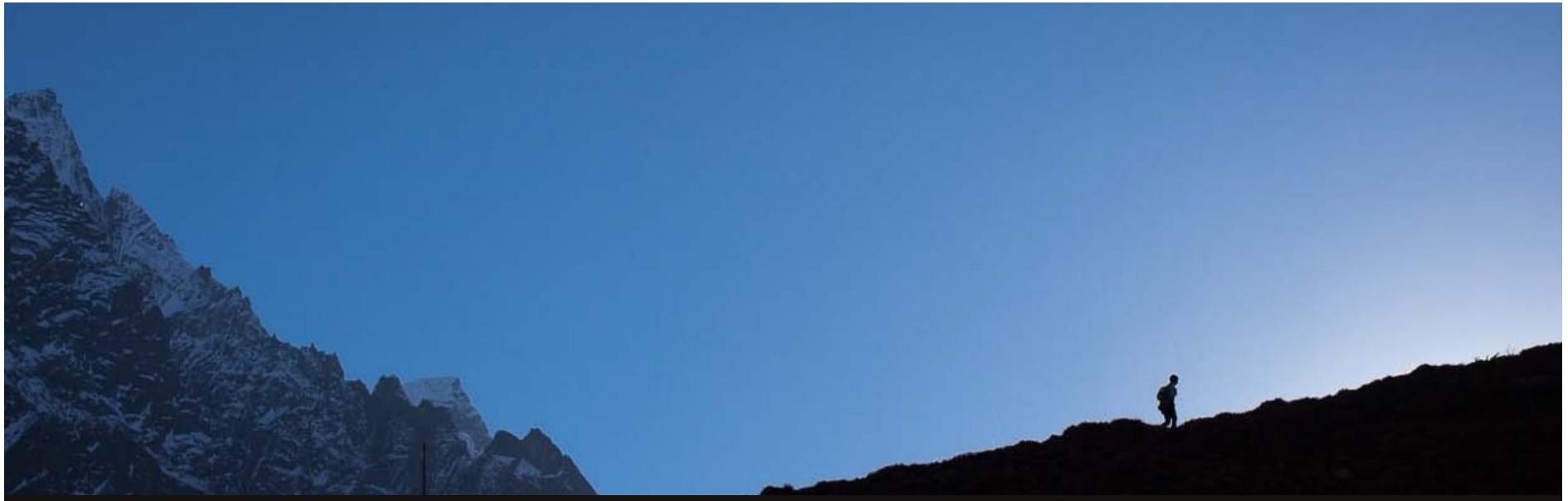
Doutoramento em Alterações Climáticas e Políticas de Desenvolvimento Sustentável



Class 11 | 21st May 2022 | Global energy and climate

Sofia G. Simoes

SEMINAR ENERGY & CLIMATE CHANGE

Climate Change and Sustainable Development Policies

LNEG

NOVA SCHOOL OF SCIENCE & TECHNOLOGY

CENSE center for environmental and sustainability research

1	04/03 6ª Feira	16h-18h	Session reserved for students meeting with the Scientific Committee on practical aspects of the PhD Program, and choice of tutors.	Comissão Científica
2	11/03 6ª Feira	16h-18h	ENERGY & CLIMATE CHANGE: A COMPLEX RELATION, PERENE AND INTERDISCIPLINARY. Framework and purpose of the course in the PDACPDS. Practicalities and seminar program. Basic concepts of the energy systems.	J. Seixas, FCT NOVA
3	18/03 6ª Feira	16h-18h	**Current state of the global energy system :** main energy carriers, energy production and consumption regions; energy access; concepts of energy and carbon intensity.	S. Simões
4	25/03 6ª Feira	14h-16h	**Global balance of CO_2 emissions** associated with energy and industrial processes. Estimates of the Global Carbon Budget (http://www.globalcarbonproject.org/) and its relationship to the global energy system and changes in land use. Future scenarios for greenhouse gas emissions: RCPs (Representative Concentration Pathways). Global emissions based on consumption vs. production.	S. Simões
5	02/04 Sábado	09h-11h	**Renewables:** Economic, environmental and energy security of endogenous vs. imported resources. Renewable technologies. Sustainability issues related with renewables. Land & water use, critical raw materials. Discussion: Where to place 7GW of solar PV in Portugal till 2030?	S. Simões
6	08/04 6ª Feira	16h-18h	**Energy concepts:** Primary/final energy; Sankey diagrams; energy efficiency; Energy services; Energy carriers; Final energy supply cost curves; learning curves of energy technologies. Definition and usefulness of LCOE. System value of Renewables. Global renewables' market.	S. Simões
7	22/04 6ª Feira	16h-18h	**Drawdown** - Climate Solutions for a New Decade	João P. Gouveia, FCT NOVA
8	30/04 Sábado	09h-11h	**Green hydrogen:** technological options, costs and the role for a carbon neutral energy system	P. Fortes, FCT NOVA
9	06/05 6ª Feira	18h-20h	**CARBON PRICING.** Regulatory framework in the European Union: 2020 - 2030 targets. Fit for 55. European low-carbon Roadmap 2050. Paris Agreement, and its implications.	S. Simões
10	13/05 6ª Feira	16h-18h	**Debate Como perspetivar o futuro da energia e alterações climáticas?** Baseado no artigo *An energy vision: the transformation towards sustainability — interconnected challenges and solution s*	students / S. Simões
11	21/05 Sábado	11h-13h	**Hands-on energy data:** access to energy databases, Portuguese and European (PORDATA, DGEG, EUROSTAT). i) How to find and explore energy statistics and emissions of greenhouse gas (GHG) emissions for Europe and Portugal; ii) How to make energy conversions; iii) How to build indicators and charts with added value; iii) How to analyze economic sectors, and interpret their performance in terms of energy consumption and greenhouse gas emissions.	S. Simões
12	27/05 6ª Feira	16h-18h	**Integrated assessment of energy systems:** The energy system addressed by the systems analysis approach. How to envisage the future energy system? Implications for the decision making in the medium and long term. Concept and formulation of cost-effectiveness within the integrated energy systems. Hands on Climate Mitigation Simulation	S. Simões
13	03/06 6ª Feira	16h-18h	Mentoring with each students' group : discussion on the approach and methods adopted by the students, expected results to be obtained with the final work; assessing preliminary results, if any.	S. Simões
14	17/06 6ª feira	18h-20h	**Smart and Sustainable cities:** concept, components and implications for the energy systems. The concept of Postive Energy Districts, and implications for future planning at the city level.	João P. Gouveia, FCT NOVA
	2 julho, 14h	14h-16h	Avaliações: apresentação dos trabalhos pelos alunos.	S. Simões / J. Seixas

