Café com Física

Connecting the gaps: Assessing uncertainty of energy and CO2 emission projections and implications for climate mitigation

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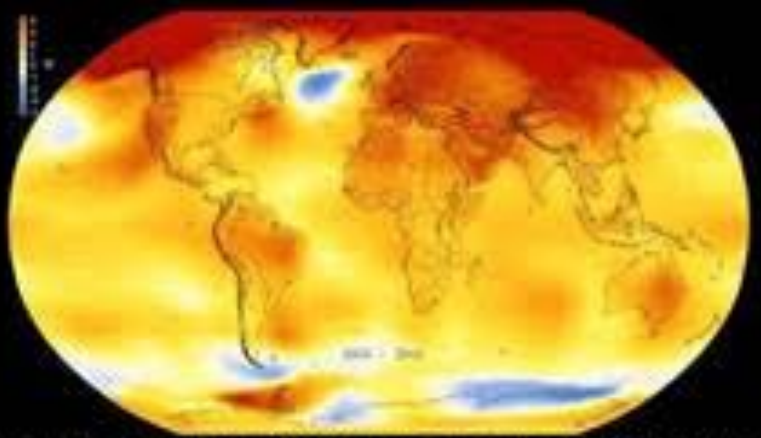

18 de novembro às 14h00

no zoom

(transmissão no Anfiteatro AD.1)

Outline

0- Motivation: Dynamical systems and climate change;

1- Previous work on analysis of uncertainty in projections of: energy demand (TPED), CO2 emissions from energy and renewable energy implementation (and how they compare with observed values);

2- Review of projections for Portugal - (and policy targets for emission reductions);

3- Discussion and Conclusions

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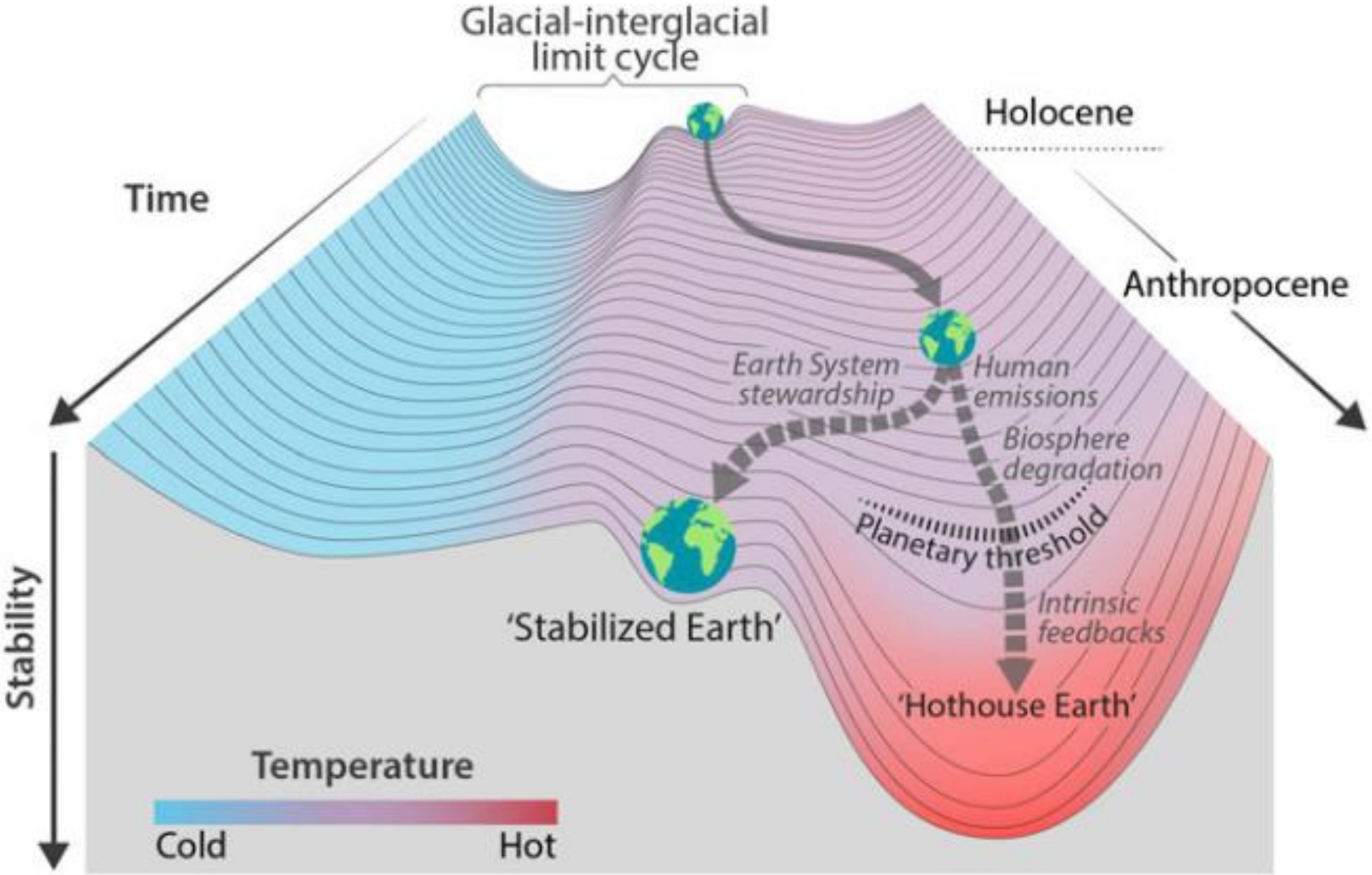
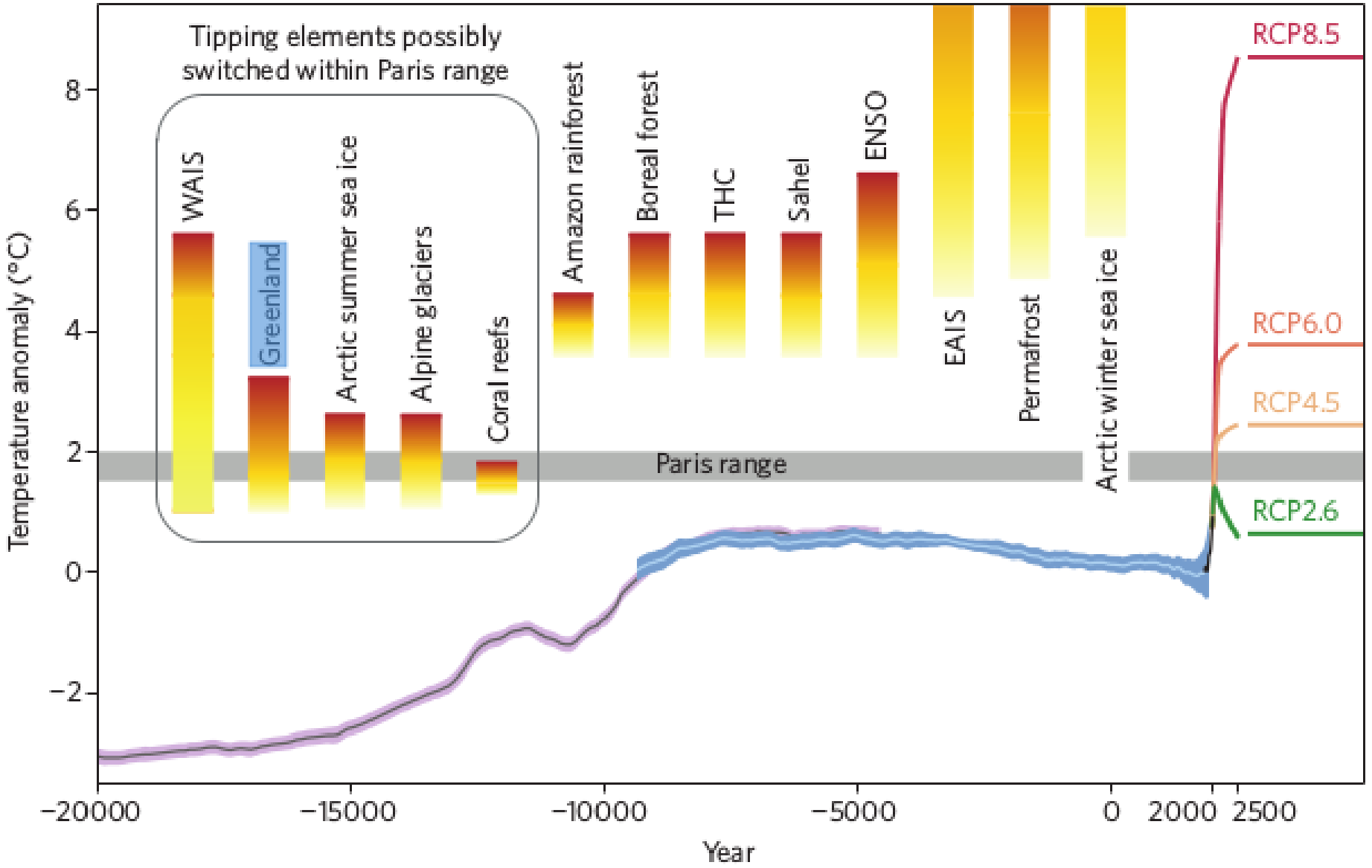


