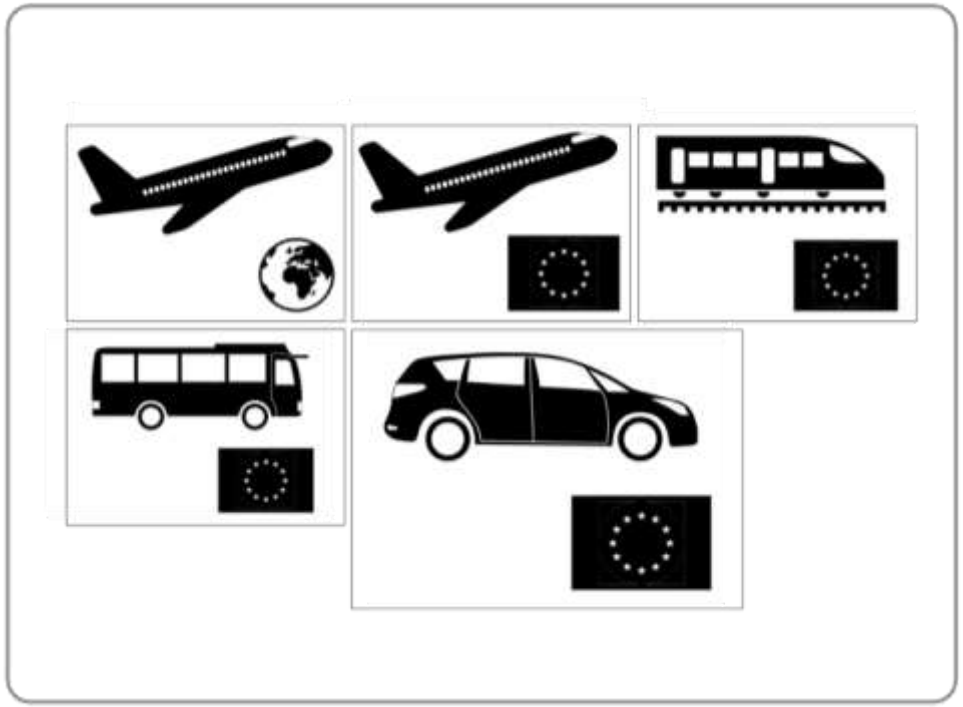
phillip.dale@uni.lu

5. Where do you work / go to school ?



E4L.uni.lu

6. How do you travel for vacation ?



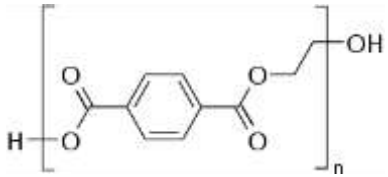
E4L.uni.lu

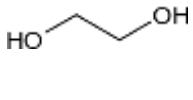
phillip.dale@uni.lu

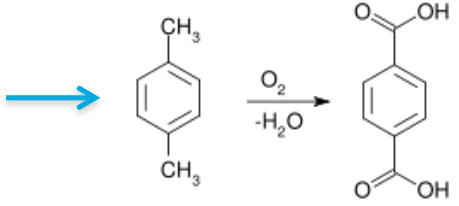
7. Things you buy ?