NOVA SCHOOL OF SCIENCE & TECHNOLOGY

Júlia Seixas
mjs@fct.unl.pt

Sofia Simões
sofia.simoes@lneg.pt

João Gouveia
jplg@fct.unl.pt

Patrícia Fortes
p.fs@fct.unl.pt.pt

NOVA SCHOOL OF SCIENCE & TECHNOLOGY

CENSE center for environmental and sustainability research

If you need to discuss topics related to the course, including the assignment, I am available on Fridays 10h-11h – send me an e-mail to book this slot at least 4 days before

Para discussão de assuntos relacionados com o seminário, incluindo o trabalho final, estou disponível às sextas 10h-11h – têm que enviar-me e-mail previamente (pelo menos 4 dias antes)

Às 5as feiras 12h-13h é dada aula complementar em Português (zoom) para quem tem mais dificuldades com o inglês

Sofia G. Simões
sofia.simoes@lneg.pt
sgcs@fct.unl.pt

PROGRAM & RESOURCES @
https://moodle.fct.unl.pt/course/view.php?id=7450

Climate Change and Sustainable Development Policies

LNEG

NOVA SCHOOL OF SCIENCE & TECHNOLOGY

CENSE center for environmental and sustainability research

Discussion was very good, but what about if a rich oil company comes to your country wanting to invest billions in oil and gas???

What will you say?

https://www.theguardian.com/environment/ng-interactive/2022/may/11/fossil-fuel-carbon-bombs-climate-breakdown-oil-gas

Climate Change and Sustainable Development Policies

The climate game

https://ig.ft.com/climate-game/

Outline

- Assignment – where do we stand
- Energy units and conversion
- GHG emissions estimates and emissions inventories
- Energy balances

Climate Change and Sustainable Development Policies

Assignment

Challenge: Within the scope of your personal interests, select an economic activity from the following areas:

Communication | Final Product | Industry | Services | Mobility | Other

Assuming your country by 2030, will be in the midst of a pathway to achieve a carbon neutral economy by 2050 (as stated in the Paris Agreement) or earlier, how do you envisage the selected activity will picture in that time horizon (2030)?

Team work | Think out of the box | Innovate

What is the challenge for the activity? Who are the challenge owners? What do you envisage the activity must/should deliver in the future?

Climate Change and Sustainable Development Policies

Assignment | Suggestion of script for development:

- firstly, **formulate (and detail) the problem** as far as you are able;
- characterize the **activity at present** [for example, production / import technologies| type of markets and consumers | competition from other markets? | energy consumption profile | indicators of carbon intensity]
- **envisage the activity up to 2030** [technological options | product change - green| change of consumers | energy consumption profile | indicators of carbon intensity]
- systematize **opportunities for the mitigation** of the selected activities (identify needs of R & D, act on consumption preferences, the product value chain, among others)
- identify and anticipate **constraints and barriers to the desired mitigation**, and explain how to overcome them.

Tips: Start now; try to be objective and quantify what is possible; do not try to be exhaustive (you can not do it within just one course); explore examples that already exist in other countries; be creative.

Climate Change and Sustainable Development Policies

LNEG

NOVA SCHOOL OF SCIENCE & TECHNOLOGY

CENSE center for environmental and sustainability research

GROUPS

Gideon – join group 3???
Domingos - join group 9???

1		Beatriz Costa Oliveira	Agriculture in Portugal
2	Group 1	Miguel Silva Rodrigues	
3		Vanessa Azevedo Domingos	
4		Johanna Jeukendrup Rothman Hanneke	Beekeeping
5	Group 2	Maria Marise Simões de Almeida	
6		Yvette Ramos	
7		Flavia Queiroz Lima	Banking
8	Group 3	Francesco Ferrario	
9		Vanessa Soares Tavira	
10		Adekunle Joseph Adeogun	Energy supply in megacities
11	Group 4	Aura Maria Bustillo Mendoza	
12		Tambe Honourine Enow	
13		Carla Castelo	Energy decentralization – local authority
14	Group 5	Luiz Eduardo Rielli	
15		Maria Sofia Mourão de Carvalho Cordeiro	
16		Isabella Pereira de Melo Wanderley Costa	Solid Waste (BR)
17	Group 6	Joao Pedro Maciente Rocha	
18		Yasmin Hurtado Sarmiento	
19		Mariana Campista Chagas	Municipal waste management in Portugal
20	Group 7	Nélia Maria Sequeira de Sousa	
21		Raul Emilio Fretes	
22	Group 8	**Gideon Osabutey Ofori**	Banking Industry
23	Group 9	Antonio Ngovene Junior	Shade growing coffee and Biodiversity
24		Artur Marulo	
25		Francisco Mahú	
26		**Domingos Malú Quadé**	**will join group 8?**
27		Euclides Siquile	Not here anymore?
28		Filipa Fontes Heitor	Sofia will ask
29		Lorene Martins Brito	never showed up
30		Mahugnon Djohy	never showed up
31		Bilardo António da Silva Nharreluga	Not here anymore?