[3]

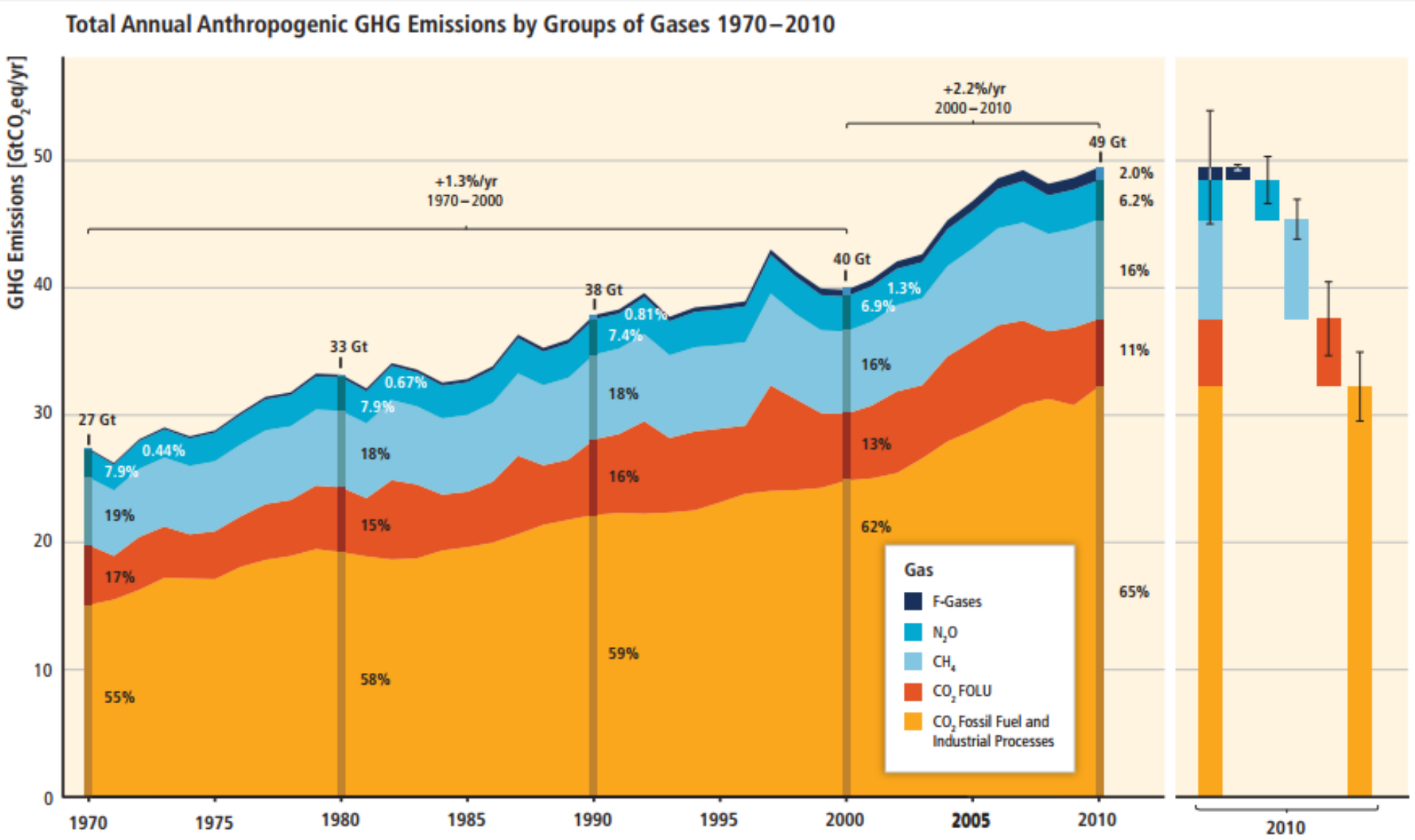
Steffen, Rockstrom et al., Trajectories of the Earth System in the Anthropocene, PNAS, 2018. Fig. 2



Schellnhuber et al., Nature Climate Change, 2016.

[4]

