Sustainability in ATLAS

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Sustainability in ATLAS

- ATLAS management
  - Top-down
  - “official” efforts
  - Whatever requires executive decisions (e.g. exchanging gas mixtures, switching off resources)

- ATLAS Sustainability forum
  - Initiated in 2020 as a grassroot initiative
  - A few irregular meetings
  - Since this year: regular (once a month)

- The collaboration members: personal decisions
- The member universities/institutes → overlapping efforts
- Overarching initiatives: ECFA, Snowmass, ….

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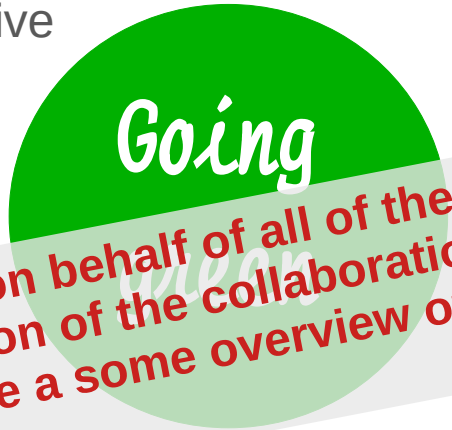

Disclaimer: Can not speak on behalf of all of these people and certain numbers are at the discretion of the collaboration
But I will try my best to give a some overview of ATLAS’ plans and discussions

- The collaboration members: personal decisions
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Sustainability Forum in ATLAS

- Purpose of the ATLAS sustainability Forum: Input of the members
- Open forum for every interested colleague
  → bring your ideas or worries
- Exchange ideas & collect information specific to ATLAS
- Identify and incorporate mitigation or adaptation techniques specific to ATLAS
  → (remote work, gases, efficient computing, etc…)
- Cooperate with similar initiatives in other experiments (at LHC/CERN or elsewhere)
  → Will be interesting to hear what CMS' approach is
  → Idea is to have data/plans before liaising and getting official support
- Raise awareness for sustainability subjects within our collaboration
- Initiate a carbon assessment of ATLAS (with/for CERN-HSE-ENV, funding agencies, etc…)
-

Why does sustainability matters (in ATLAS)

- **Collaboration:** several members are interested in being more sustainable
  → e.g. former deputy spokesperson, now DESY HEP director founded a working group dedicated to evaluating/improving the sustainability in HEP

- **Legal:** e.g. German scientists self-committed to be CO2e neutral by 2035 & many countries demand to reach the Paris agreement

- **Funding:** will (likely) be tied to sustainability in the future
  → “A detailed plan for the minimisation of environmental impact and for the saving and re-use of energy should be part of the approval process for any major project.” (European Strategy for HEP 2020, Ch. 7, Paragraph A; example: LHCb phase-II upgrade TDR)

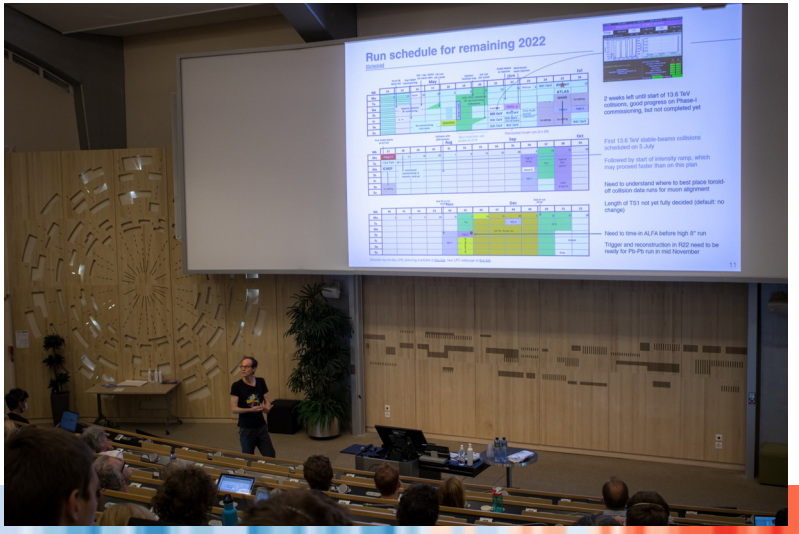
- **Outreach:** we may want to tell the world in the future how sustainable we are and how we got there