Assuming your country by 2030, will be in the midst of a pathway to achieve a carbon neutral economy by 2050 (as stated in the Paris Agreement) or earlier, how do you envisage the selected activity will picture in that time horizon (2030)?

Group / economic activity	**Which country? Which role / who are you??**	**Formulate the problem** [scope of activity, what is the challenge, challenge owners]	**Characterize activity at the present** [e.g. production / import technologies| type of markets and consumers | competition from other markets? | energy consumption profile | indicators of carbon intensity]	**Envisage the activity up to 2030** [technological options | product change - green| change of consumers | energy consumption profile | indicators of carbon intensity]	**Systematize opportunities for the mitigation of the selected activities** [needs of R&D, act on consumption preferences, product value chain, etc.]	**Identify and anticipate constraints and barriers to the desired mitigation, and explain how to overcome them**
1. Agriculture	Portugal Company?					
2. Beekeeping	Israel NGO Sust beek.					
3. Banking	Portugal Venture capital					
4. Energy supply in megacities	Namibia NAMpower comp.			Green H2	Green H2 (and also look at other options)	
5. Energy supply (decentralization)	Portugal AML/AMP					
6. Solid waste management	Brazil /Columbia Municipality					
7. Solid waste management	Portugal LIPOR/Valorsul?					
8 or 9. Coffee growing	Mozambique Company			Sustainable coffee improving biodiversity		

Climate Change and Sustainable Development Policies

LNEG

NOVA SCHOOL OF SCIENCE & TECHNOLOGY

CENSE center for environmental and sustainability research

Outline

- Assignment – where do we stand
- **Energy units and conversion**
- GHG emissions estimates and emissions inventories
- Energy balances

Climate Change and Sustainable Development Policies

International system of units (SI)

Table 1. SI base units

Base quantity	Name	Symbol
	SI base unit	
length	meter	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
thermodynamic temperature	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd

Table 5. SI prefixes

Factor	Name	Symbol	Factor	Name	Symbol
10^{24}	yotta	Y	10^{-1}	deci	d
10^{21}	zetta	Z	10^{-2}	centi	c
10^{18}	exa	E	10^{-3}	milli	m
10^{15}	peta	P	10^{-6}	micro	μ
10^{12}	tera	T	10^{-9}	nano	n
10^{9}	giga	G	10^{-12}	pico	p
10^{6}	mega	M	10^{-15}	femto	f
10^{3}	kilo	k	10^{-18}	atto	a
10^{2}	hecto	h	10^{-21}	zepto	z
10^{1}	deka	da	10^{-24}	yocto	y

“meter, kg, second”

https://www.nist.gov/pml/fundamental-physical-constants

Slided adapted from information kindly provided by Júlia Seixas (NOVA-FCT)

Derived quantity	Name	Symbol	Expression in terms of other SI units	Expression in terms of SI base units
Table 3. SI derived units with special names and symbols				
			SI derived unit	
plane angle	radian [a]	rad	-	$m \cdot m^{-1} = 1$ [b]
solid angle	steradian [a]	sr [c]	-	$m^2 \cdot m^{-2} = 1$ [b]
frequency	hertz	Hz	-	s^{-1}
force	newton	N	-	$m \cdot kg \cdot s^{-2}$
pressure, stress	pascal	Pa	N/m^2	$m^{-1} \cdot kg \cdot s^{-2}$
energy, work, quantity of heat	joule	J	N·m	$m^2 \cdot kg \cdot s^{-2}$
power, radiant flux	watt	W	J/s	$m^2 \cdot kg \cdot s^{-3}$
electric charge, quantity of electricity	coulomb	C	-	s·A
electric potential difference, electromotive force	volt	V	W/A	$m^2 \cdot kg \cdot s^{-3} \cdot A^{-1}$
capacitance	farad	F	C/V	$m^{-2} \cdot kg^{-1} \cdot s^4 \cdot A^2$
electric resistance	ohm	Ω	V/A	$m^2 \cdot kg \cdot s^{-3} \cdot A^{-2}$
electric conductance	siemens	S	A/V	$m^{-2} \cdot kg^{-1} \cdot s^3 \cdot A^2$
magnetic flux	weber	Wb	V·s	$m^2 \cdot kg \cdot s^{-2} \cdot A^{-1}$
magnetic flux density	tesla	T	Wb/m^2	$kg \cdot s^{-2} \cdot A^{-1}$
inductance	henry	H	Wb/A	$m^2 \cdot kg \cdot s^{-2} \cdot A^{-2}$
Celsius temperature	degree Celsius	°C	-	K
luminous flux	lumen	lm	cd·sr [c]	$m^2 \cdot m^{-2} \cdot cd = cd$
illuminance	lux	lx	lm/m^2	$m^2 \cdot m^{-4} \cdot cd = m^{-2} \cdot cd$
activity (of a radionuclide)	becquerel	Bq	-	s^{-1}
absorbed dose, specific energy (imparted), kerma	gray	Gy	J/kg	$m^2 \cdot s^{-2}$
dose equivalent [d]	sievert	Sv	J/kg	$m^2 \cdot s^{-2}$
catalytic activity	katal	kat		$s^{-1} \cdot mol$

