# The low-carbon transition: Challenges, status and possibilities

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Tomorrow

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# /whoami

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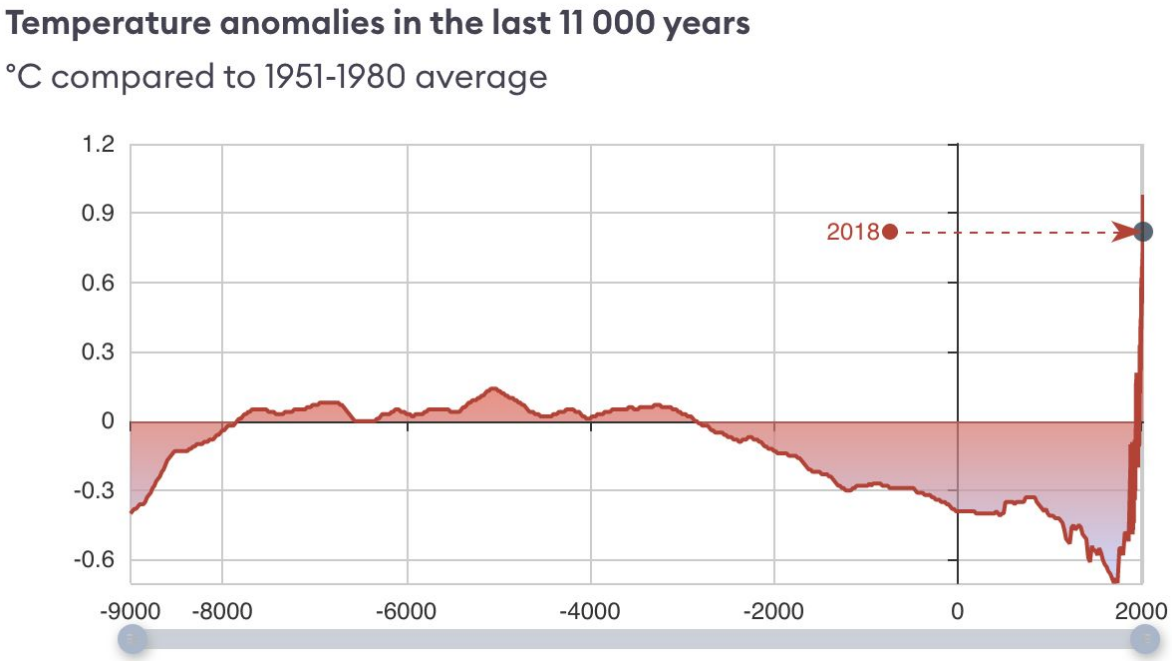
- MSc Mathematical Statistics @ DTU (Denmark)
- MSc Engineering @ Centrale Paris (France)
- IBM **Research** (Smart Grids)
- Google (Product Quality, Energy)
- VP Eng @ snips (AI startup, hired first 30+ employees)
- Founded Tomorrow in 2016

# The biggest challenge of our time

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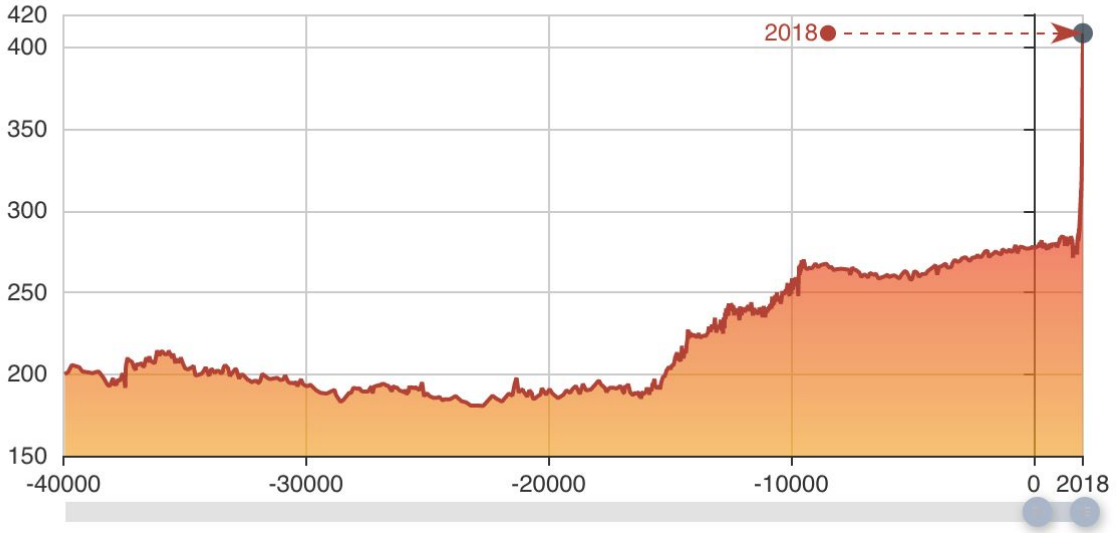
# The biggest challenge of our time