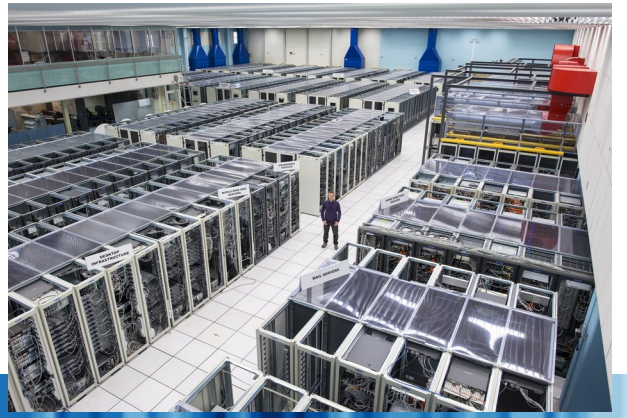
- **Society:**
  we have extraordinary many smart minds around
  we can help pioneering ideas and be a role model for society and companies
  who if not scientist will start paving the way?

ATLAS footprint (the rough version)

- Construction
- Operation (LHC)
- **Operation (detector)**
- **Data analysis / computing**
- **Commuting**
- **Travelling**
- **Conferences**
- Offices

***green = here we have the power to improve (i.e. direct influence)**





ATLAS footprint (the rough version)

- Some information can be found in CERN environmental report https://e-publishing.cern.ch/index.php/CERN_Environment_Report/issue/view/141

- Main drivers: gaseous detectors, cooling
  → Emit highly efficient greenhouse gases (e.g. C2H2F4)

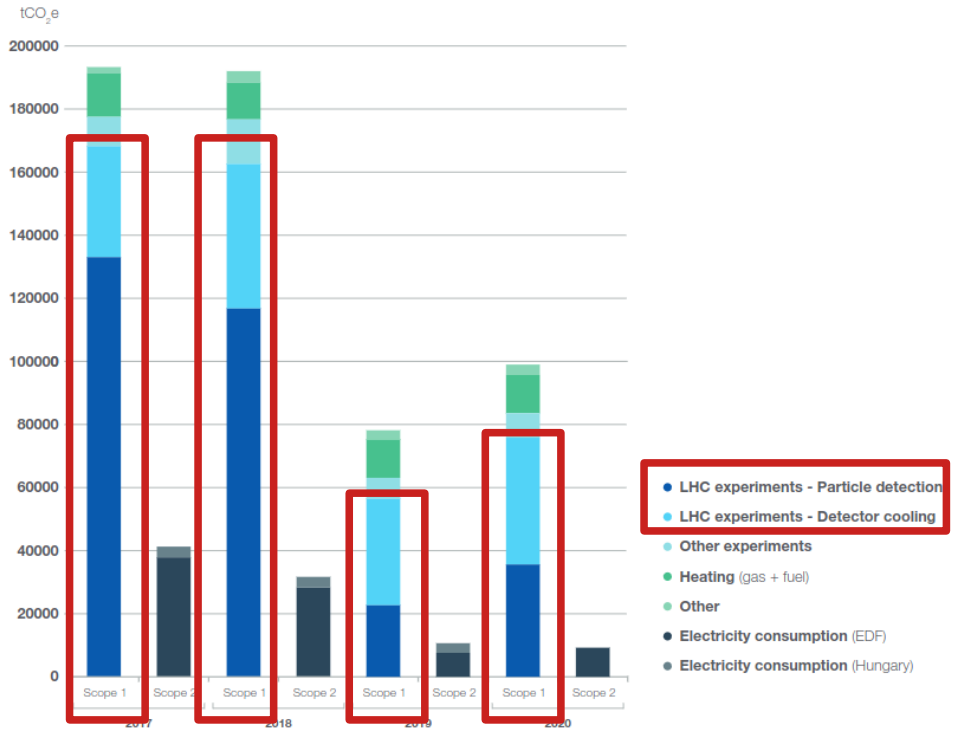
- Disclaimer: Computing here is not complete (only CERN)