https://www.nist.gov/pml/fundamental-physical-constants

Slided adapted from information kindly provided by Júlia Seixas (NOVA-FCT)

joule, symbom J, its the energy unit in the International System of Units (SI)
In principle this is the unit to use!

In SI units:
Where: kg is kilogram, m is meter, s is second
If you use 1 Joule to elevate one object 1 meter against earth's gravity (9,8m/s^2), that object is ….
… one apple (102gr) !

Slided adapted from information kindly provided by Júlia Seixas (NOVA-FCT)

More conversions

1 Joule (J) is equal to 1 Newton force acting along 1 meter.
1 Watt is the power of 1 energy Joule de energia over one second
1 kilowatt = 1000 Watts.
1 kilowatt-hour is the energy produced by the power of 1 kilowatt during 1 hour (E = P t).
1 kilowatt-hour (kWh) = 3.6 x 106 J = 3.6 million Joules
1 calory of heat is the amount needed to increased the temperature of 1 gr of water by 1ºC.
1 calorie (cal) = 4.184 J
The **tonne oil equivalent** (toe) is na energy unit defined as the heat released in the combustion of 1 tonne of crude oil, roughly 42 gigajoules.
A BTU (British Thermal Unit) the amount of heat needed to increased the temperature 1 pound of water in 1 ºF..
1 British Thermal Unit (BTU) = 1055 J
1 BTU = 252 cal = 1.055 kJ
1 000 kWh = 3.41 million BTU

Slided adapted from information kindly provided by Júlia Seixas (NOVA-FCT)

The best option to manage energy units is through the use of converters.

There are several online energy unit converters you may use.

Here is one with many options:

https://www.unitjuggler.com/energy-conversion.html

Mass of fuel, energy content and heating value (lower/ higher)

We can consider two ways of defining **heating value**:

- Higher heating value (HHV in Portuguese PCS)
- Lower Heating Value (LHV in Portuguese “poder calorífico inferior” or P.C.I)

Higher Heating Value (HHV): given by the sum of (1) the energy released in the form of heat and (2) the energy expended in the vaporization of the water formed in a combustion reaction.

Lower Heating Value (LHV): only (1), i.e. the energy released in the form of heat.

Note: For fuels that do not contain hydrogen in their composition, the HHV value is same as the LHV, because there is no formation of water and energy is not spent on its vaporization.

The heating value of a substance, usually a fuel, is the amount of heat released during the combustion of a certain amount of said fuel. The **heating value is a characteristic of each substance (i.e. the LHV of Argelian natural gas can be different from Russian natural gas)**. It is measured in units of energy per unit of generally mass or volume: kcal/kg, kJ/g, kJ/mol or Btu/m^3.

Climate Change and Sustainable Development Policies

Slided adapted from information kindly provided by Júlia Seixas (NOVA-FCT)

Mass of fuel, energy content and heating value (lower/ higher) (II)

Energy (GJ) = Consumption (t) * LHV (MJ/kg)

OR

Energy (GJ) = Consumption (Nm^3) * LHV (MJ/ Nm^3)

This information is needed to estimate GHG emissions, since most times the emission factors are in GJ and not in tonnes! Also, different fuels are reported in different units, for example tonnes of coal versus m^3 of gas. We need to be able to convert them all to the same unit to compare their energy content and/or carbon intensity.

Table 3-7 – Low Heating Value per fuel type

Fuel	LHV/NCV	
Lignite	16.42 (15.57 - 17.02)	MJ/kg
Hard Coal	25.62 (24.45 - 27.23)	MJ/kg
Fuel-oil	40.24 (39.42 - 41.15)	MJ/kg
Orimulsion	28.00	MJ/kg
Diesel oil	43.30	MJ/kg
Natural Gas	38.16 (36.02 - 39.16)	MJ/Nm^3
GPL	47.44 (47.28-48.55)	MJ/kg
Biomass	7.8	MJ/kg

Note: Orimulsion is a registered trademark name for a bitumen-based fuel that was developed for industrial use by Intevep, the Research and Development Affiliate of Petroleos de Venezuela SA (PDVSA)

National Inventory Report, APA 2016
(http://www.apambiente.pt/_zdata/Inventario/NIR_global_20160415.pdf)

Slided adapted from information kindly provided by Júlia Seixas (NOVA-FCT)

Outline

- Assignment – where do we stand
- Energy units and conversion
- **GHG emissions estimates and emissions inventories**
- Energy balances

Climate Change and Sustainable Development Policies

Estimating GHG emissions – national emission inventories

National greenhouse gas inventories are **essential tools for countries to transparently report their anthropogenic emissions and removals of greenhouse gases**.
Provide a fundamental basis for **mutual trust and confidence among countries** that are needed for effective implementation of international agreements to address climate change. They are also essential tools in **developing policies and in monitoring impact**.
Provide invaluable information for those developing policies related to climate change (IPCC 2019).