**Atmospheric CO2 concentration in the last 40 000 years**

in ppm (particles per million)

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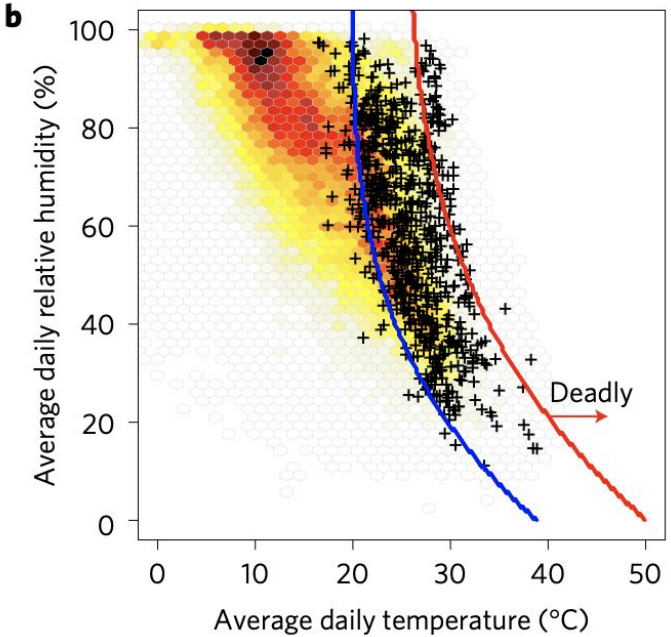
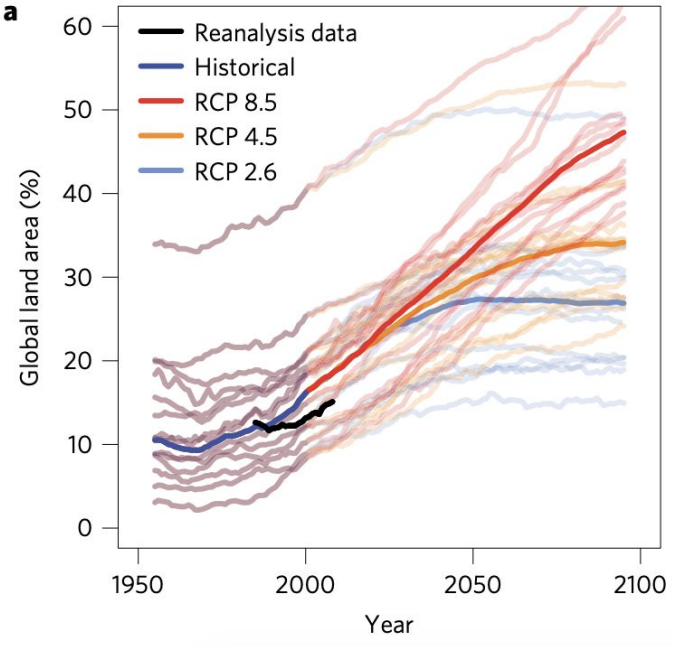
# Humans can’t survive in high temperature / humidity regions