- But we can get some idea:

  Gases are dominant part

  (though that does not mean computing and travel are negligible!)

  could be up to a quarter or third

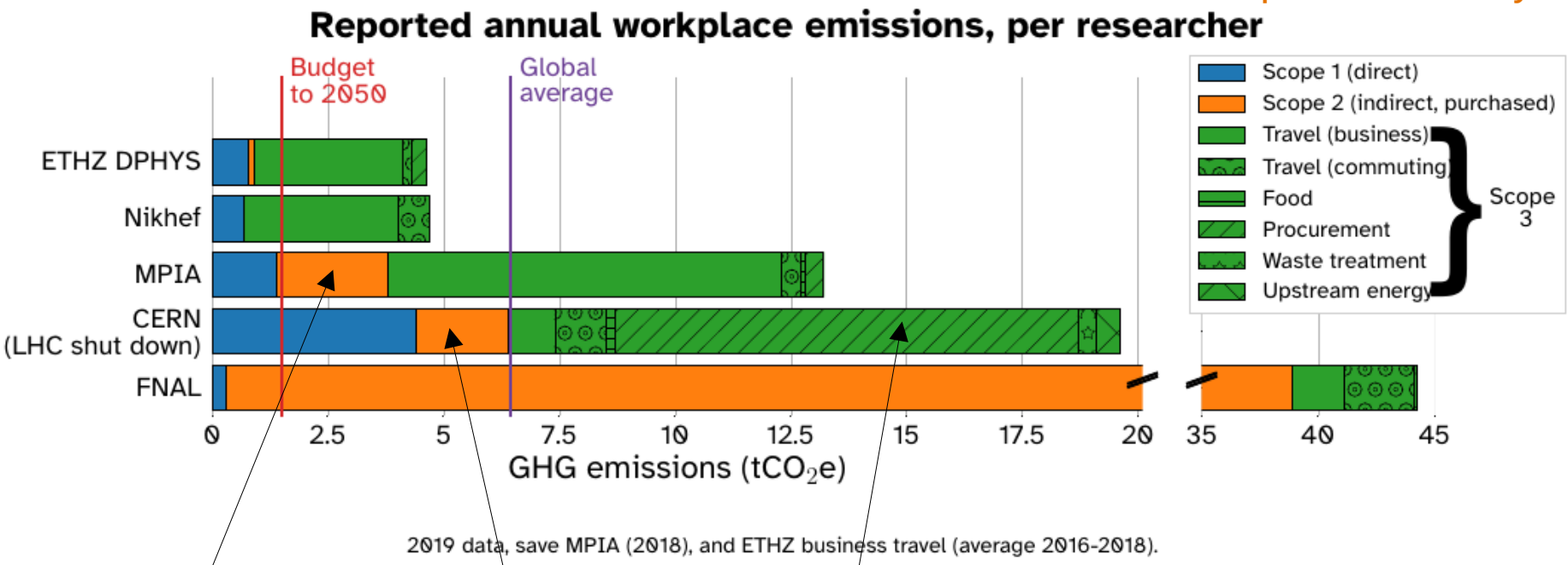


Not the “legal” thing:
ATLAS (as opposed to CERN) spans several countries, so there is double counting in this accounting

General workplace emissions

- **Workplace emissions in Physics / HECAP+**

Scope 1: gases
Scope 2: electricity



Max-Planck Institute for Astronomy:
88% of electricity is computing

CERN:
1/3 is data centre in Hungary

CERN:
some hardware procurement

- **Current estimate:**
  >10^6 tCO2e in total
  → ~1000 tCO2e / paper
  → 0.3 tCO2e / paper / author
- **Compare to e.g. astronomy with**
  → 0-200 tCO2e / paper,
  → 0-20 tCO2e / paper / author
  arXiv:2201.08748