The Parties to the United Nations Framework Convention on Climate Change (UNFCCC) develop, periodically update and publish their national greenhouse gas inventories, using comparable methodologies to be agreed upon by the Conference of the Parties.

The "comparable methodologies" agreed on are those produced by the Intergovernmental Panel on Climate Change (IPCC). Further, the Parties to the Paris Agreement decided in December 2018 that each Party shall use the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and shall use any subsequent version or refinement of the IPCC guidelines agreed upon by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement (IPCC 2019).

Climate Change and Sustainable Development Policies

LNEG

NOVA SCHOOL OF SCIENCE & TECHNOLOGY

CENSE center for environmental and sustainability research

Slided adapted from information kindly provided by Júlia Seixas (NOVA-FCT)

Estimating GHG emissions – national emission inventories (II)

The IPCC methodologies supporting the greenhouse gas emissions may be accessed here: https://www.ipcc-nggip.iges.or.jp/

Under the UNFCCC reporting guidelines on annual inventories for Annex I Parties, inventory submissions are in two parts:

1. **Common reporting format (CRF) tables** – a series of standardized data tables containing mainly quantitative information
2. **National Inventory Report (NIR)** – a report containing transparent and detailed information on the inventory. It should include descriptions of the methodologies used in the estimations (including references and sources of information), the data sources, the institutional arrangements for the preparation of the inventory (including quality assurance and control procedures), and recalculations and changes compared with the previous inventory
   https://unfccc.int/resource/docs/2013/cop19/eng/10a03.pdf#page=2

GHG emission inventory methodology and format

IPCC 2019, 2019 Refinement to the 2006 **IPCC Guidelines for National Greenhouse Gas Inventories**, Calvo Buendia, E., Tanabe, K., Kranjc, A., Baasansuren, J., Fukuda, M., Ngarize, S., Osako, A., Pyrozhenko, Y., Shermanau, P. and Federici, S. (eds). Published: IPCC, Switzerland.

https://www.ipcc.ch/report/2019-refinement-to-the-2006-ipcc-guidelines-for-national-greenhouse-gas-inventories/

Structure of the NIR – National Inventory Report

Chapter 1: Introduction

Chapter 2: Trends in greenhouse gas emissions

Chapter 3: Energy (CRF sector 1)

- 3.2. Fuel combustion (CRF 1.A): 1. Energy industries, 2. Manufacturing industries and construction, 3. Transport, 4. Other sectors, 5. Other
- 3.3. Fugitive emissions from solid fuels and oil and natural gas and other emissions from energy production (CRF 1.B)
- 3.4. CO_2 transport and storage (CRF 1.C)

Chapter 4: Industrial processes and product use (CRF sector 2)

A. Mineral industry; B. Chemical industry; C. Metal industry; D. Non-energy products from fuels and solvent use; E. Electronic industry; F. Product uses as substitutes for ODS; G. Other product manufacture and use; H. Other

Chapter 5: Agriculture (CRF sector 3)

A. Enteric fermentation; B. Manure management; C. Rice cultivation; D. Agricultural soils; E. Prescribed burning of savannas; F. Field burning of agricultural residues; G. Liming; H. Urea application; I. Other carbon-containing fertilizers; J. Other

Chapter 6: Land use, land-use change and forestry (CRF sector 4)

A. Forest land; B. Cropland; C. Grassland; D. Wetlands; E. Settlements; F. Other land; G. Harvested wood products; H. Other

Chapter 7: Waste (CRF sector 5)

A. Solid waste disposal; B. Biological treatment of solid waste; C. Incineration and open burning of waste; D. Waste water treatment and discharge; E. Other

Chapter 8: Other (CRF sector 6) (if applicable)

Chapter 9: Indirect CO_2 and nitrous oxide emissions

Chapter 10: Recalculations and improvements

https://unfccc.int/resource/docs/2013/cop19/eng/10a03.pdf#page=2

Sustainable Development Policies

NOVA SCHOOL OF SCIENCE & TECHNOLOGY

center for environmental and sustainability research

GHG emission inventory methodology and format : Energy (CRF sector 1)

Fuel combustion (CRF 1.A):

1. Energy industries

a. Public electricity and heat production
b. Petroleum refining
c. Manufacture of solid fuels and other energy industries

2. Manufacturing industries and construction

a. Iron and steel
b. Non-ferrous metals
c. Chemicals
d. Pulp, paper and print
e. Food processing, beverages and tobacco
f. Non-metallic minerals
g. Other (please specify)

3. Transport

a. Domestic aviation
b. Road transportation
c. Railways
d. Domestic navigation
e. Other transportation

4. Other sectors

a. Commercial/institutional
b. Residential
c. Agriculture/forestry/fishing

5. Other

a. Stationary
b. Mobile

Fugitive emissions from fuels (CRF 1.B):

1. Solid fuels

a. Coal mining and handling
b. Solid fuel transformation
c. Other

2. Oil and natural gas and other emissions from energy production

a. Oil
b. Natural gas
c. Venting and flaring
d. Other

CO_2 Transport and storage (CRF 1.C):

1. Transport of CO_2
2. Injection and storage
3. Other

https://unfccc.int/resource/docs/2013/cop19/eng/10a03.pdf#page=2

Estimating GHG emissions – national emission inventories – energy combustion

Emissions of CO_2 (t CO_2) = Energy consumption (t ou GJ) * Oxidation Factor (%) * EF (emission factor) (gCO_2/t or GJ)