Distribution of recent lethal heat events



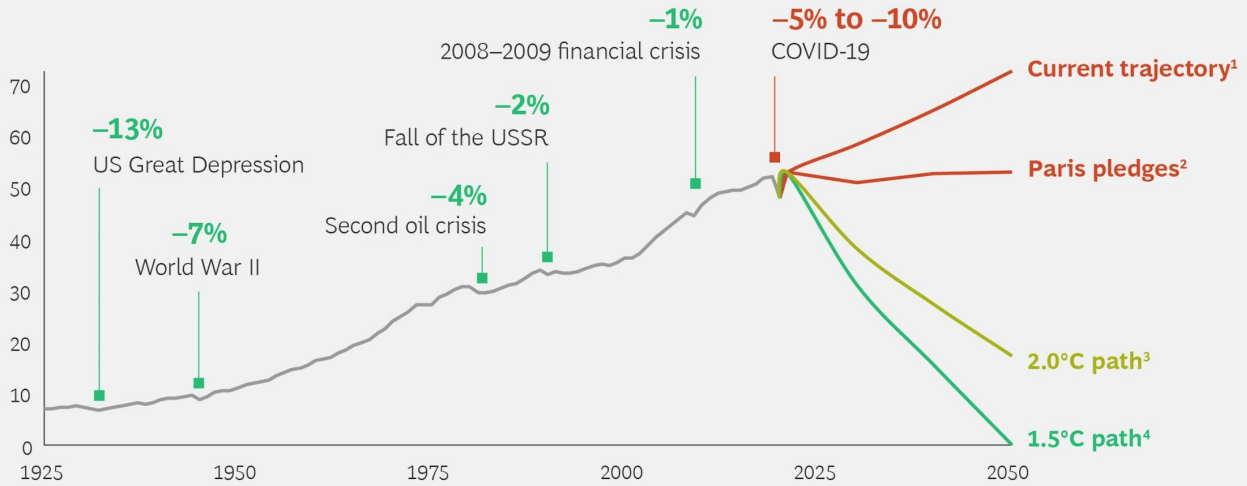

Exposition to extreme conditions for > 20 days a year



# 2°C = One covid a year

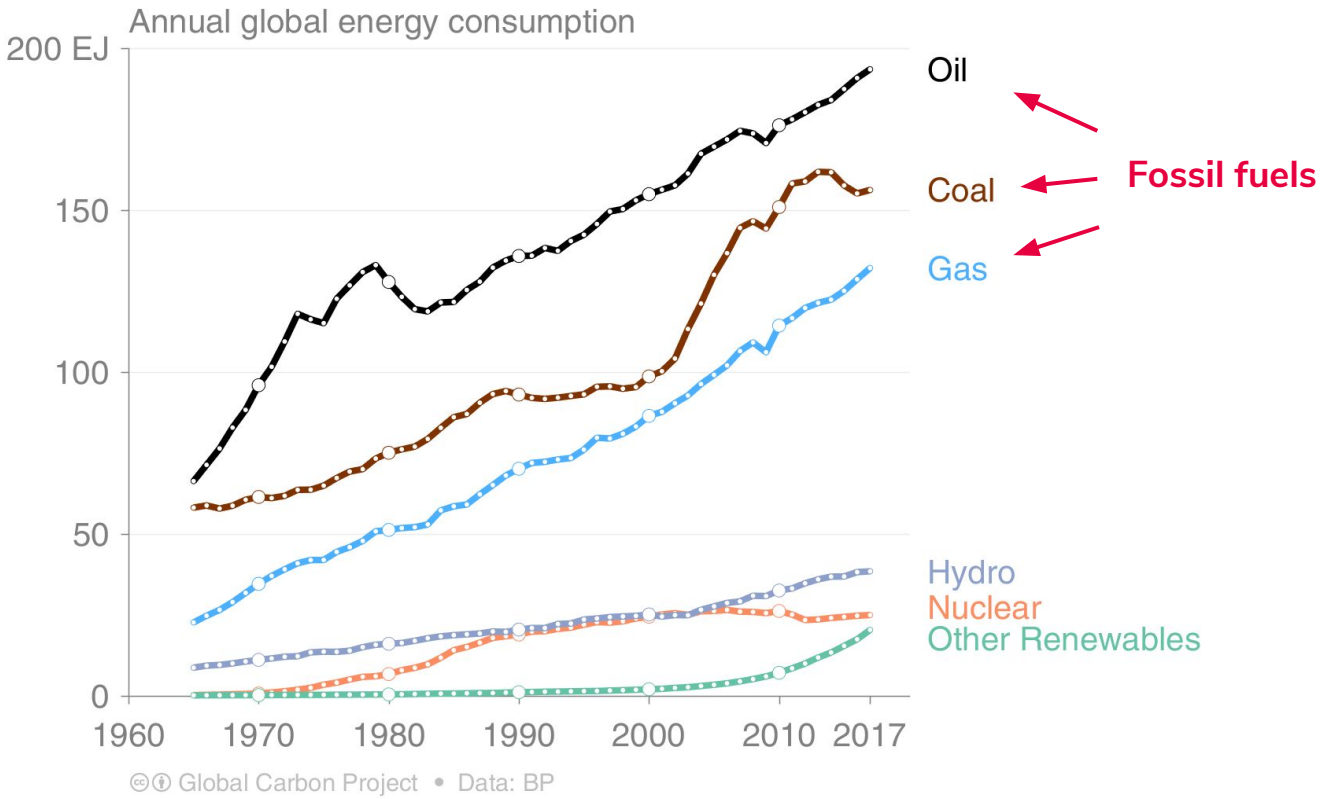
## Exhibit 1 | COVID-19 Has Triggered the Largest Emissions Drop Since World War II