GHG Global Emissions



- IPCC AR5, WG3, SPM, Fig. SPM.1

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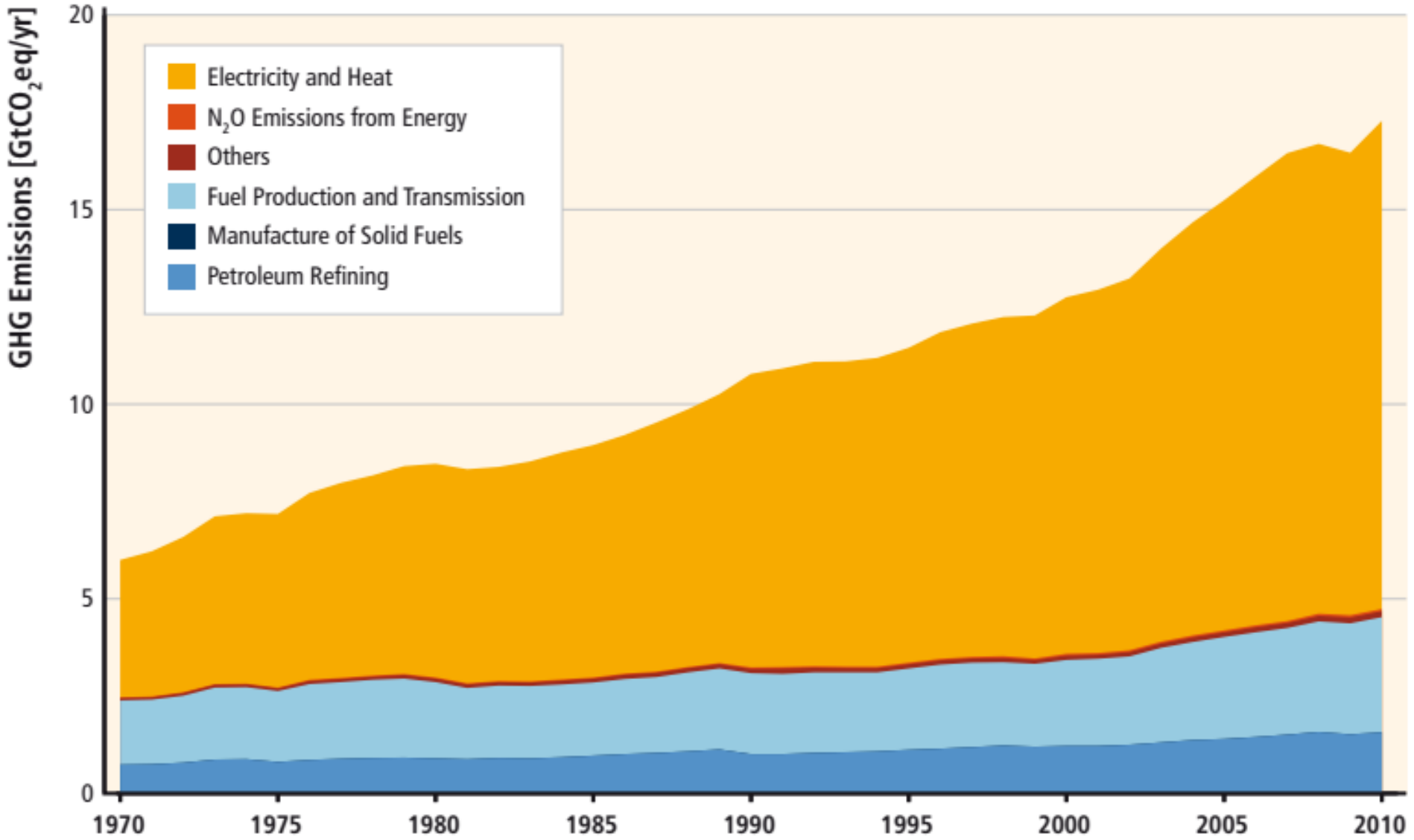
GHG SHARE OF ENERGY (SUPPLY) SECTOR - WORLD



"In 2010, the **energy supply sector** was responsible for approximately **35% of total anthropogenic GHG emissions**" – IPCC, AR5, WG3, Chapter 7, 2014;

- IPCC AR5, WG3, 2014, chapter 7, Fig. 7.3

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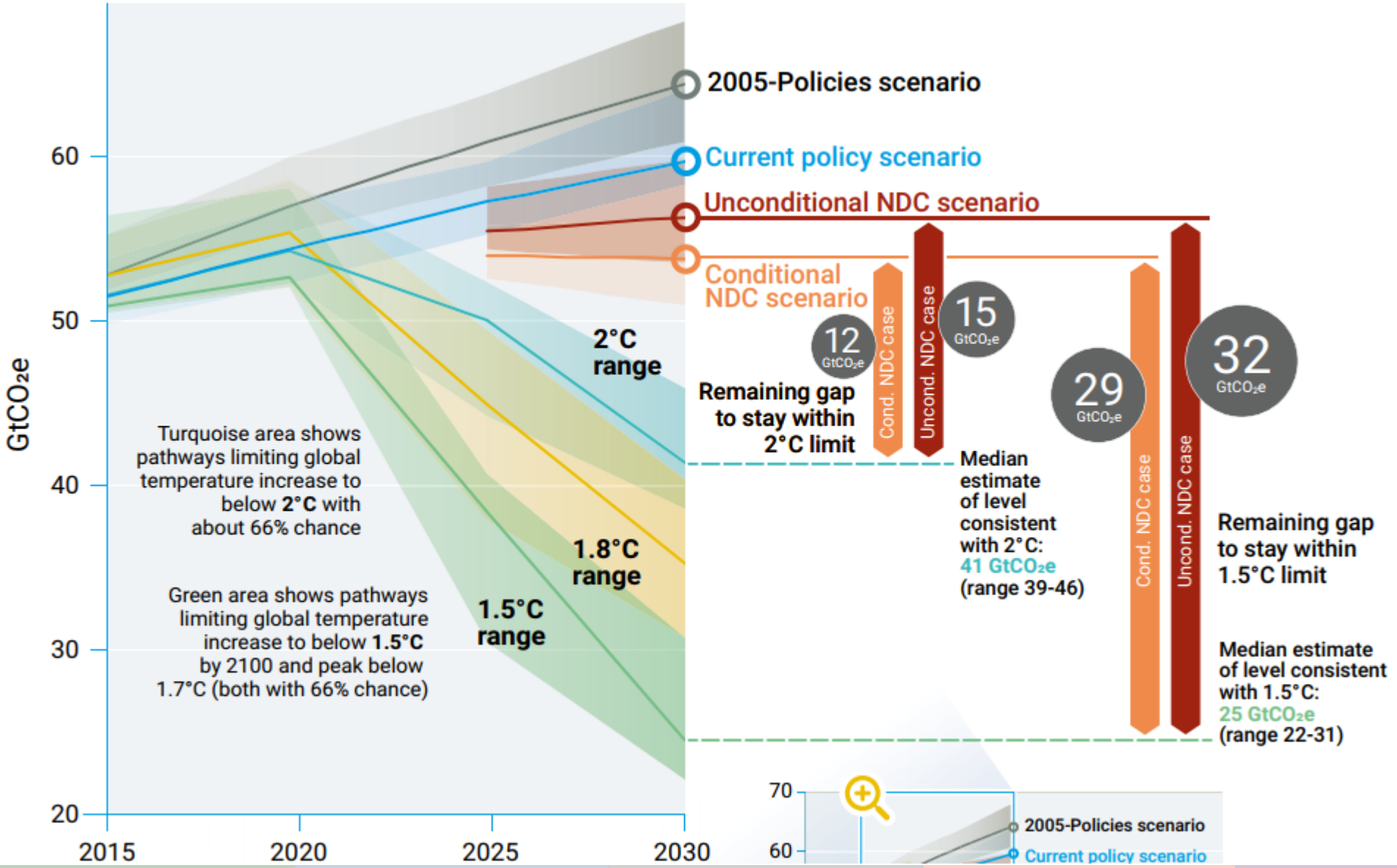
0- Motivation: UNEP Emissions Gap



For 2030 emissions level
(with a chance > 66% of **staying below 2ºC**) the gap is:

15 GtCO2eq
(unconditional NDCs – 27% of the total 56Gt;

12 GtCO2eq
(conditional NDCs)

NDCs to be **reviewed in 2020**….