Emissions of CH_4 (t CH_4) = Energy consumption (t or GJ) * EF (gCH_4/t or GJ)

Emissions of N_2O (t N_2O) = Energy consumption (t or GJ) * EF (gN_2O/t or GJ)

Table 3-3 – Emission Factors for energy production sector. Greenhouse Gases

Fuel	UCO2 (i) kg/GJ	Fac_{ox} (ii) 0..1	FossilC %	CH4 (i) g/GJ	N2O (i) g/GJ
Lignite	101.0	0.980	100	1.0	1.5
Hard Coal	92.0(ii)	0.980	100	0.7(ii)	1.4(ii)
Fuel-oil	77.4	0.990	100	0.8	0.3
Orimulsion	77.0	0.990	100	3.0	0.6
Natural Gas	56.1	0.995	100	1.0	1.0 – 3.0
LPG	63.1	0.995	100	1.0	0.1
Biomass	112.0	1.000	0	11.0	7.0
Diesel	74.1	0.990	100	3.0	0.6

National Inventory Report, APA 2016 (http://www.apambiente.pt/_zdata/Inventario/NIR_global_20160415.pdf)

(i) IPCC (2006); (ii) IPCC (1997);

Slided adapted from information kindly provided by Júlia Seixas (NOVA-FCT)

Estimating GHG emissions – national emission inventories - transport

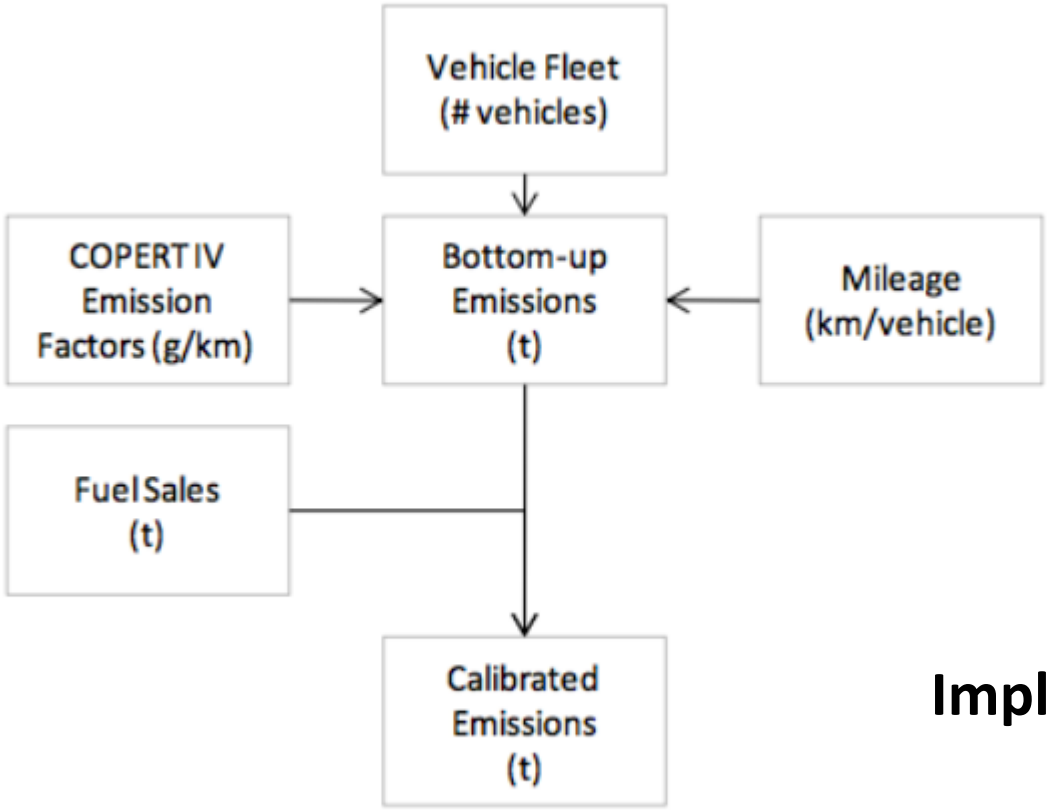


Figure 3-59 – General scheme of methodology applied for road transport emissions estimates (Passenger cars, light duty vehicles and motorcycles)

Implicit emission factors

National Inventory Report, APA 2016
(http://www.apambiente.pt/_zdata/Inventario/NIR_global_20160415.pdf)

Slided adapted from information kindly provided by Júlia Seixas (NOVA-FCT)