Global annual greenhouse gas emissions (billion tons of $CO_2$ equivalent)




**Sources:** EDGARv5.0; Food and Agriculture Organization of the United Nations; PRIMAP-hist v2.1; Global Carbon Project; Intergovernmental Panel on Climate Change; United Nations Environment Programme "Emissions Gap Report 2019"; World Resources Institute; BCG analysis.
**Note:** These figures exclude land use, land use change, and forestry.
[1] Assumes that greenhouse gas emissions continue to grow at 1.1% per annum after 2018 (corresponding to the current policies scenario in United Nations Environment Programme "Emissions Gap Report 2019").
[2] Assumes that countries decarbonize in accordance with their intended nationally determined contributions (INDCs) by 2030 and then continue on the same emissions trajectory until 2050.
[3] Assumes 25% reduction by 2030 and net zero by 2070.
[4] Assumes 45% reduction by 2030 and net zero by 2050.

# We're addicted to fossil fuels



# The biggest opportunity of our time

- **Energy** is our ability to transform our environment. Some measure it as GDP 🙂

- **>80% of our energy** comes from fossil fuels

The global economy is entering the most profound transformation in history, as we need to **reinvent >80% of the way we do things**

# Watch out for the pitfalls

- **Rebound effect**: new technologies almost always induce more usage, thus more emissions

- We need to make sure we accurately measure and restrict **emissions associated to increased usage**.