E4L.uni.lu

Embedded energy





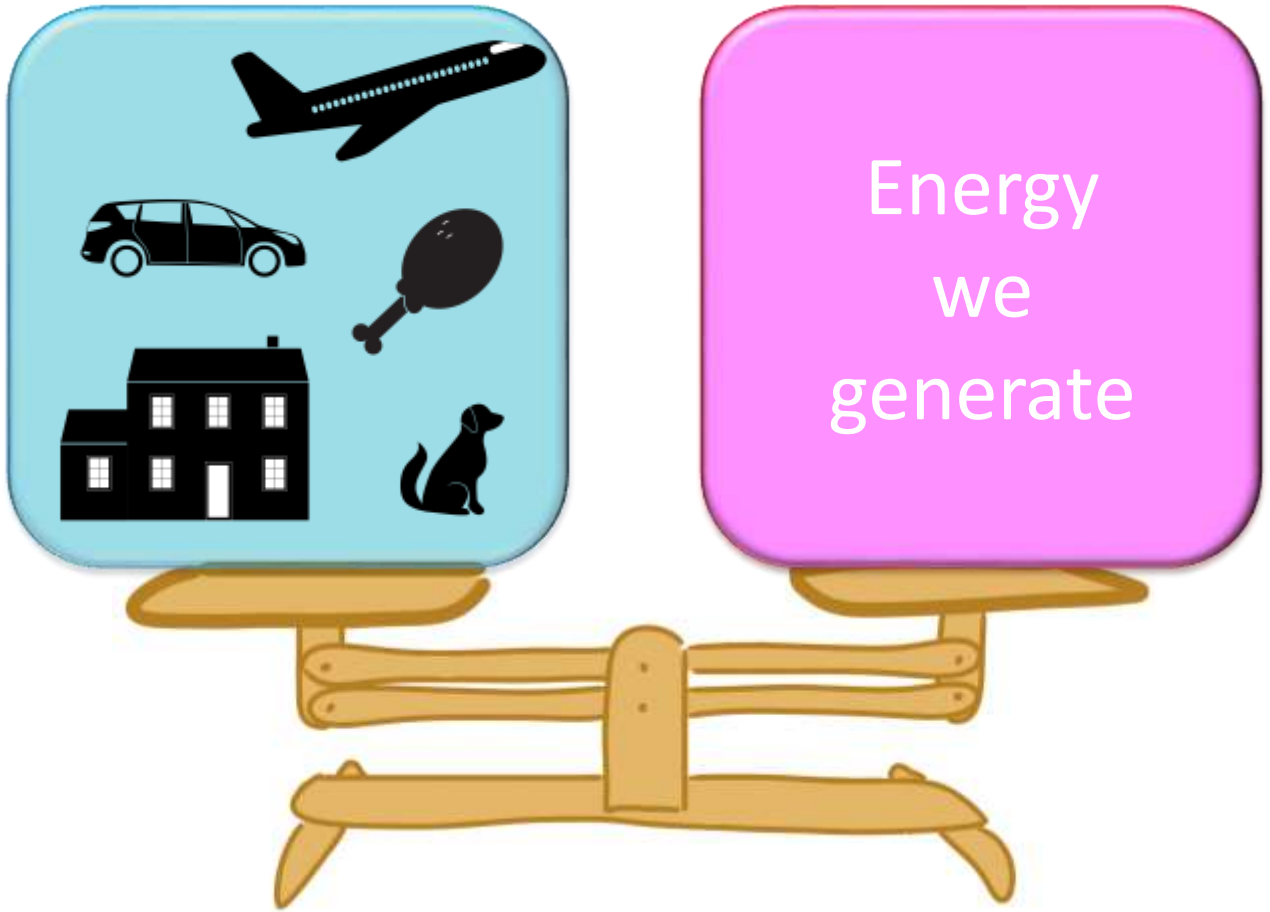


is the energy consumed to make an object or product

phillip.dale@uni.lu

Average personal energy footprint

Population of Luxembourg



phillip.dale@uni.lu


swr.de

2

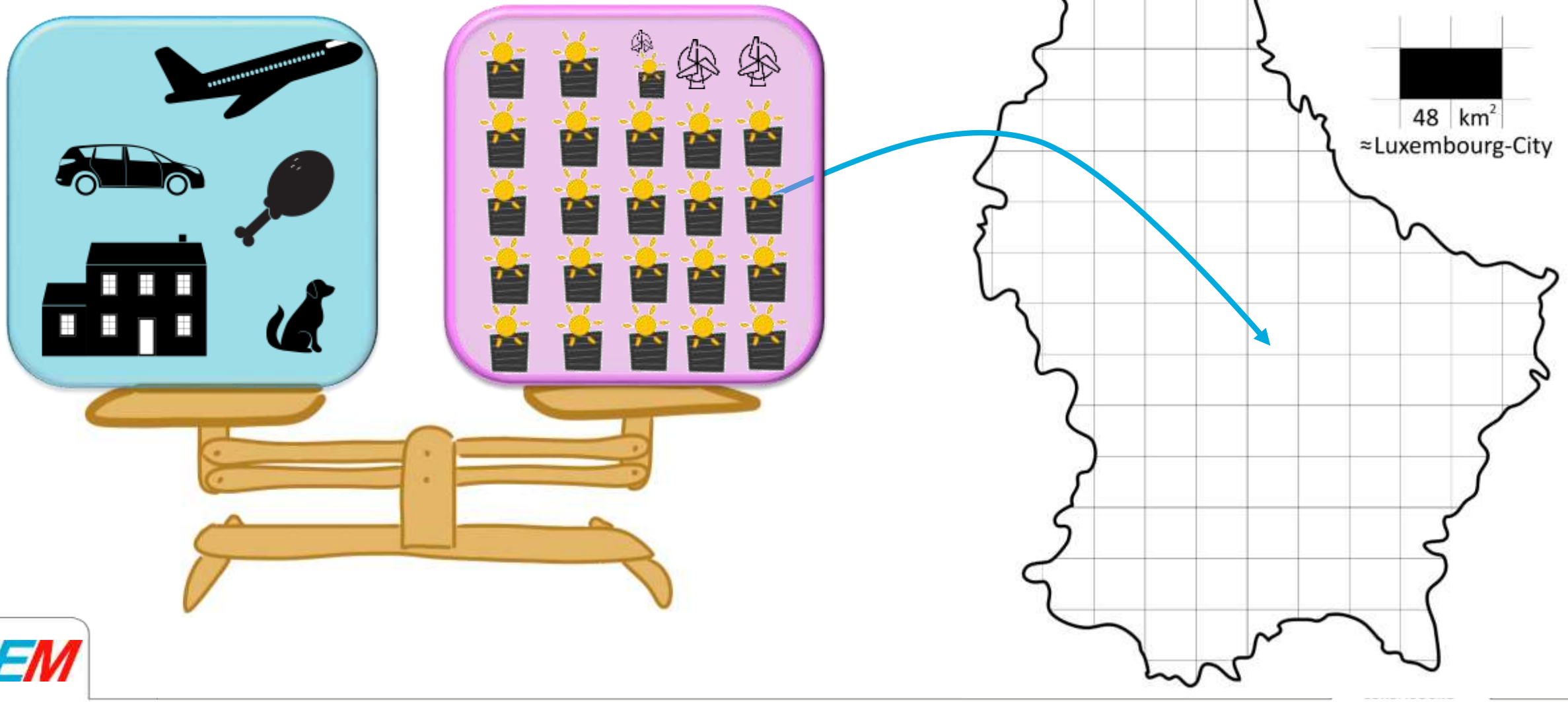
22

200

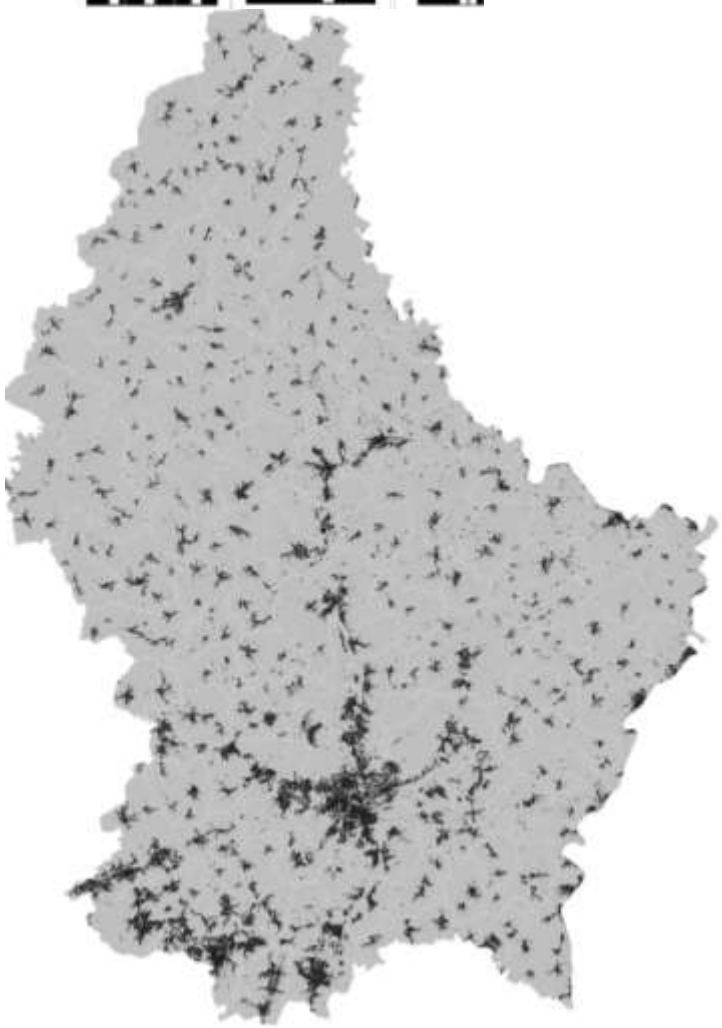
kWh / m^2 / year

phillip.dale@uni.lu

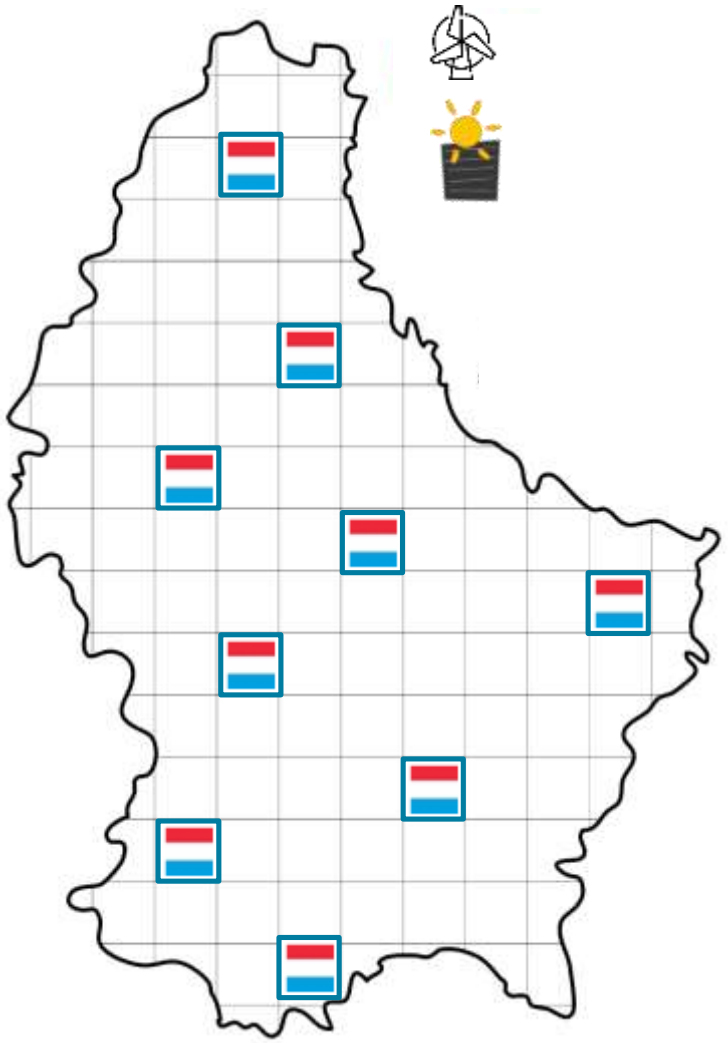
phillip.dale@uni.lu



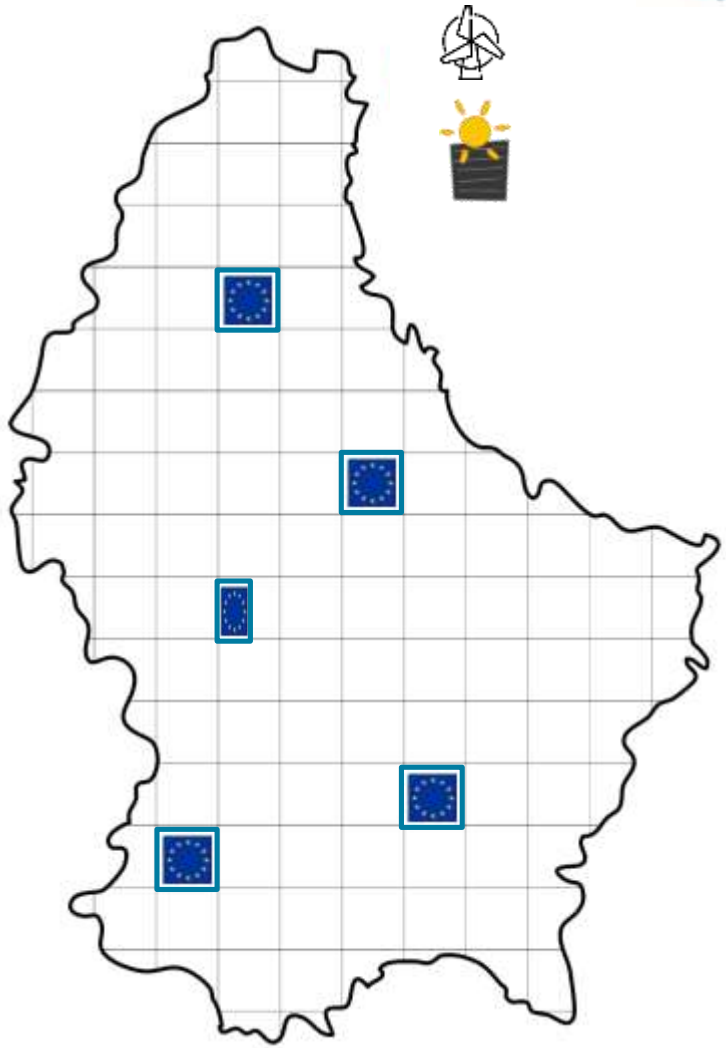
phillip.dale@uni.lu