Estimating GHG emissions – national emission inventories - transport

Implicit emission factors

Fuel combustion activities - sectoral approach
(Sheet 3 of 4)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	IMPLIED EMISSION FACTORS		
	CO_2 (1)	CH_4	N_2O
	(t/TJ)	(kg/TJ)	
1.A.3 Transport			
Liquid fuels	72,16	4,92	2,18
Solid fuels	NO	NO	NO
Gaseous fuels	55,82	92,00	0,10
Other fossil fuels (4)	NO	NO	NO
Biomass (5)	73,33	1,55	2,36
a. Domestic aviation (3)			
Aviation gasoline	69,33	39,02	2,00
Jet kerosene	70,79	3,05	2,00
Biomass	NO	NO	NO
b. Road transportation (3)			
Gasoline	68,61	15,86	1,60
Diesel oil	73,33	1,55	2,29
Liquefied petroleum gases (LPG)	62,75	12,14	2,83
Other liquid fuels (*please specify*)			
Gaseous fuels	55,82	92,00	0,10
Biomass (5)	73,33	1,55	2,29
Other fossil fuels (*please specify*) (4)			
i. Cars			
Gasoline	68,61	10,11	1,65
Diesel oil	73,33	0,56	2,85
Liquefied petroleum gases (LPG)	62,75	12,14	2,83
Other liquid fuels (*please specify*)			
Gaseous fuels	NO	NO	NO
Biomass (5)	73,33	0,56	2,85
Other fossil fuels (*please specify*) (4)			
ii. Light duty trucks			
Gasoline	NO	NO	NO
Diesel oil	73,33	0,58	1,98
Liquefied petroleum gases (LPG)	NO	NO	NO
Other liquid fuels (*please specify*)			
Gaseous fuels	NO	NO	NO
Biomass (5)	73,33	0,58	1,98
Other fossil fuels (*please specify*) (4)			
iii. Heavy duty trucks and buses			
Gasoline	NO	NO	NO
Diesel oil	73,33	4,68	1,23
Liquefied petroleum gases (LPG)	NO	NO	NO
Other liquid fuels (*please specify*)			
Gaseous fuels	55,82	92,00	0,10
Biomass (5)	73,33	4,68	1,23
Other fossil fuels (*please specify*) (4)			
iv. Motorcycles			
Gasoline	68,61	53,89	1,25
Diesel oil	NO	NO	NO
Liquefied petroleum gases (LPG)	NO	NO	NO

Common Report Format, APA 2016 (http://www.apambiente.pt/_zdata/Inventario/PRT_2016_1994_16042016_051700_submitted .zip)

Slided adapted from information kindly provided by Júlia Seixas (NOVA-FCT)

Outline

- Assignment – where do we stand
- Energy units and conversion
- GHG emissions estimates and emissions inventories
- **Energy balances**

Climate Change and Sustainable Development Policies

Energy balances

Direção-Geral de Energia e Geologia

Portuguese Energy statistics
https://www.dgeg.gov.pt/pt/estatistica/energia/balancos-energeticos/

You may download the last version available in excel format.
You may also access different energy statistics files:

- *Balanços Energéticos* (excel files in portuguese)
- *Indicadores Energéticos* (Energy Indicators: table (xls) with indicators in Portuguese)
- and other statistics regarding '*Renováveis*', '*Gás Natural*', '*Petróleo*', '*Carvão*'

The Energy Balance is a spreadsheet organized in terms of energy producers and energy consumers (in rows) of different energy forms (in columns).
In Europe, all the national authorities send their energy national balances to EUROSTAT, which consolidate them to the EU level.

Slided adapted from information kindly provided by Júlia Seixas (NOVA-FCT)

different energy carriers (in columns)

energy producers and consumers (in rows)

Direção-Geral de Energia e Geologia
Direção de Serviços de Planeamento Energético e Estatística

BALANÇO ENERGÉTICO tep 2019 provisório		Hulha e Antracite *Coal* 1	Coque de Carvão *Coking coal* 2	Total de Carvão *Total Coal* 3 = 1 + 2	Petróleo Bruto *Crude oil* 4	Refugos e Produtos Intermédios *Waste oil* 5	GPL *LPG* 6	Gasolinas *Gasoline* 7	Petróleos *Oil* 8	Jets *Jet* 9
PRODUÇÃO DOMÉSTICA *Domestic production*	02									
VARIAÇÃO DE "STOCKS" *Stock variation*	03	276 461	- 238	276 223	48 878	- 76 234	- 29 395	11 369	- 61	- 37 661
SAÍDAS *EXITS*	04	99 544	79	99 623		147 226	90 470	1 666 052		1 474 527
Exportações *Export*	04.01	*99 544*	*79*	*99 623*		*147 226*	*90 470*	*1 666 052*		*16 424*
Transportes Marítimos Internacionais *Int. shipping*	04.02									
Aviação Internacional *Internat. aviation*	04.03									*1 458 103*
CONSUMO DE ENERGIA PRIMÁRIA *Total energy production*	05	1 241 333	6 998	1 248 331	11 429 232	1 481 535	764 971	-1 401 588	322	-1 178 486
PARA NOVAS FORMAS DE ENERGIA *To new energy forms*	06	1 237 895		1 237 895	11 423 655	917 683	- 111 408	-2 530 212	- 197	-1 382 626
Briquetes *Briquettes*	06.01									
Coque *Coke*	06.02									
Produtos de Petróleo *Oil products*	06.03				*11 423 655*	*1 002 277*	*- 181 717*	*-2 530 212*	*- 197*	*-1 382 626*
Hidrogénio *Hydrogen*	06.04									
Petroquímica *Petrochemical*	06.05					*- 113 219*	*70 309*			
Eletricidade *Electricity*	06.06	*1 237 895*		*1 237 895*						
Cogeração *CHP*	06.07					*28 625*				
Produção de Eletricidade *(...)*	06.07.01									
Refinação de Petróleo	06.07.02					*28 625*				

Climate Change and Sustainable Development Policies

Slided adapted from information kindly provided by Júlia Seixas (NOVA-FCT)