Working groups (within forum)

- Have setup voluntary working groups to discuss and evaluate emissions (+ some other projects)
- Detectors
- Computing
- Travel
- Infrastructure
- Note: his is not an official ATLAS activity and that people are doing this out of their “free” time, so please be respectful of this!
- It’s ok if some WG or parts of WG go slower than others…

Activities so far: Detectors

- 1) Concentrating on understanding gas emissions

  → https://indico.cern.ch/event/1022051/contributions/4325945/attachments/2231022/3780366/CMS_ATLAS_talk_22_4_21.pdf

  → How can one get accurate data ?

  → main source of GHG gases are leaks (+ replenishing rate) in muon system RPCs (current possible solutions: fixing leaks, exchanging gases for sth greener)

- 2) Active advertisement and recruitment of volunteers to fix leaks during next technical stop

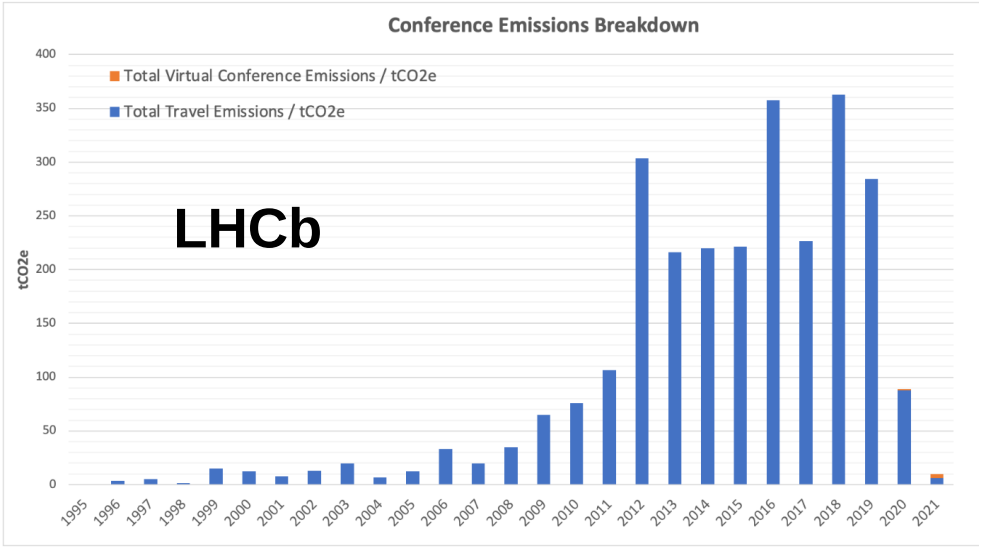
  → extending beyond institutes/people anyhow already associated with RPCs (fix rate is limited by person power!)

  → OTP etc. granted, recruitment drive supported by management

  → Forum (Ben Bruers!) very active in supporting RPC team to deliver training, find people etc.
  (do not underestimate what a bit of organisation/advertisement can do!)

Activities so far: Travel

- Establish pipeline to (semi-)automatically evaluate travel footprint for ATLAS
- Travel is part of scope 3 carbon footprint and often plays a big role (see e.g. ETH Zurich)
- Start with workshop travel
  → Relatively easy to evaluate and contained



https://cds.cern.ch/record/2776420/files/LHCB-TDR-023.pdf

- Further idea would be to extend, e.g. include other commuting, smaller workshops

- First test case is current ATLAS week in Vancouver
  → use participant list versus self-report survey (understand biases occurring when using affiliation which might be different from travel starting point, e.g. CERN-based staff)

Activities so far: Travel

- Have some pipeline setup" – i.e. code ~ready:

  → scrape published participant list from web page – works well with caveats below

  → Automatically run on multiple external ATLAS weeks between a date range inside indico category, location is automatically extracted

  → Calculate distance from meeting location (standard python library)

  → Apply distance-based assumption on gCO2e/km/person for travel undertaken (using reasonable assumptions)