206 kWh / d / p



102 kWh / d / p



2%

9%

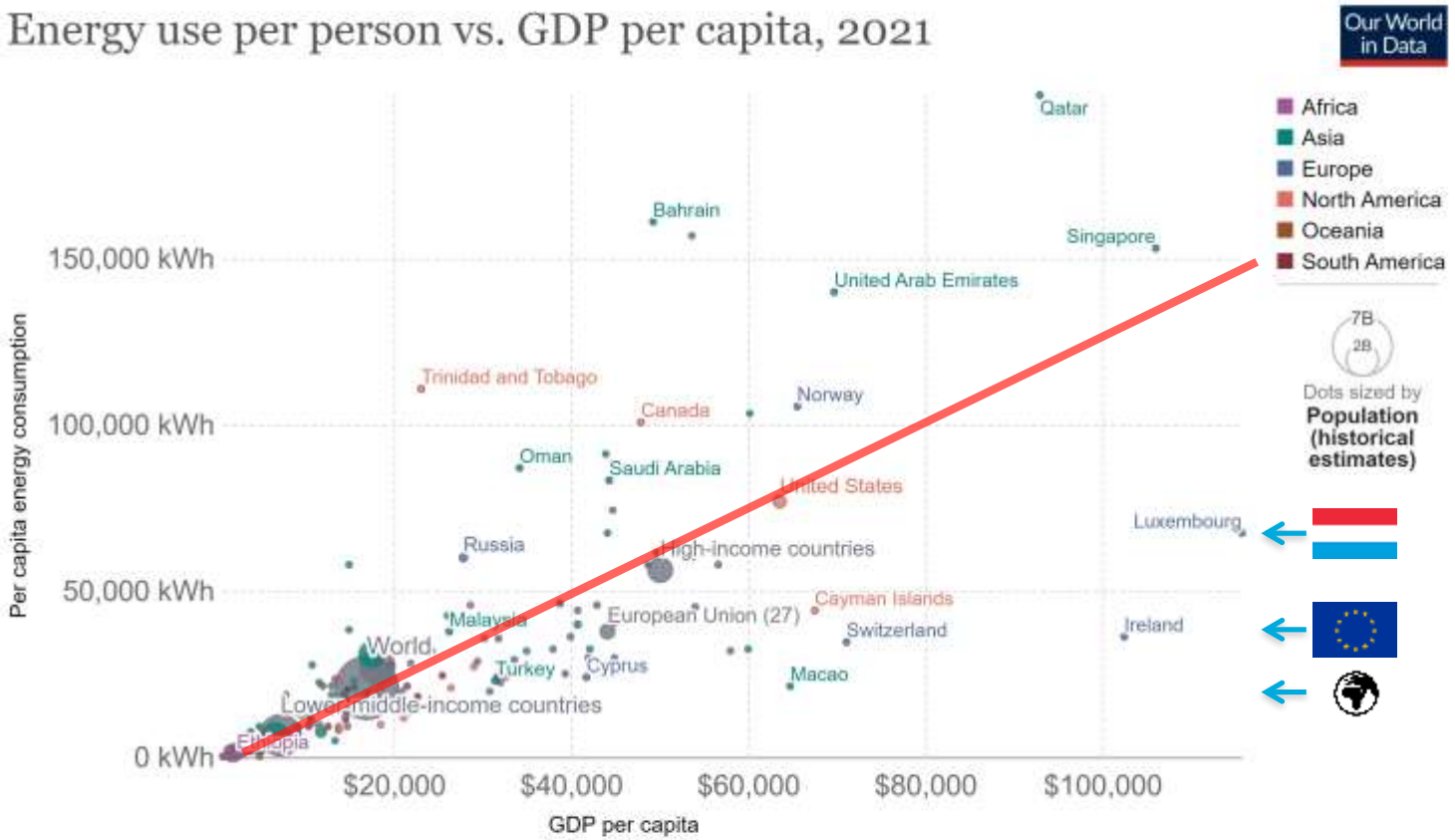
4.5%

Living like Europeans leaves land free

Laboratory for Energy Materials

phillip.dale@uni.lu

Is power consumption related to gross domestic product?



Source: U.S. Energy Information Administration (EIA); Energy Institute Statistical Review of World Energy (2023); Data compiled from multiple sources by World Bank

Note: Energy refers to primary energy – the energy input before the transformation to forms of energy for end-use (such as electricity or petrol for transport).