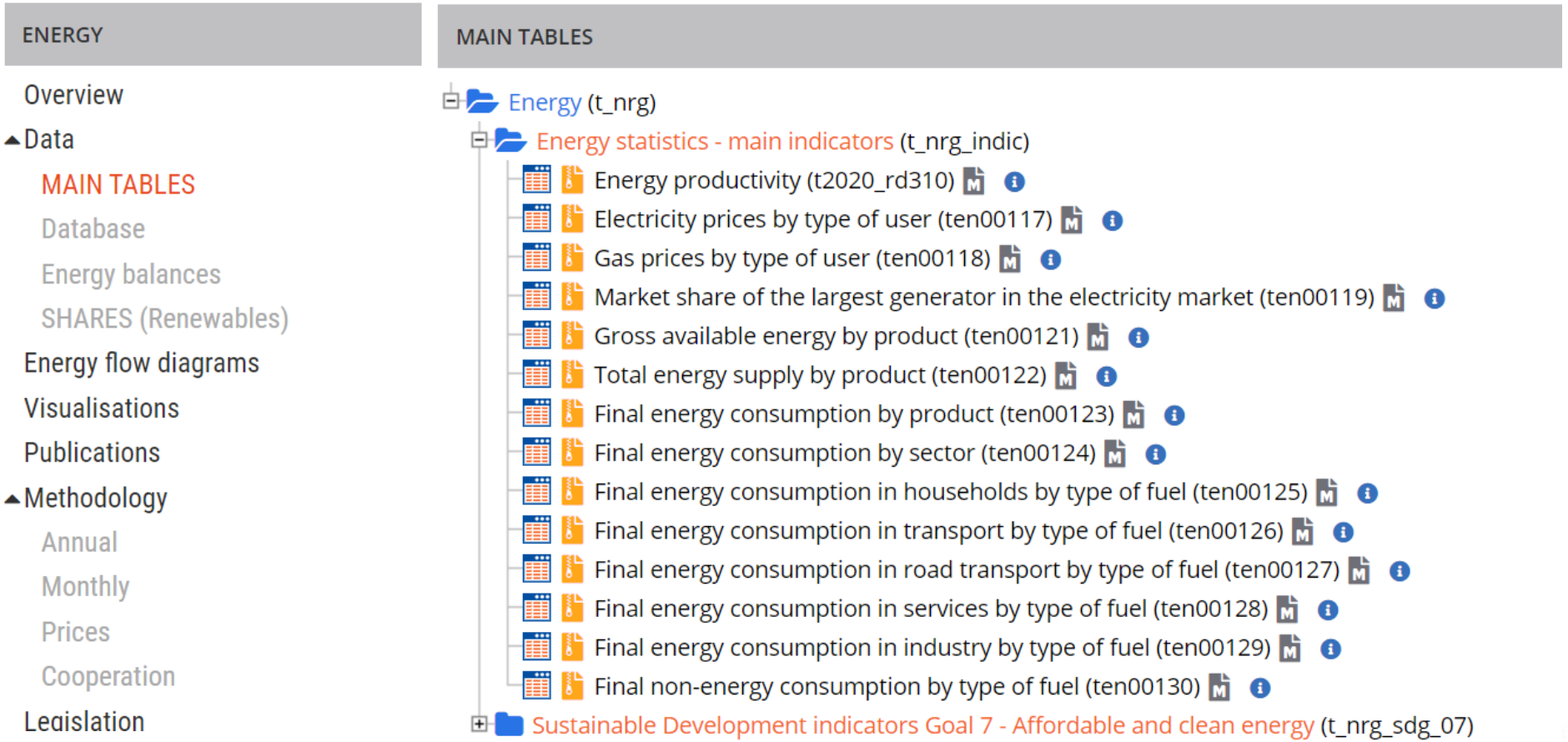
Energy data - EUROPE

European Energy Statistics: EUROSTAT

http://ec.europa.eu/eurostat/web/energy/data/main-tables

eurostat
Your key to European statistics

You may select **ENERGY BALANCES** (in the left) and then Energy Balances in the MS Excel file format (2021 edition) (in the right) where you can find the Energy Balances for all the member States and for the EU28 and EU27.



Slided adapted from information kindly provided by Júlia Seixas (NOVA-FCT)

Energy data – EUROPE - explore

You may **download the file** (country or EU) of your interest, and may want to analyze:

- the **Primary Production of energy by resource**: take a look at the consumption of natural gas and oil.
- the **Electricity consumption by industry, transport activities or households/services**: take a look at a specific sector of consumption (e.g. the same as you picked previously).
- Decide upon a **couple of indicators you find useful** to explore (e.g. how has been evolved the energy consumption in industry in Portugal in the last decade, in comparison with Spain and the European Union?).

Energy data – World

International energy Agency
https://www.iea.org/data-and-statistics/data-products

- **Balances/Statistics**
- Coal
- Efficiency
- Electricity
- Emissions
- Free
- Gas
- Oil
- Other
- Prices
- Renewables
- Scenarios

Most of it is subscription based…

"This free extract of World Energy Balances contains a selection of the most requested for flows, covering all sources of energy, all 37 OECD countries and 8 IEA Association countries as well as relevant aggregates and complete time series from 1971 (1960 for OECD countries) wherever possible. "

An IEA account is required to download data.

https://www.iea.org/data-and-statistics/data-product/world-energy-balances
Subscription!!!

Climate Change and Sustainable Development Policies

Key information you should have apprehended after the class

- Basic understanding on different energy units and how to convert them
- Low and High heating value and why it is important
- How to estimate GHG emissions from fuels combustion for the energy sector and for transport
- What are national emission inventories and where to find them
- What are national energy balances and where to find them