- Convert **institute affiliations** into country and city – WIP

  → Problem are "not-a-place" institutes, e.g. TRIUMF

  → to automate: use some tricks, pre-knowledge of ATLAS institutes (and preparing manual conversion where affiliation seemingly > 20km away from known institute)

  → Hopefully valid for mid-long-term (since pre-coded in indico profile)

  → Will provide instructions on how to setup travel info in indico registration for future

Activities so far: Computing

- Emissions from Computing will include:
  1. Grid processing for anything ATLAS related
  2. Tier 3 farms: need survey to groups
  3. Personal computers/ipad/phones for ATLAS work related

Activities so far: Computing

1. Grid processing for anything ATLAS related

$$n\_cores \times core\_power\_consumption \times \int_{starttime}^{endtime} emission\_intensity(t)dt$$

How power hungry the HW is

How CO2 intense the local power is

- Generally it is feasible to extract these numbers
- Could be reported / integrated

Activities so far: Computing - Tier-3 survey

- **S&C already planning a survey which will include:**
  - Exact location of farm (so we can work out the carbon intensity)
  - Number of ATLAS users using this farm
  - Hardware used
    → Need to come up with list to help answer this (disks, CPUs, GPUs, switches, etc.)
  - At what frequency do you typically replace your hardware
  - Is your Tier 3 farm part of a Tier 2 farm?
  - Fraction of time farm used for ATLAS related jobs

- **Might be able to add to this survey:**
  - Do you monitor your Co2 usage? (→ this includes cooling!)
  - If yes: would you be willing to share your numbers with the Forum on a yearly basis?
  - If no: are you interested in getting advice on how to monitor it?
  - Are you interested in getting advice and best practice tips on how to reduce your emissions?
  - Other questions?

Activities so far: Infrastructure

- Anything not included in the Detector, Computing, Travel Wgs!

- **Long answer:**
  1. LHC operations
  2. Construction of new buildings at CERN and at Users' locations mainly used by ATLAS activities (eg a computer centre, a fabrication lab for upgrade, etc.)
  3. Offices at CERN and at Users' locations mainly used by ATLAS
  4. Catering at CERN and at Users' locations used by ATLAS members

  Others?

- For CERN-based activities → use CERN HSE numbers (with some attribution)

- For user-location activities → surveys, extrapolations, ….

- Attribution based on Labos1.5* methodology?

*see next slides

Other activities of the Forum so far

- **Topical meetings around the themes of the Working groups**

- **Topical meetings on forum-related activities / initiatives**
  - Your DESY forum
  - Max-Planck activities
  - Sheffield university
  - Also: Labos1.5 project

- **Labos1.5 → general tool of french labs to do carbon accounting (https://labos1point5.org/)**

  - Targeted towards university / small labs

  - Recently started working on including effect of large labs (i.e. translating from CERN to e.g. ATLAS group in Grenoble)

  - Complementary problem to ATLAS evaluation: Assume to know the footprint of the local lab, but similar issues with regards to CERN-based ATLAS Co2.

  - To our last knowledge: weighting by authors

Conclusions

- **Started regular sustainability meetings (bottom-up)**

- **Plan is to evaluate footprint of ATLAS to have a starting value for (needed) reductions**
  - Tricky because of missing information from home institutions
  - Some double counting (i.e. it's counted for the university/country as well), but this is build in and not a problem → ATLAS spans many countries!

- **Initiated a broader advertisement of RPC leak fix programme**
  → can have real and direct impact!!