OurWorldInData.org/energy • CC BY

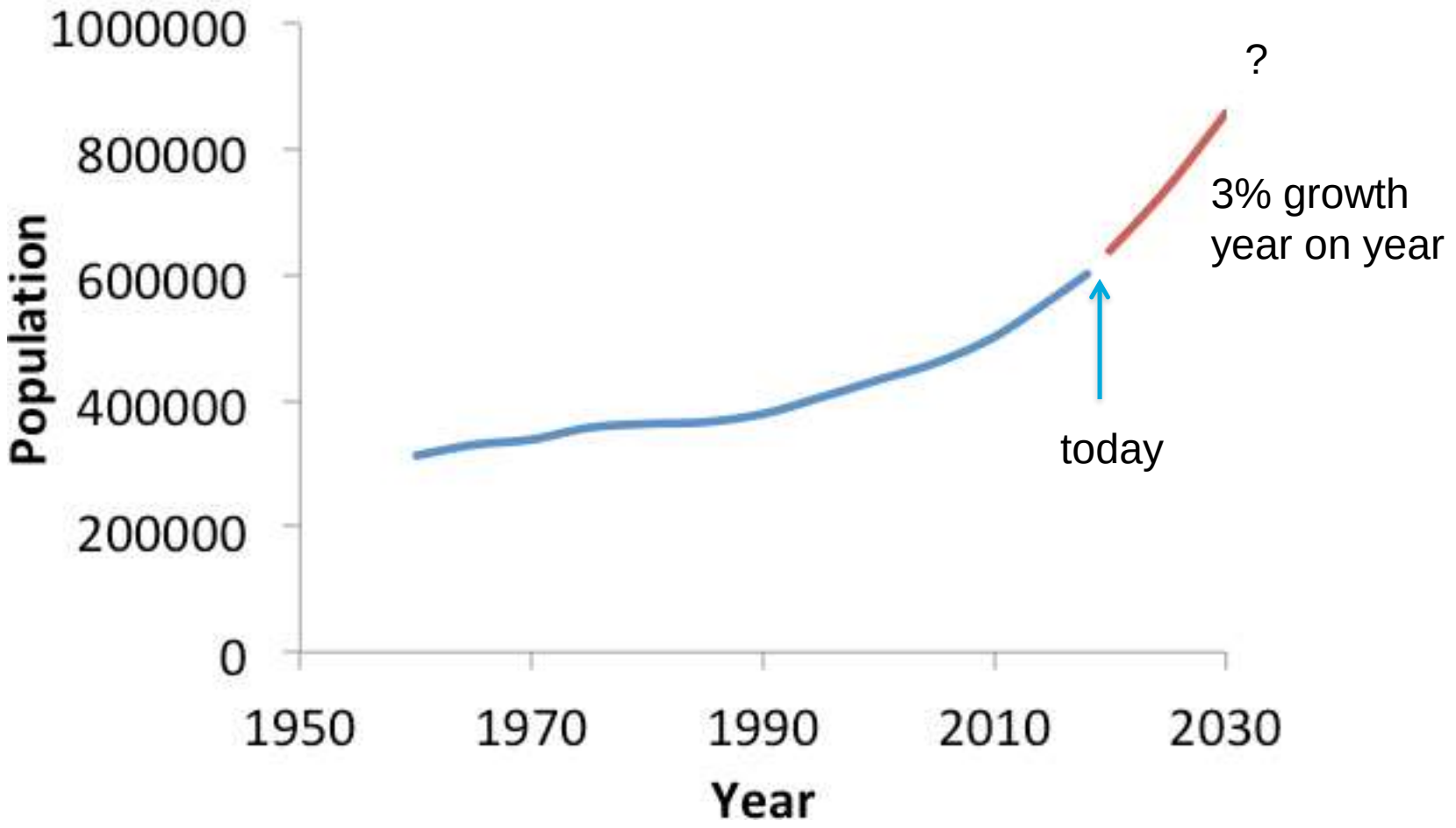
phillip.dale@uni.lu

How much energy do we need Luxembourg today?

Das Bildungssystem der Zukunft muss die Potenzialentfaltung der Schüler in den Vordergrund stellen, statt sie mit Wissen zu überhäufen, das sie für ein gelingendes Leben nicht brauchen. *Foto: Guy Jallay*

phillip.dale@uni.lu

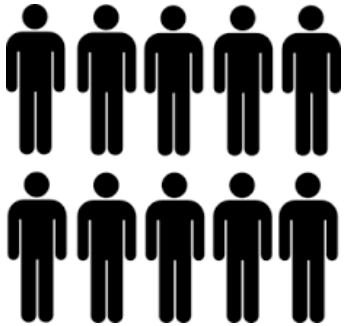
Population is growing!