Source: **UNEP Emissions Gap Report, 2019,** Fig. ES.4**:**

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1- Path to decarbonization (energy sector)

1- **Reduce energy use**, whenever possible;

2- **Increase energy efficiency** as much as possible;

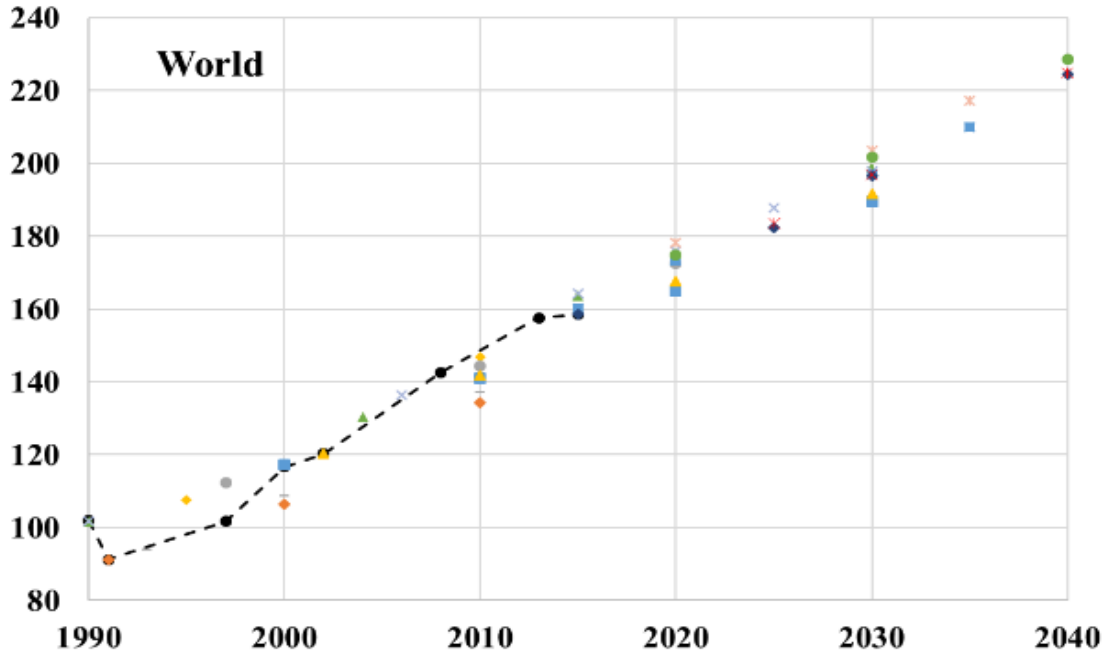
3- **Electrify** whenever possible;

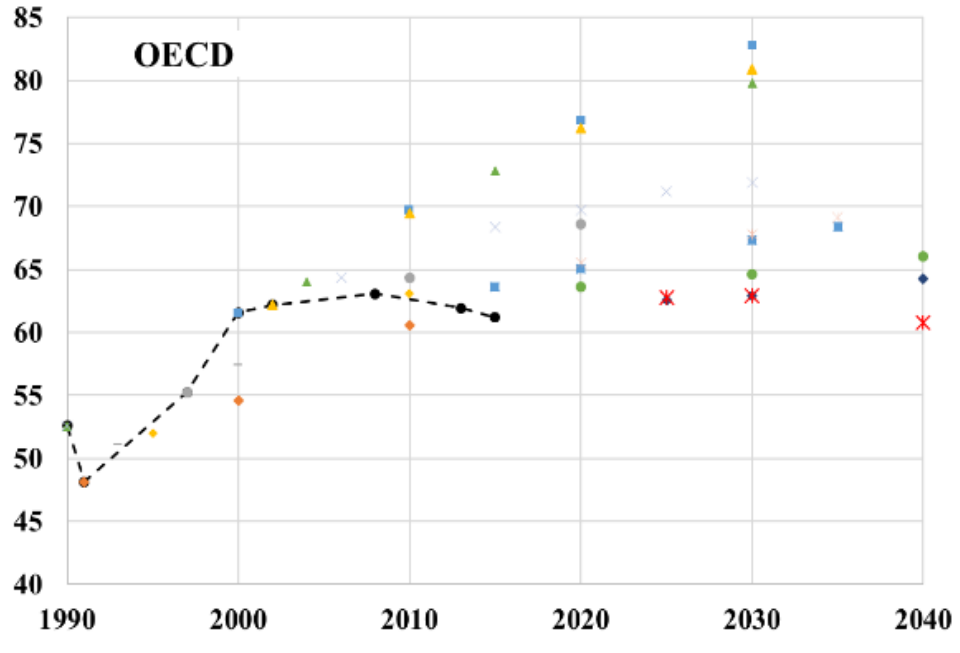
4- **Renewable (and sustainable) energy systems**, whenever possible;

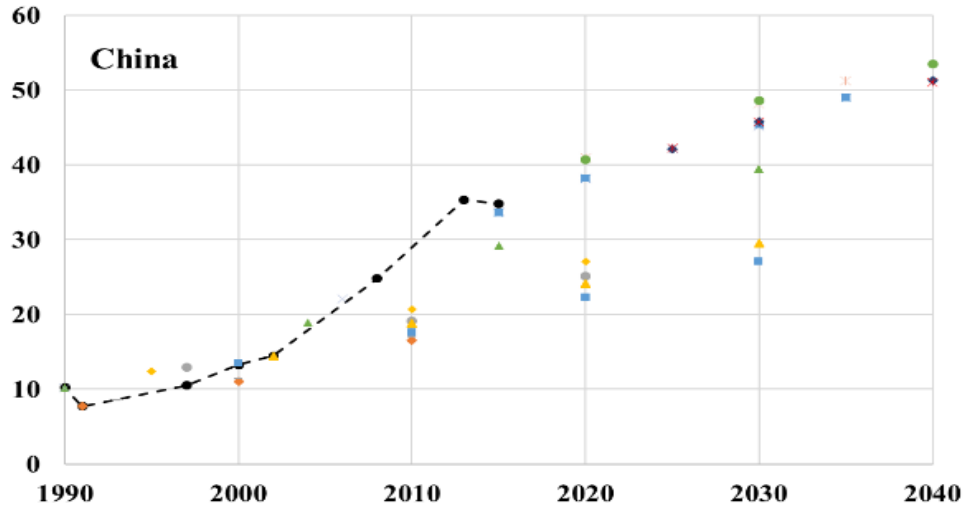
Refs: Seixas, Simões et al., The Pivotal Role of Electricity in the Deep Decarbonization of Energy Systems; 2018;
van Vuuren, Nakicenovic et al., Curr. Opin. Environ. Sustain. 4 (2012) 18–34;
Bruckner et al., AR5 2014: Mitigation of Climate Change, Chapter 7, IPCC (2014);
Jacobson & Delucchi, Energy Policy. 39 (2011) 1154–1169; Figueres, et al., Nature. 546 (2017) 593–595;

TPED (M GWh)

Total Primary Energy Demand estimated in IEA-WEO (Ref scenario), 13 editions
Between 1994-2018, for World, OECD, China