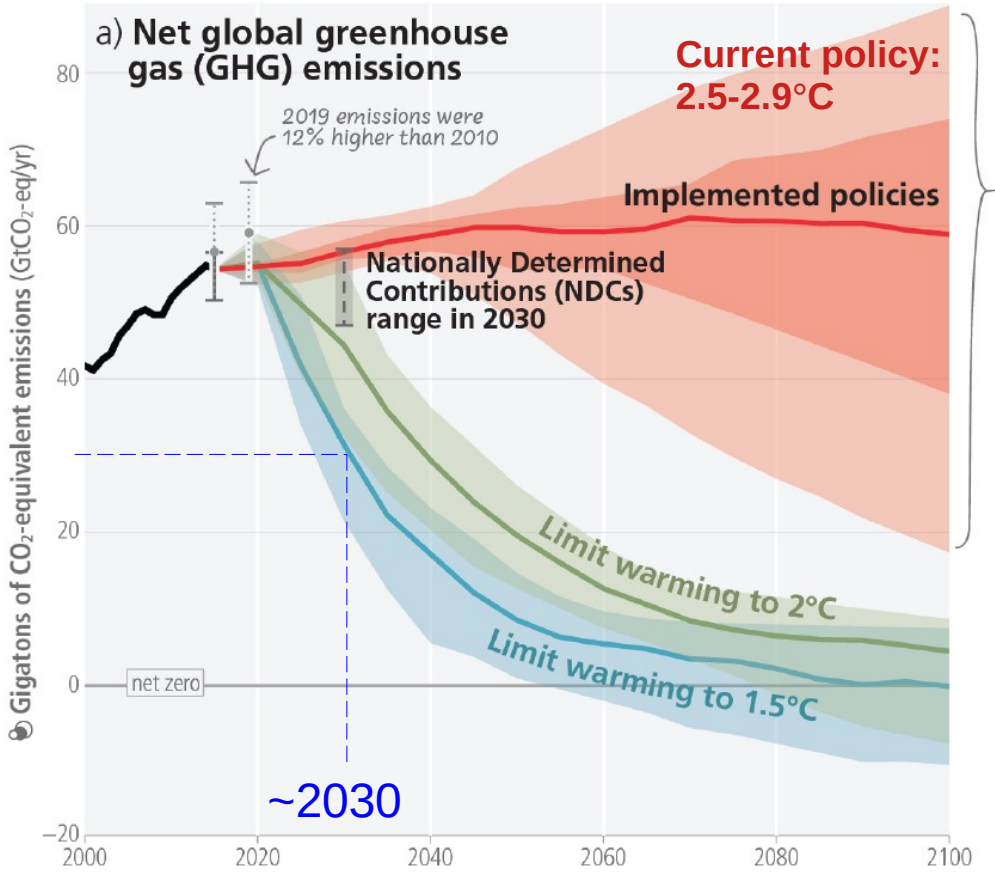
- **Management does support the initiative in principle**
  - Introductory talk at ATLAS week
  - Management themselves looking into gas replacements etc.

- **Eventually would like to collaborate with CMS/LHCb/Alice on that topic**

Backup

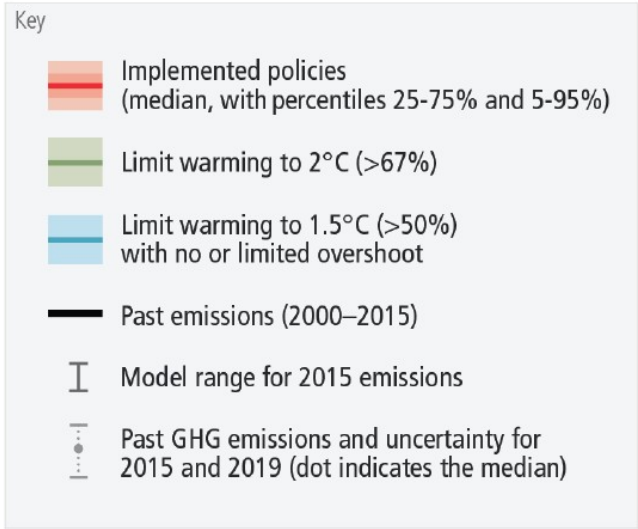
Translation of Paris into Goals

- **Reduction to zero emissions around 2100**
  → A lot of time?
  → 50% of the reduction should be achieved by ~2030 → **in 7 years**