Government policy is to grow to 1,1 million people (!)

phillip.dale@uni.lu

How much energy do we need Luxembourg today?

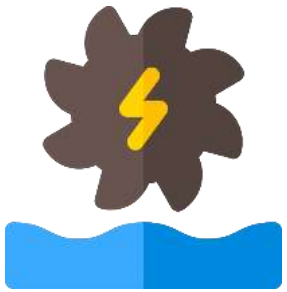


206 kWh / d / p × 600.000 × 365 = 49472 GWh/year

206 kWh / d / p × 858.000 × 365 = 70489 GWh/year

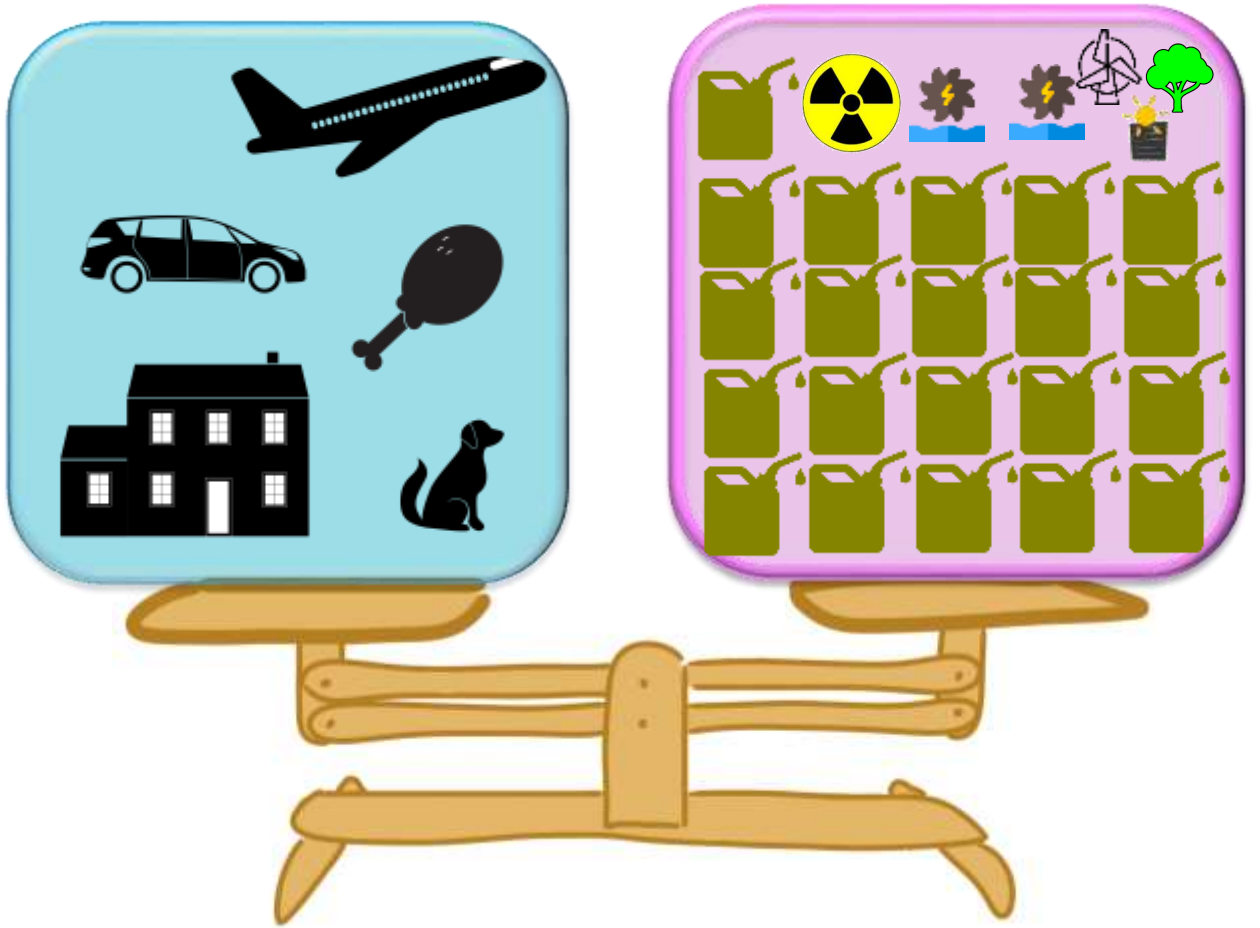
So what can we generate renewably?