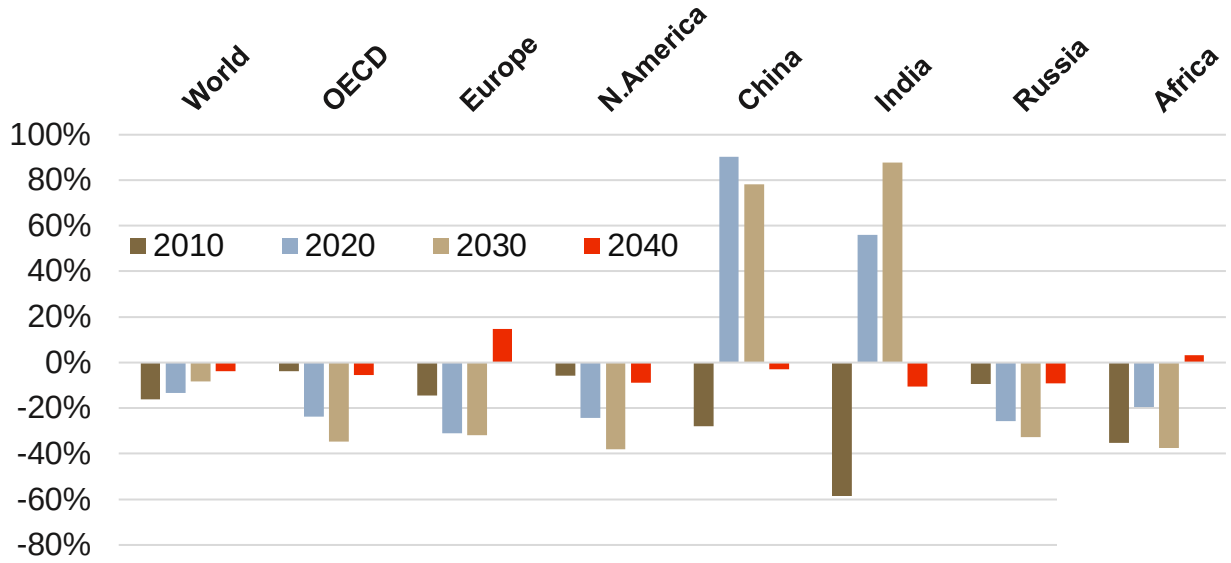






historical
WEO 1994
WEO 1996
WEO 1998
WEO 2000
WEO 2002
WEO 2004
WEO 2006
WEO 2008
WEO 2010
WEO 2012
WEO 2015
WEO 2017
WEO 2018

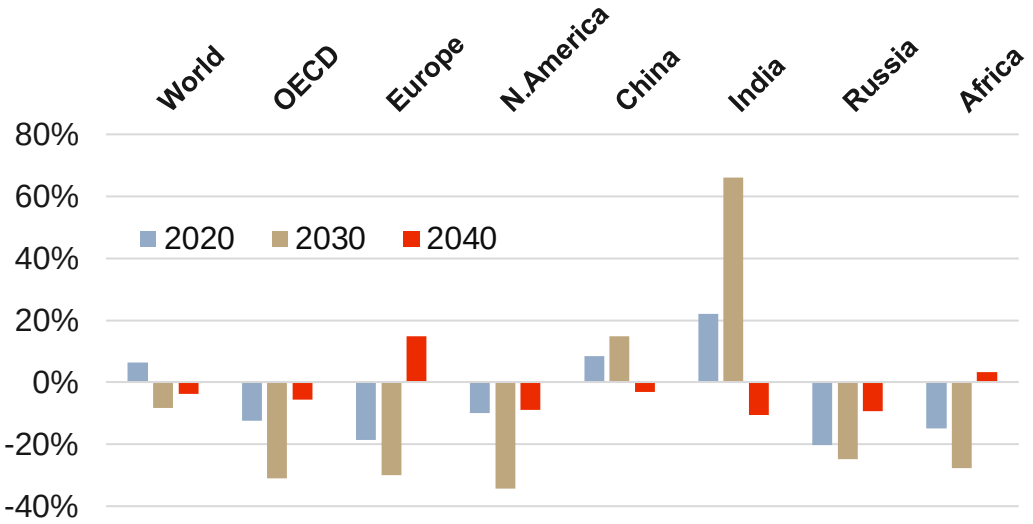
CO2 EMISSIONS (FROM THE ENERGY SECTOR)



Max variation in CO2 projections made between 1994-2018

- Variation of CO2 emissions projections from **the energy sector** IEA-WEO (Ref scenario), 13 editions between 1994-2018
- Positive variation: corrected upwards;
- **Negative variation: corrected downwards;**

2006-2018: same time interval between 2018-2030…



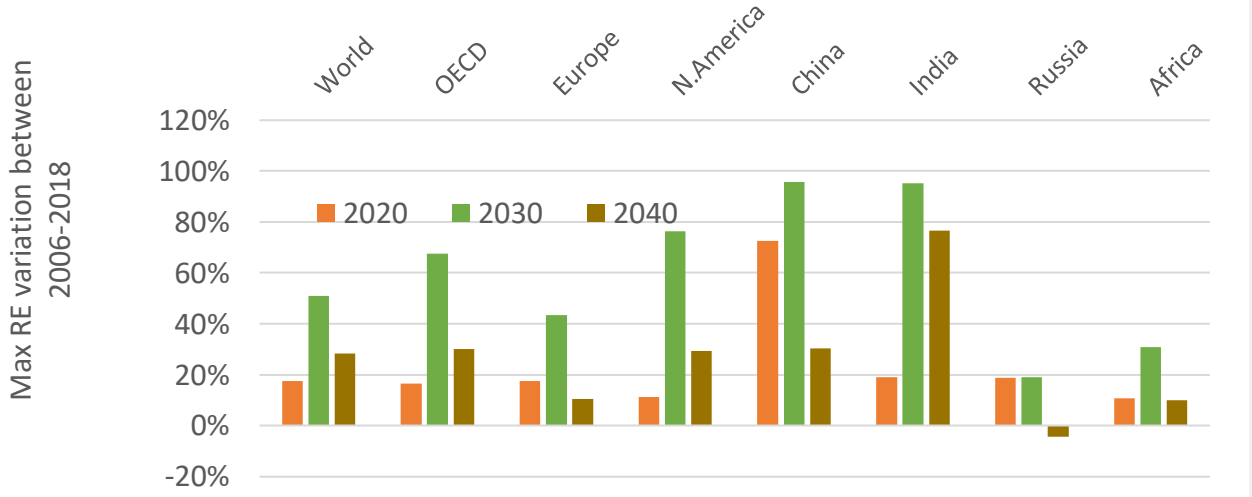
Max variation in CO2 projections made between 2006-2018

ELECTRICITY GENERATED FROM RES

Max variation of projections of RES electricity made between 1994-2018

- Max variations found between RES electricity projections in the IEA-WEO (Ref scenario), 13 editions between 1994-2018;
- **Positive variation: corrected upwards;**
- Negative variation: corrected downwards;

2006-2018: same time interval between 2018-2030…



Max variation of projections of RES electricity made between 2006-2018

COMPARISON WITH NDCS

- **Current gap between existing (unconditional) NDCs and reduction in GHG emissions** (until 2030) needed to comply with the Paris Agreement (2ºC, 66%) estimated at 15 GtCO2eq, or **~27% of 56 GtCO2eq** (UNEP, 2019);

- We found variations of **-31%, -30% and -34%, for OECD, Europe and North America regions**, respectively, in **CO2 emissions** (from the energy sector) *projected for 2030* by the IEA-WEO (in the **period 2006-2018**);

- For the same period (2006-18), **projections for the percentage of RES electricity in 2030 have maximum (all positive) variations of 51%, 68%, 44%, 76%, 96% and 95%**, for the World, OECD, Europe, North America, China and India, respectively;

- "**Connecting the gaps: Assessing uncertainty of energy and CO2 emission projections and implications for climate mitigation**", L. M. Fazendeiro and S. G. Simões, submitted to *Energy Strategy Reviews,* 2020.