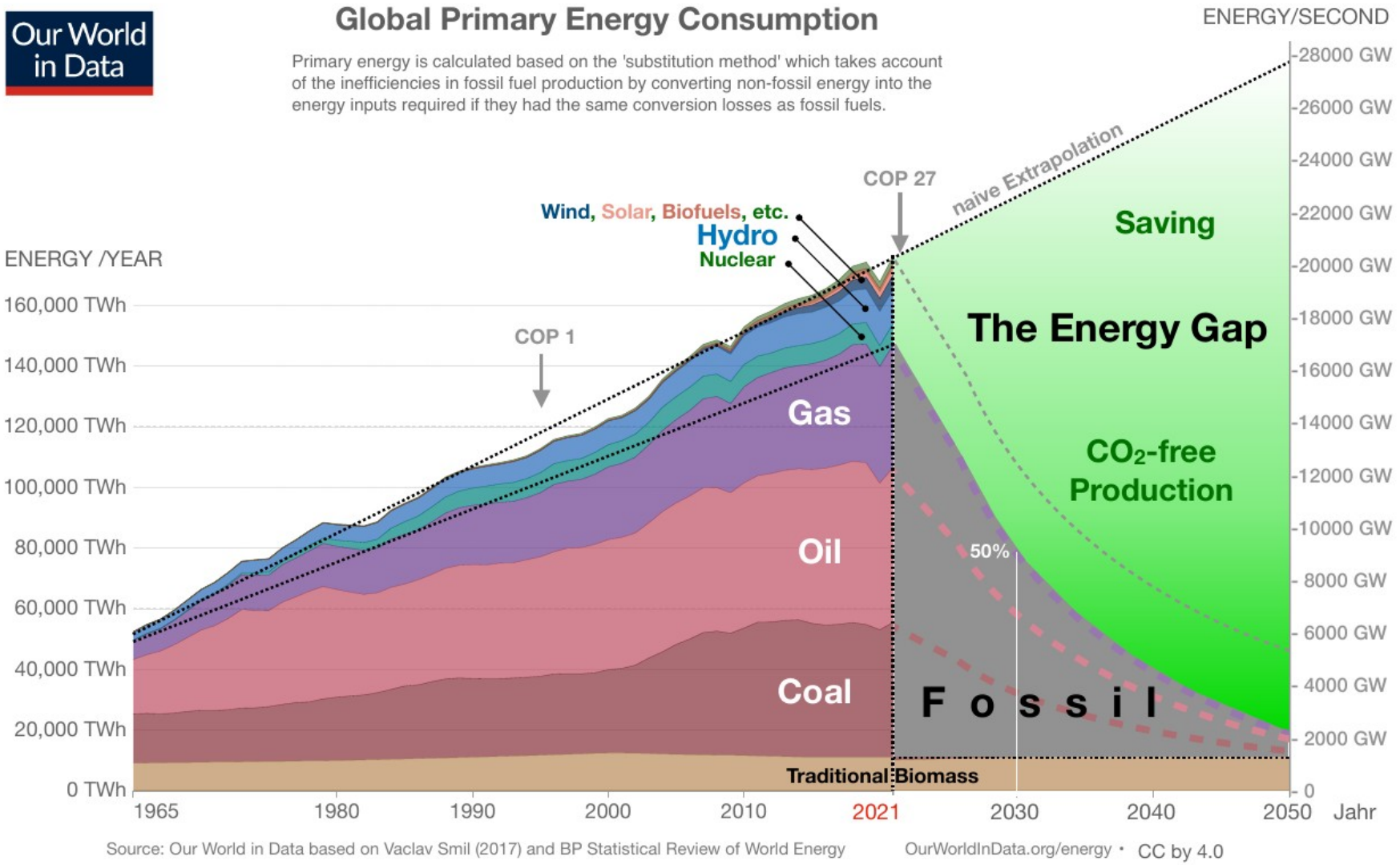


This is actually tough
(keep in mind that most developed countries should reduce faster/more to allow for human development!!)