phillip.dale@uni.lu



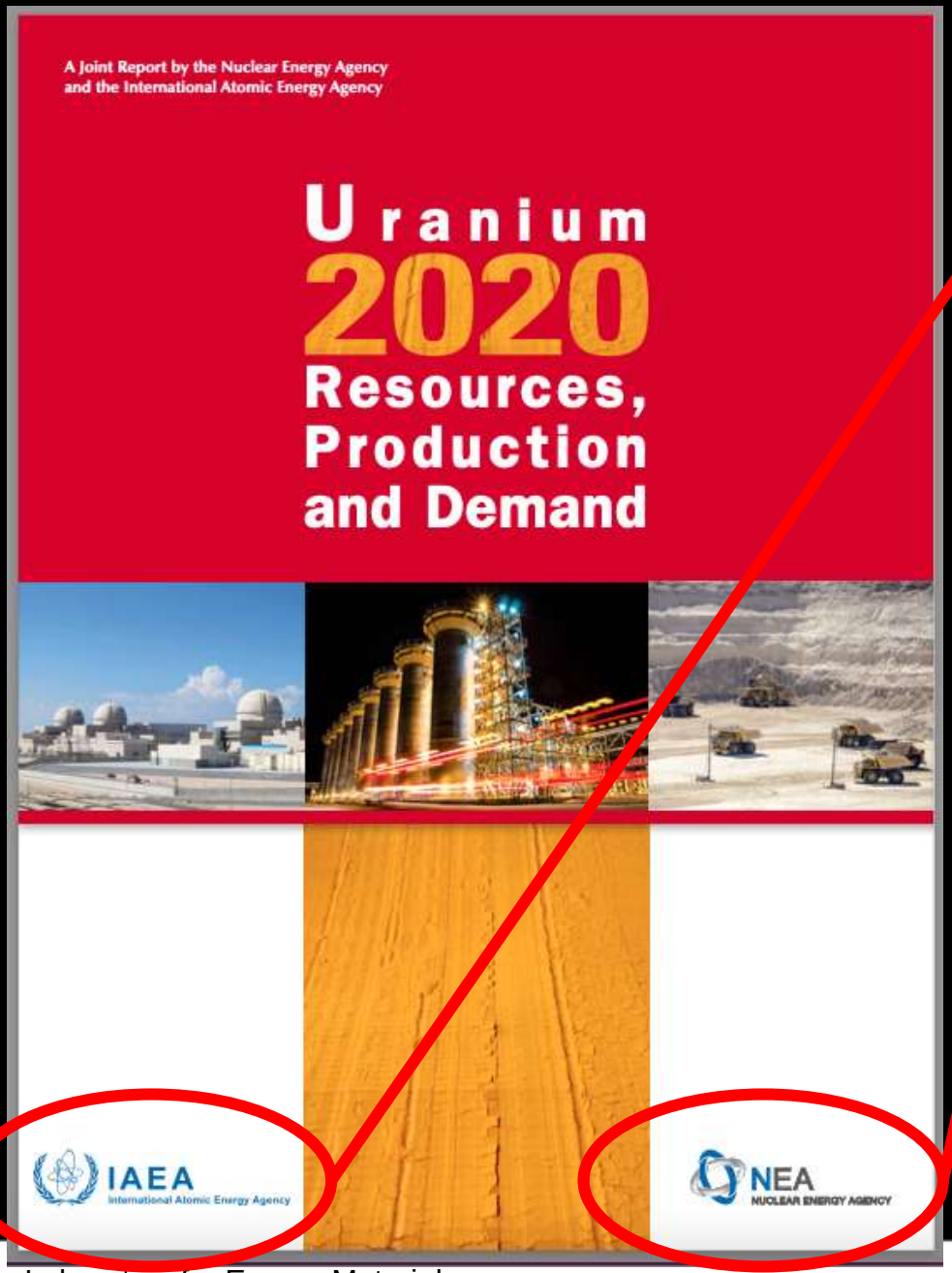
phillip.dale@uni.lu

Current world energy supply mix



phillip.dale@uni.lu

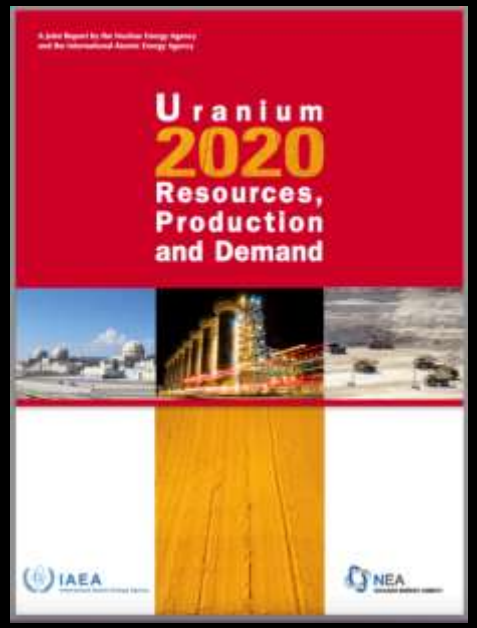
https://www.oecd-nea.org/jcms/pl_52718/uranium-2020-resources-production-and-demand



IAEA
International Atomic Energy Agency

NEA
NUCLEAR ENERGY AGENCY

phillip.dale@uni.lu

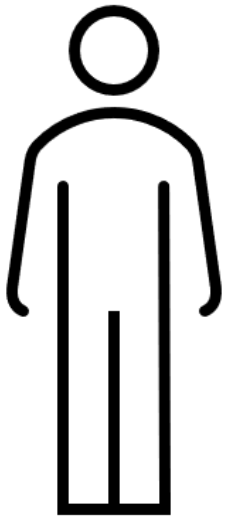


"Identified recoverable resources, including reasonably assured resources and inferred resources are sufficient for over **135 years**, considering uranium requirements as of 1 January 2019."

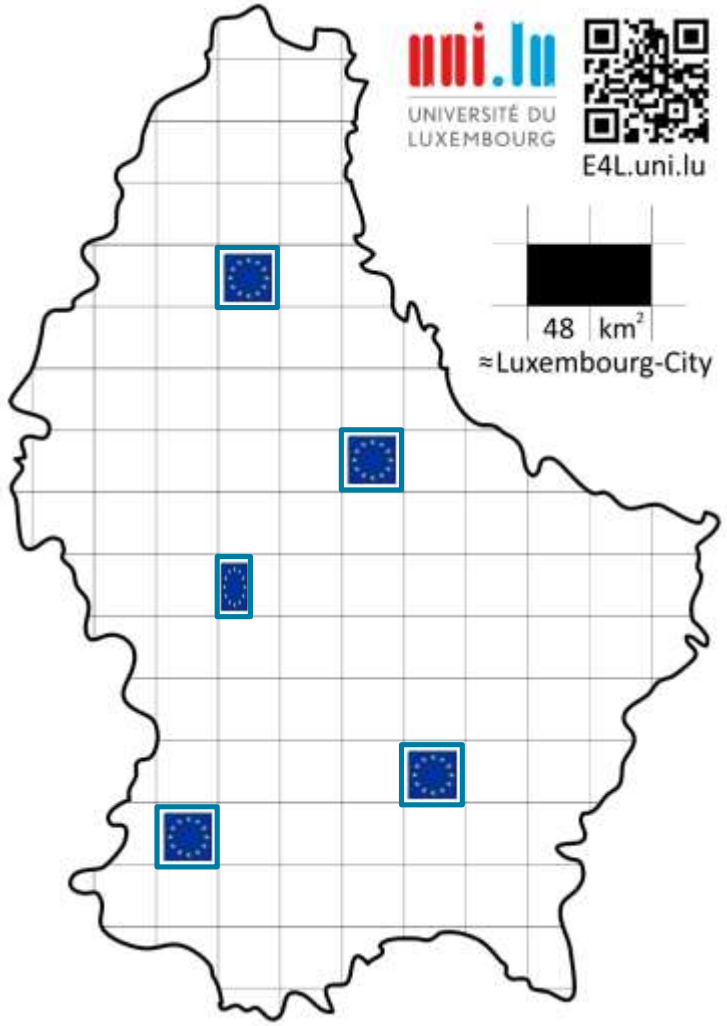
Nuclear provided 4% of the worlds energy in 2019
Increasing it to 40%, there would be nuclear fuel for 13.5 years only !!!!!!!!

https://www.oecd-nea.org/jcms/pl_52718/uranium-2020-resources-production-and-demand

Summary

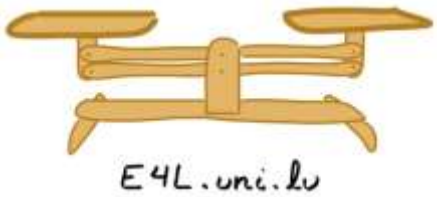


I am, therefore I consume



Acknowledgements

Prof Phillip Dale



Kevin Blewesch

Alfredo Blazquez

Dr. Alfredo Capozucca

Venkateshwaran Thamilselvan

Vanitha Varadharajan

Dr. Max H. Wolter

Alice Debot

Joana Ferreira

Boris Floka

Dr. Una Karahasanovic

Dr. Conrad Spindler

Elisabeth John

David Kieffer

Dr. Michele Melchiorre

Ricardo Poeira

Dr. Robert A.P. Reuter

Thierry Meyrath

Louis Krieger

Sancho Moro

Sébastien Elixader

Alessandro Manacorda

Sergey Ershov

Pascal Waechter

Romain Roland

Jonathan Rommelfangen

Thibault Simonetto

Maxime Cid
Jeremy Ramos
Uzair Farooq

Luxembourg National Research Fund

Inform and set up the issue we are trying to resolve

- Have everyone on the same background knowledge level
- Give context for the Luxembourgish scale
- If the information involves you, you are more invested

DIFFERENT RENEWABLE ENERGY TECHNOLOGIES

Basic understanding & Bringing in the nuance

- Putting everything in scale
- Seeing their own numbers used
- Interacting with the technology

SCIENTEENS LAB

UNIVERSITÉ DU LUXEMBOURG

BALANCE

Bringing it all together!