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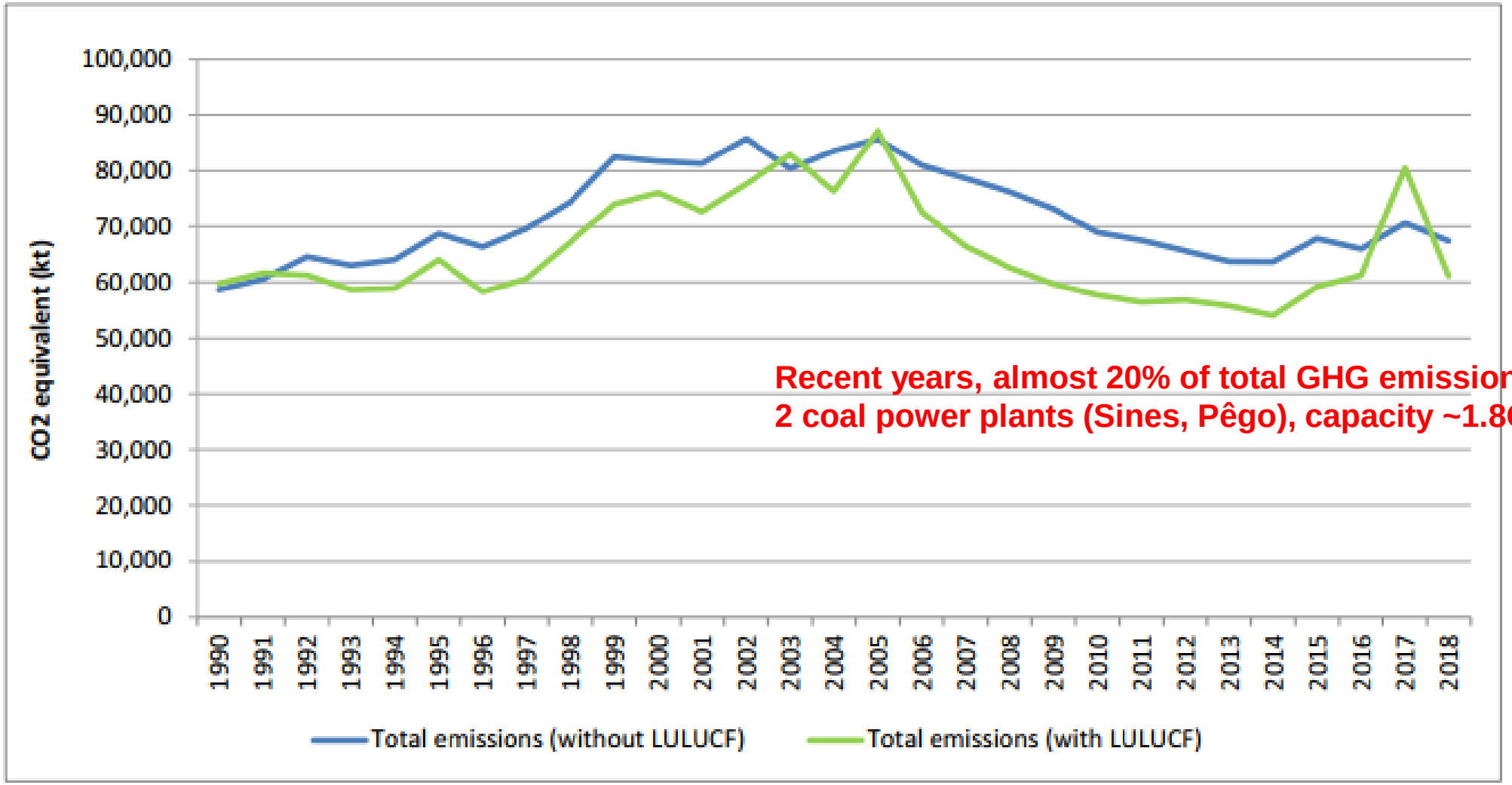
2 - GHG EMISSIONS – PORTUGAL (1990-2018)



Recent years, almost 20% of total GHG emissions came from 2 coal power plants (Sines, Pêgo), capacity ~1.8GW!

- **APA**, National Inventory Report of GHG, 15/3/2020 (Fig. 2.1);

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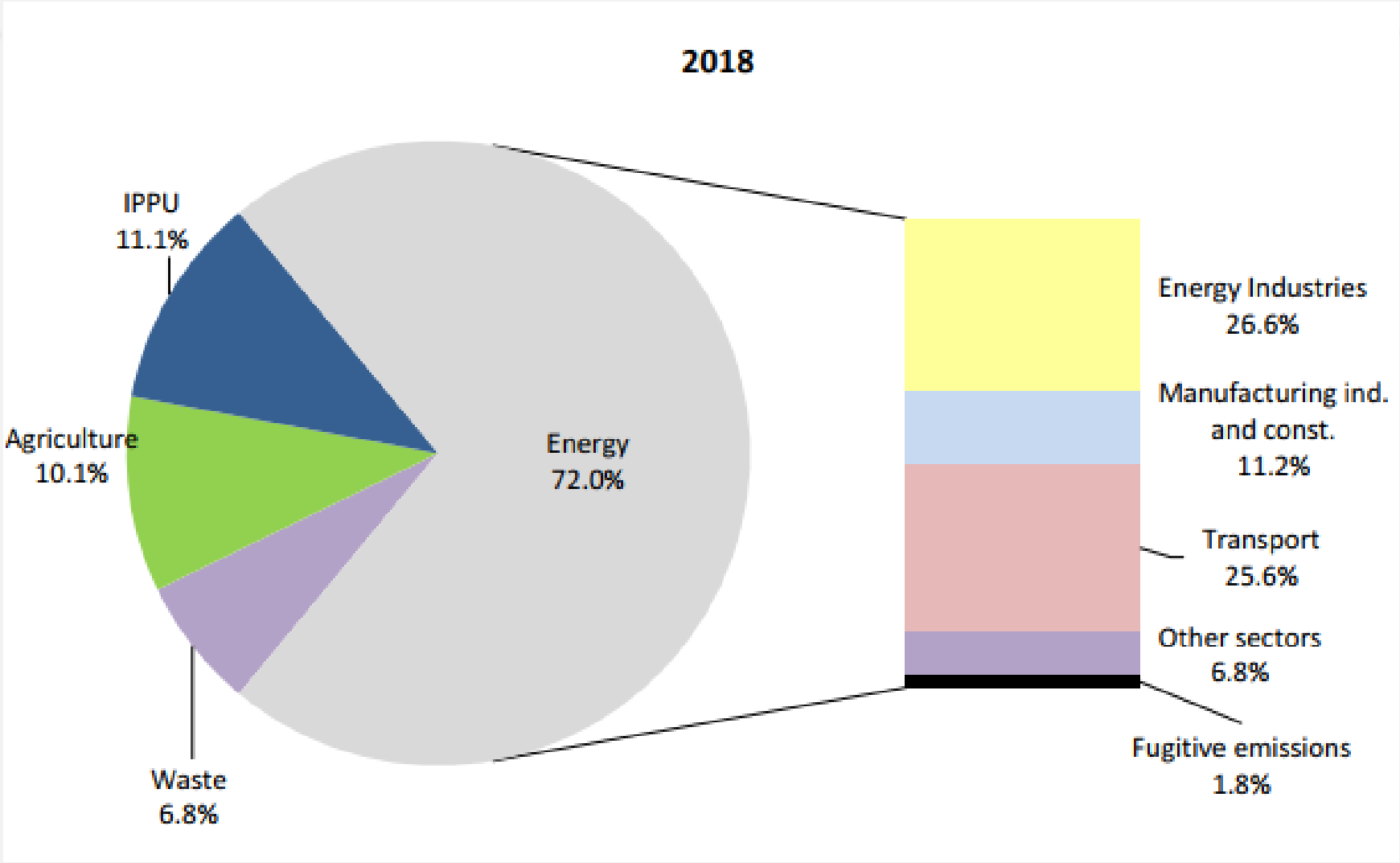
GHG share of Energy sector – Portugal (2018)