Implemented policies result in projected emissions that lead to warming of 3.2°C, with a range of 2.2°C to 3.5°C (medium confidence)



The energy gap



The energy gap

Our World in Data

Global Primary Energy Consumption

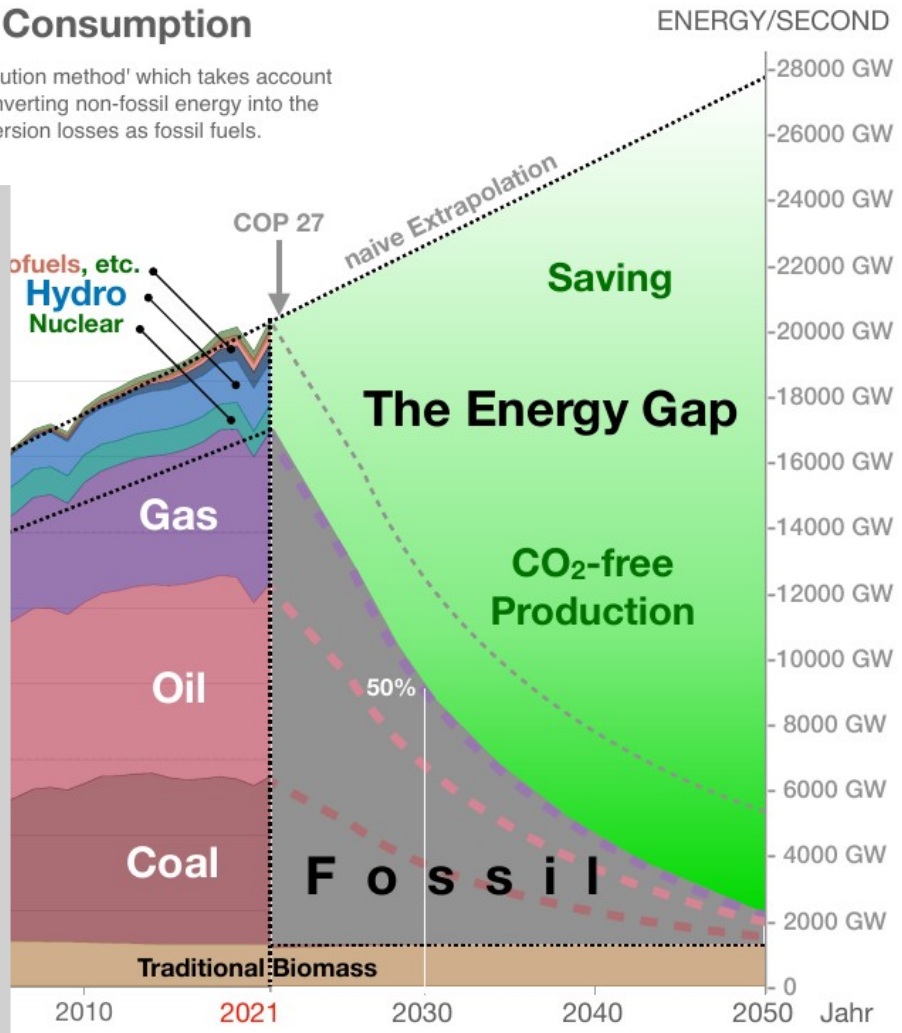
Primary energy is calculated based on the 'substitution method' which takes account of the inefficiencies in fossil fuel production by converting non-fossil energy into the energy inputs required if they had the same conversion losses as fossil fuels.

Options:

1) Expand CO2-free energies
→ factor ~12 in 7 years required;

2) Increase energy efficiency
→ factor ~2 in 7 years
e.g. Electrification of engines (factor 3-5 vs. combustion engine)
e.g. LEDs for lighting (factor 10 vs. light bulb)

3) Save energy
→ factor ~2 in 7 years
e.g.Less travel: online conferences, holidays nearby
e.g. Fewer consumer items, more repair options
e.g. Energy priority for essential things



Source: Our World in Data based on Vaclav Smil (2017) and BP Statistical Review of World Energy

OurWorldInData.org/energy · CC by 4.0