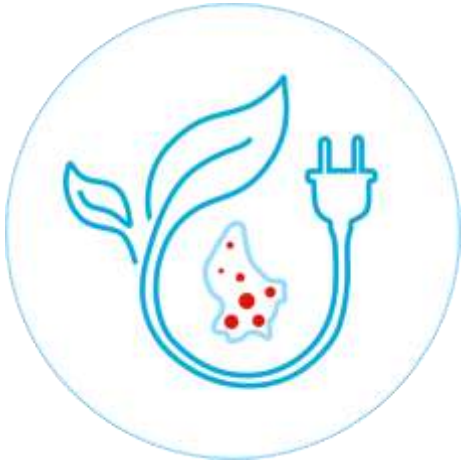
- Consumption & Generation – seeing both sides
- Space needed in Luxembourg – answering our initial question

SCIENTEENS LAB
DE LABO FIR JONker

UNIVERSITÉ DU LUXEMBOURG

Physics and Sustainability workshops

SCIENTEENS LAB
DE LABO FIR JONKER



"Tell me and I forget,
Teach me and I may remember,
Involve me and I learn."

Confucius

UNIVERSITÉ DU LUXEMBOURG

Have you ever done outreach?

SCIENTEENS LAB
DE LABO FIR JONker

UNIVERSITÉ DU LUXEMBOURG

Overview

Idea

Devel-
opment

Testing

Rehearsal

Day-X

SCIENTEENS LAB
DE LABO FIR JONker

UNIVERSITÉ DU
LUXEMBOURG

Idea / Opportunity

Others:
- At School
- Faire
- Installation
- Exhibit

Festival

Lab

SCIENTEENS LAB
DE LABO FIR JONker

UNIVERSITÉ DU LUXEMBOURG

TARGET AUDIENCE

TARGET AUDIENCE

Take Home Message

What would you like them to learn?

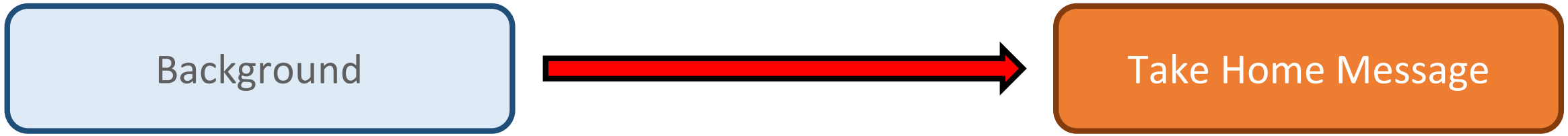
TARGET AUDIENCE

Take Home Message

Background

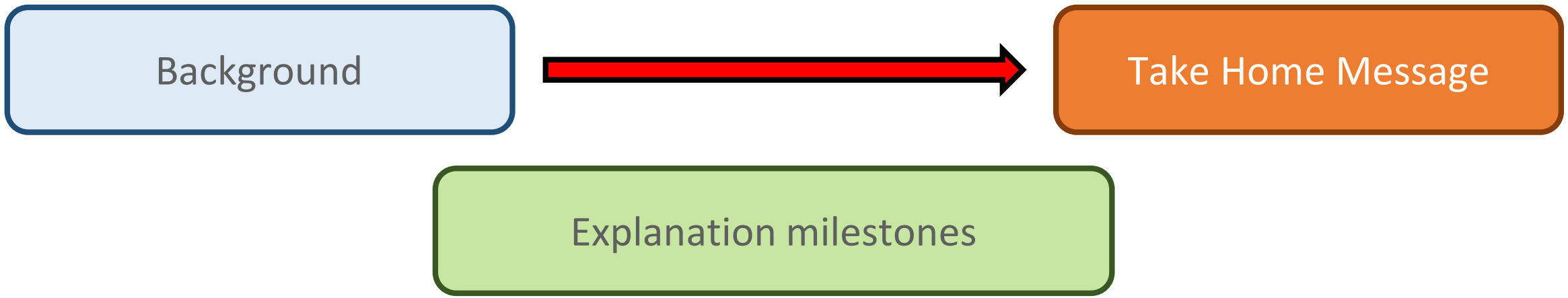
Where do you need to start?

TARGET AUDIENCE



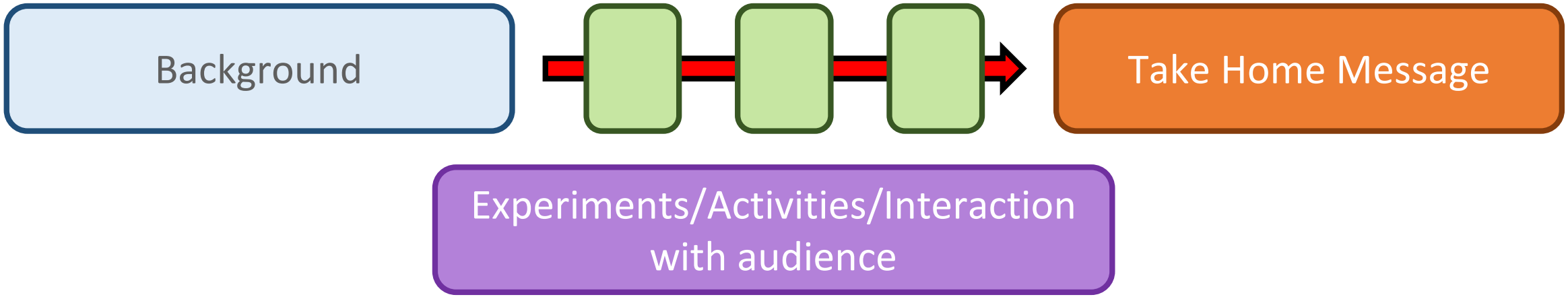
How do you get there?