IPPU = Industrial Processes and Product Uses



- Source: APA, **National Inventory Report of GHG, 15/3/2020 (Fig. 2.8);**

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2 - Future "projections" for Portugal

1 – Roteiro para a Neutralidade Carbónica 2050 (RNC2050)

- **TIMES_PT** (Nova University) for the energy sector; cuts of **45%-55% GHG emissions in 2030, compared to 2005**;

- **~80% of all electricity from renewable sources**, in 2030;

2- "Replacing coal-fired power plants by photovoltaics in the Portuguese electricity system", Figueiredo, Nunes et al., Journal of Cleaner Production 222 (2019) 129-142;

- model: **"EnergyPLAN"** (supply and demand, includes carbon taxes, public policies…);

- looked at possibility of **coal-free electricity before 2025**, with **solar PV (~8GW)** and hydro pump storage (2.75GW, roughly what there is already….);

- but at the current rate of implementation, **8GW of solar PV will not be achieved before 2030**!!!! (PNEC only assumes **maximum of 7.4 GW solar PV** in 2030…)

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2 - Future "projections" for Portugal

- How do these compare with EU targets and the Paris Agreement?

Ano	Emissões PT (MtCO2eq)	UE, meta para 2030 (-40% face a 1990)	IPCC, meta para 2030, 1.5°C (-45% face a 2010)	IPCC, meta para 2030, 2°C (-25% face a 2010)	PNEC 2030/ RNC2050 (PT, -50%, face a 2005)
1990	59				
2005	86				
2010	69				
2017	71				
2030		**35**	**38**	**52**	**43**
2050		?	Net zero (Mundo)		Net zero (PT)
2070				Net zero (Mundo)	

In spite of perceived ambition, Governamental targets in Portugal are still below EU...
Compatible with IPCC 2ºC target, but not 1.5ºC…

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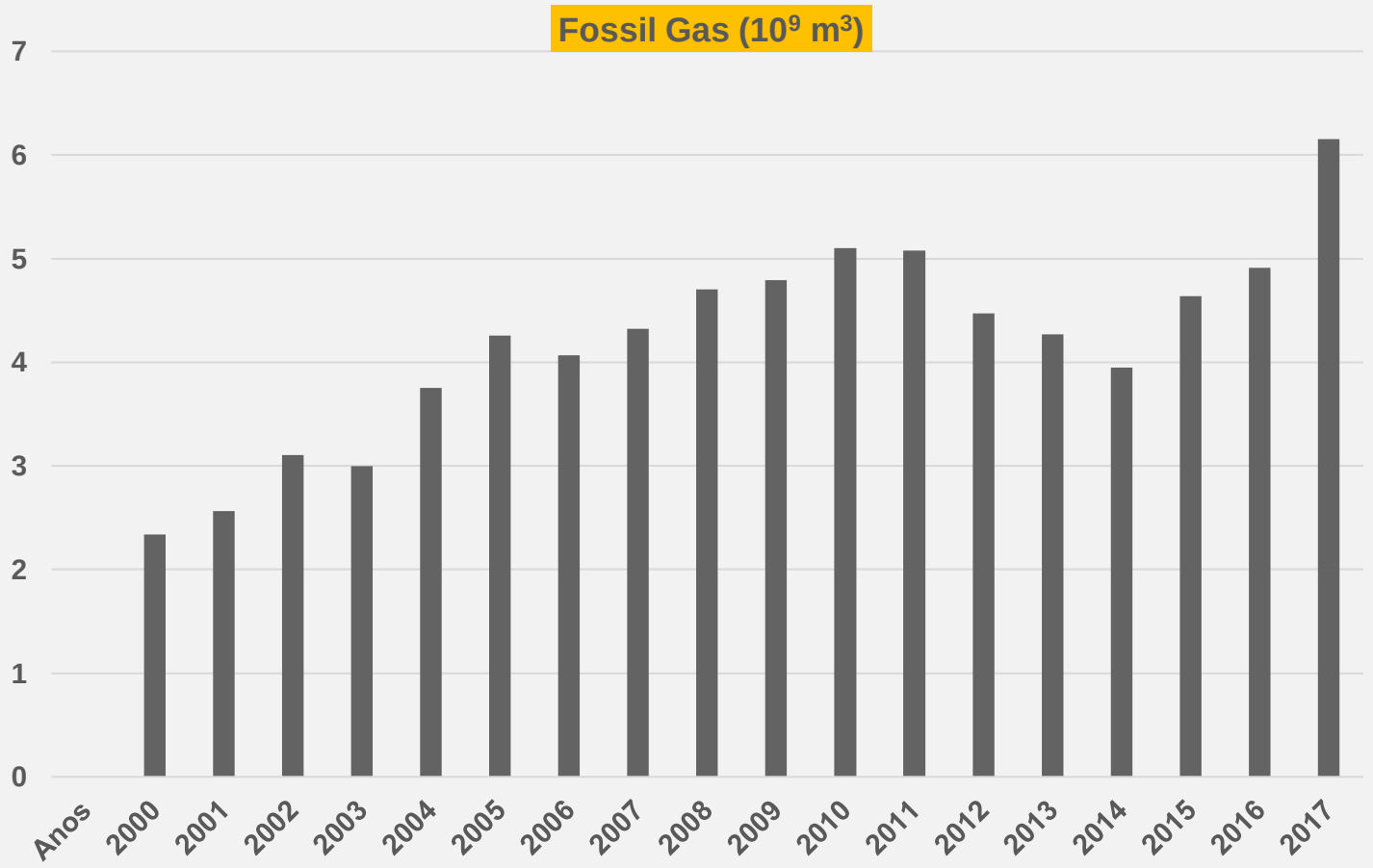
(Interlude) What about so-called "natural" Gas?



Evolution of **total consumption in Portugal (2000-2017)**, in thousands of million (10^9) of cubic meters (m^3);

Pordata, https://www.pordata.pt/DB/Portugal/Ambiente+de+Consulta/Tabela

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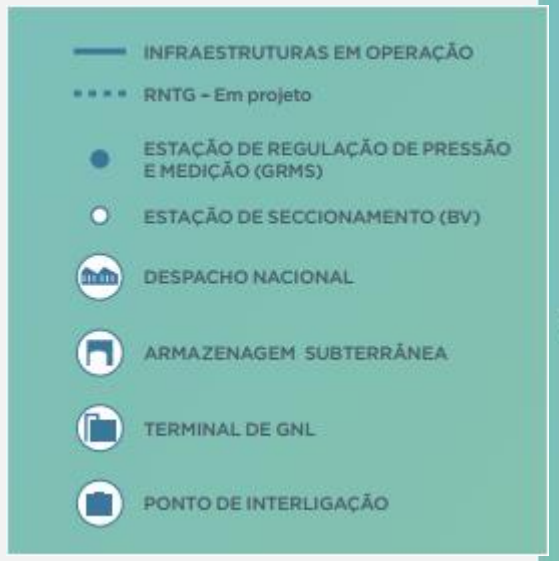
Where does the gas come from?



- **North-east portion not built**; Spain and France firmly oppose it!

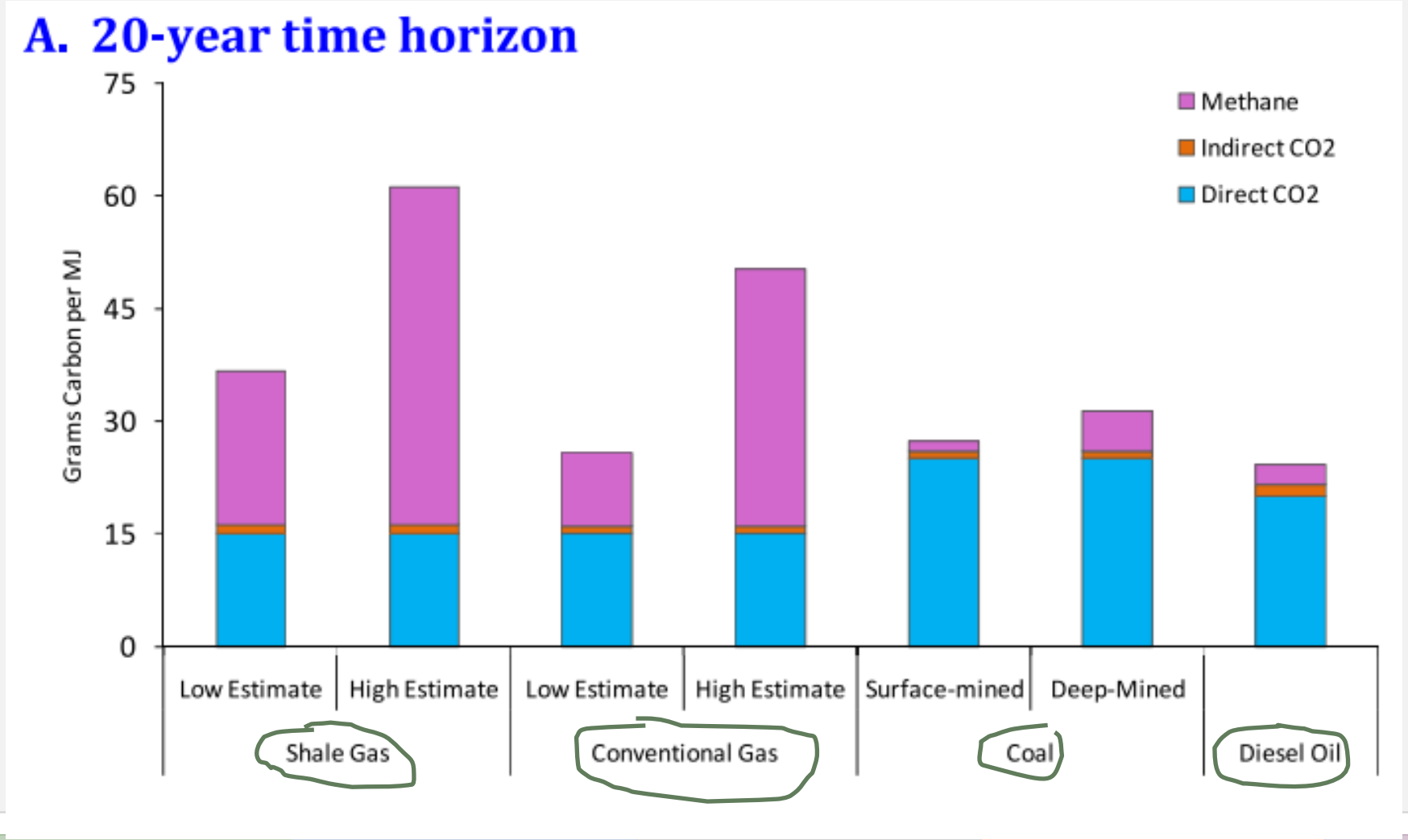
- **1375km pipeline, along 2 main axis:**

- **Maghreb-Europe pipeline**, portuguese segment since 1997, gas flows from Argelia through Morocco and Spain; (East-West)

- **Sines LNG terminal**, South-North, since 2003

But isn't "natural" gas supposed to be cleaner than oil and coal?!

But isn't "natural" gas supposed to be cleaner than oil and coal?!



Well… not if we look at the WHOLE pcture!

[20]

Liquified Natural Gas (LNG)

- The gas is **cooled to around -160ºC**, becomes liquid;

- Liquifying process is already very **energy-intensive** (**~20.000 tones CO2eq** per standard vessel volume, 150.000 m3);

- Then transported by ship, around the world; Due to very low temperature, **gas can be lost at a rate of 0.1-0.25%** per day (“boil-off”);

- Carbon foot print of LNG in a single ship can be **100.000 to 440.000 tones of CO2eq**!!!! (before final combustion…) – **average yearly CO2eq emission is 6-7 tonnes per capita, in Portugal**

LNG carbon footprint (before combustion)

Port of origin	Voyage	Conventional extraction		Non-conventional	
		Min	Max	Min	Max
Ras Laffan (Qatar)	14d 3h	113	338	213	438
Skikda (Algéria)	2d 13h	111	336	211	436
Bonny Island (Nigéria)	11d 15h	113	337	213	437
St. Arthur, Texas (EUA)	11d 15h	113	338	213	438

- Assuming a **vessel containi… 150.000 m³ of LNG, headed to Barcelona**;
- **GHG emissions given in CO2eq (thousands of tones)**; including **extraction, transportation, liquifying and shipping** (but ***not*** **final combustion**);
- (liquifying process alone is **~20.000 tones CO2eq**);
- (Adapted from A. Pérez, 2018, “Global Gas Lock-in: Bridge to Nowhere”, Rosa Luxemburg Stiftung; page 76)

- **Domestic emissions from combustion** (after shipping)? Assuming **average factor of 2kg CO2eq/m3** (Chicago Climate Exchange) it is: 150.000*600*2 = **180 thousand tones of CO2eq** (less than half of worst-case scenario!!!!)

3 – Discussion and Conclusions

- **<u>Climate change is arguably the greatest threat Humanity has ever faced</u>; GHG emissions' reduction must now be carried out in a very short time-frame.**

- **The energy sector is responsible for most of the emissions, which means that energy systems modelling** becomes an even more critical tool for **policy advice** and industrial planning;

- However, **modelling results also tend to become "self-fulfilling prophecies"**, as pointed out by several authors (e.g., Trutnevyte, 2014; Carrington & Stephenson, 2018; Muttitt et al., 2018);

- For example, **"business-as-usual" scenarios are often interpreted** as "**this is what is most likely to happen**", instead of the correct interpretation: "**if nothing else changes**, and under *certain assumptions*, this is what can reasonably be expected to happen";

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3 – Discussion and Conclusions II

- In the case of the IEA we find some **systematic biases, towards larger shares of fossil fuel consumption and underestimation of renewable energy implementation**;

- In **a time of systemic change and transitions**, energy systems modelling (and all of scientific endeavour?) needs to be able to think (and imagine) **"out-of-the-box"**;

- Dare to consider **"radical" scenarios, such as zero GDP growth, or even degrowth** (e.g., Tim Jackson, "Prosperity without growth", 2009, and others);

- Take into account **social movements** (Youth Climate Strikes, Extinction Rebelion, etc.) **and push for accelerated decarbonization** and fossil fuel divestment; Energy transition is inevitable in the *long term* **but speed matters a lot!!! And time is short!!!**

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"It is very hard to make predictions… specially about the future!"

- Niels Bohr

THANK YOU!

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