TARGET AUDIENCE



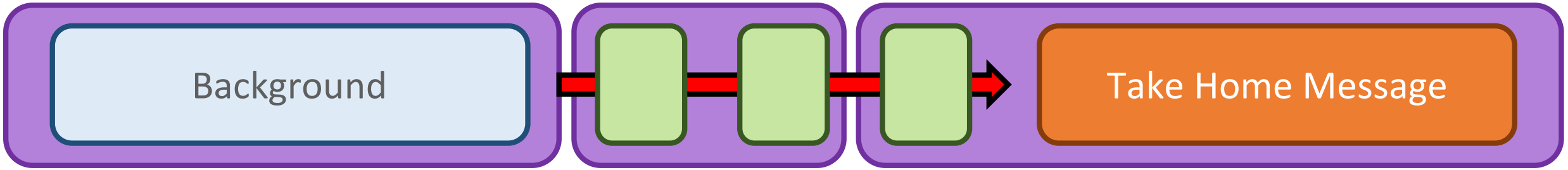
What logical steps are needed?
What should be left out?

TARGET AUDIENCE



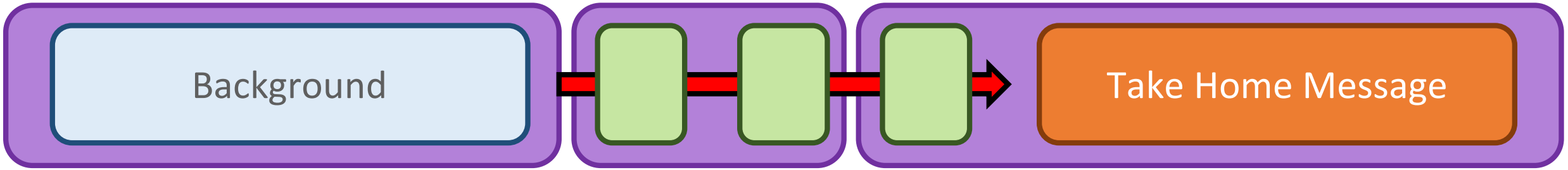
How will you explain it?

TARGET AUDIENCE

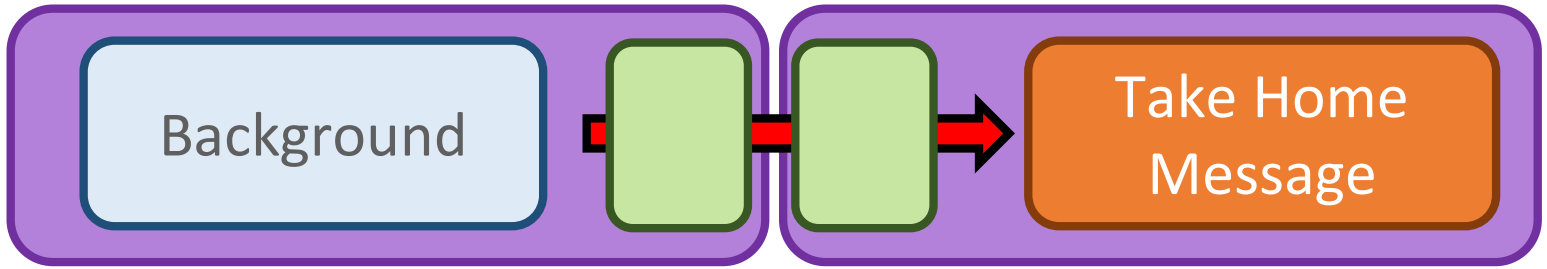


Now you have a complete structure

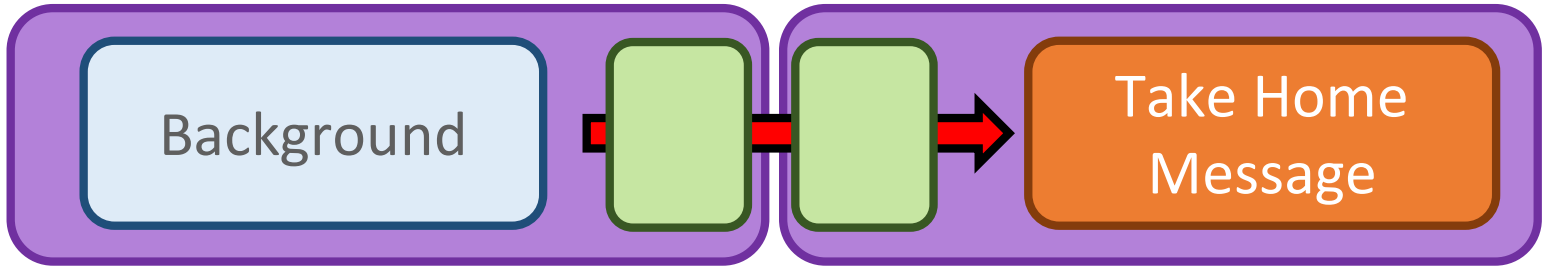
TEST WITH TARGET AUDIENCE



After testing



Rehearsal



Try the whole thing in the context
(if possible)

Day-X

Make little notes/get feedback:

What went right?
What went wrong?
What could be better?

Day-X

Enjoy

Interactivity

phillip.dale@uni.lu

Feedback, Recycling workshops

SCIENTEENS LAB
DE LABO FIR JONker

UNIVERSITÉ DU LUXEMBOURG

Defining Success

What does success look like?

- Reaching the intended audience
- Engaging and educating effectively
- Inspiring action or behavioral change

SCIENTEENS LAB
DE LABO FIR JONker

UNIVERSITÉ DU LUXEMBOURG

How do I determine my success?

Direct observation (assessing engagement or behaviour in real-time):

- Observing the audience reactions
- Interaction with educational resources

Allows for quick adjustments

SCIENTEENS LAB
DE LABO FIR JONker

UNIVERSITÉ DU LUXEMBOURG

How do I determine my success?

Indirect observation (evaluating impact and success through secondary data sources):

- Analyzing data you collected (e.g. study)
- Collecting feedback

Quantitative data that supports long-term evaluation

SCIENTEENS LAB
DE LABO FIR JONker

UNIVERSITÉ DU LUXEMBOURG

Importance of Feedback

Evaluating the “reach” in outreach

Feedback should not be an afterthought

Feedback loop

Recycling Workshops

Relation between feedback and recycling workshops?

- Values the work done
- Helps identify specific areas for improvement
- Implementing feedback-based improvements boosts the chances of achieving the workshop's goals

The process is iterative

Self assessment

Do not underestimate your judgement (don’t be too harsh on yourself though)

Example: developing efficiency

SCIENTEENS LAB

UNIVERSITÉ DU LUXEMBOURG

Conclusion

Feedback is a vital development tool

Feedback is a driving force for workshop evolution

The target audience is best positioned to assess your outreach efforts

SCIENTEENS LAB
DE LABO FIR JONker

UNIVERSITÉ DU LUXEMBOURG

The best transition to…

Your feedback for this event!