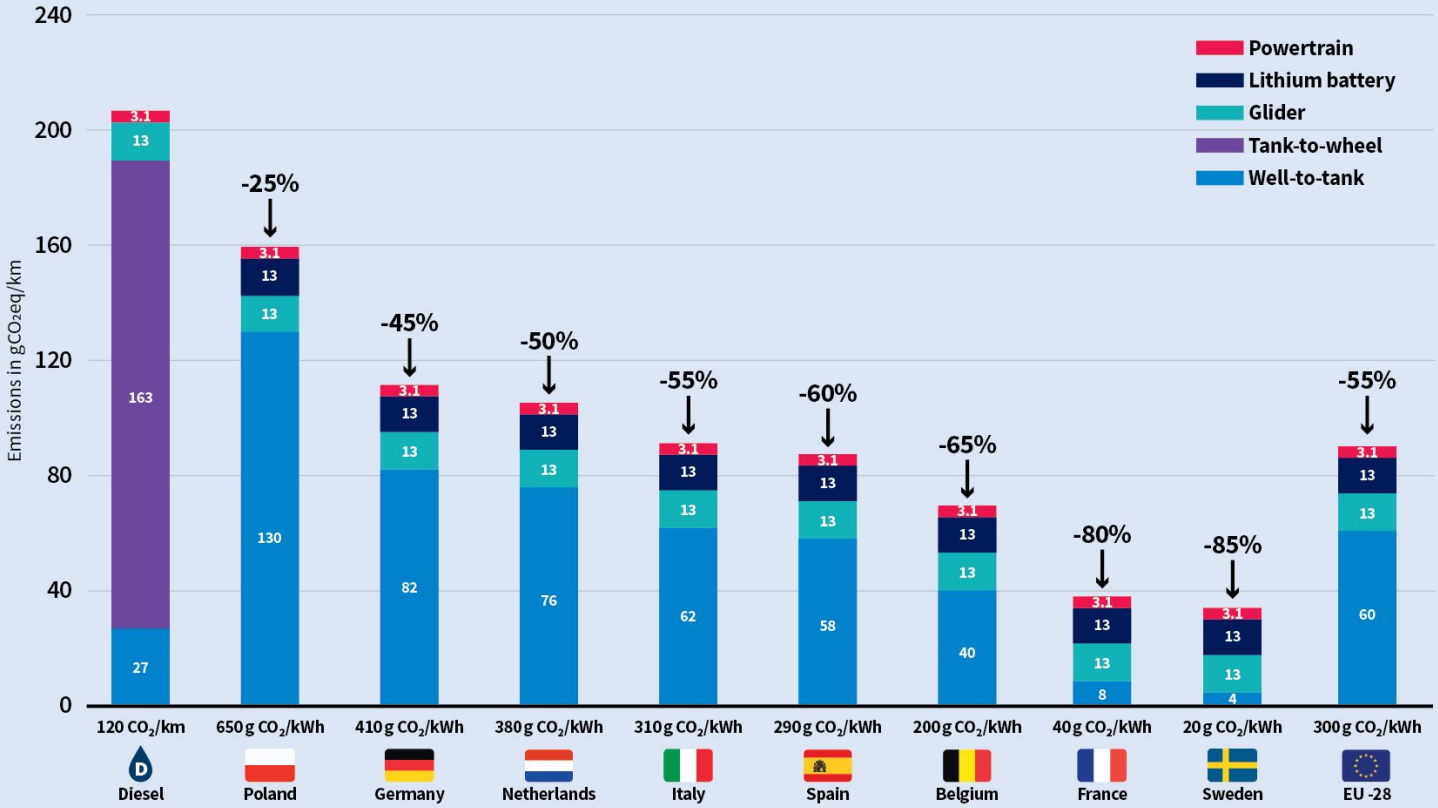
  Carbon accounting needs to be **ubiquitous**, standardised and enforced

“ the real danger is when companies and politicians are **making it look like real action is happening, when in fact, almost nothing is being done apart from clever accounting and creative PR** “

- Greta Thunberg, July 23rd 2019, Paris

# Zero Emission Vehicles

# Electric vehicles' climate impact in different energy mixes

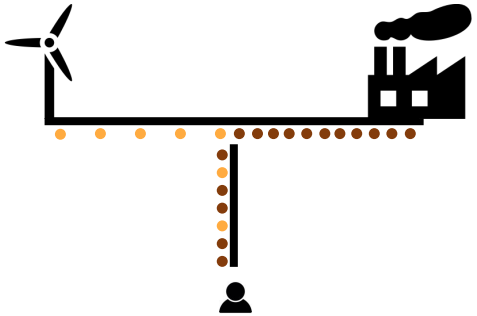





Source: Messagie, M. *Life Cycle Analysis of the Climate Impact of Electric Vehicles*, October 2017. VUB university, Brussels.

# Meaningfully measuring the climate impact of electricity use

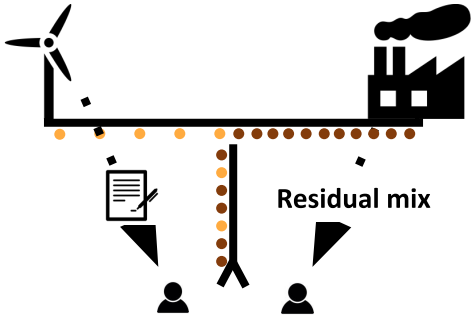
**Location-based** approach



33%
wind
**67% coal**

Using **average** carbon intensity

**Market-based** approach




**100%**
**wind**
0% coal

0% wind
**100%**
**coal**

Using "Guarantees of Origin" or RECs

**Challenges with having both:**

- 2 methodologies means **two consumers can claim the same greenness**
- Doesn't match up with **taxpayers' intuition**
- Granular GOs (hourly) **duplicates** the location-based method

Market-based is a **subsidy** system, not an **accounting** system.

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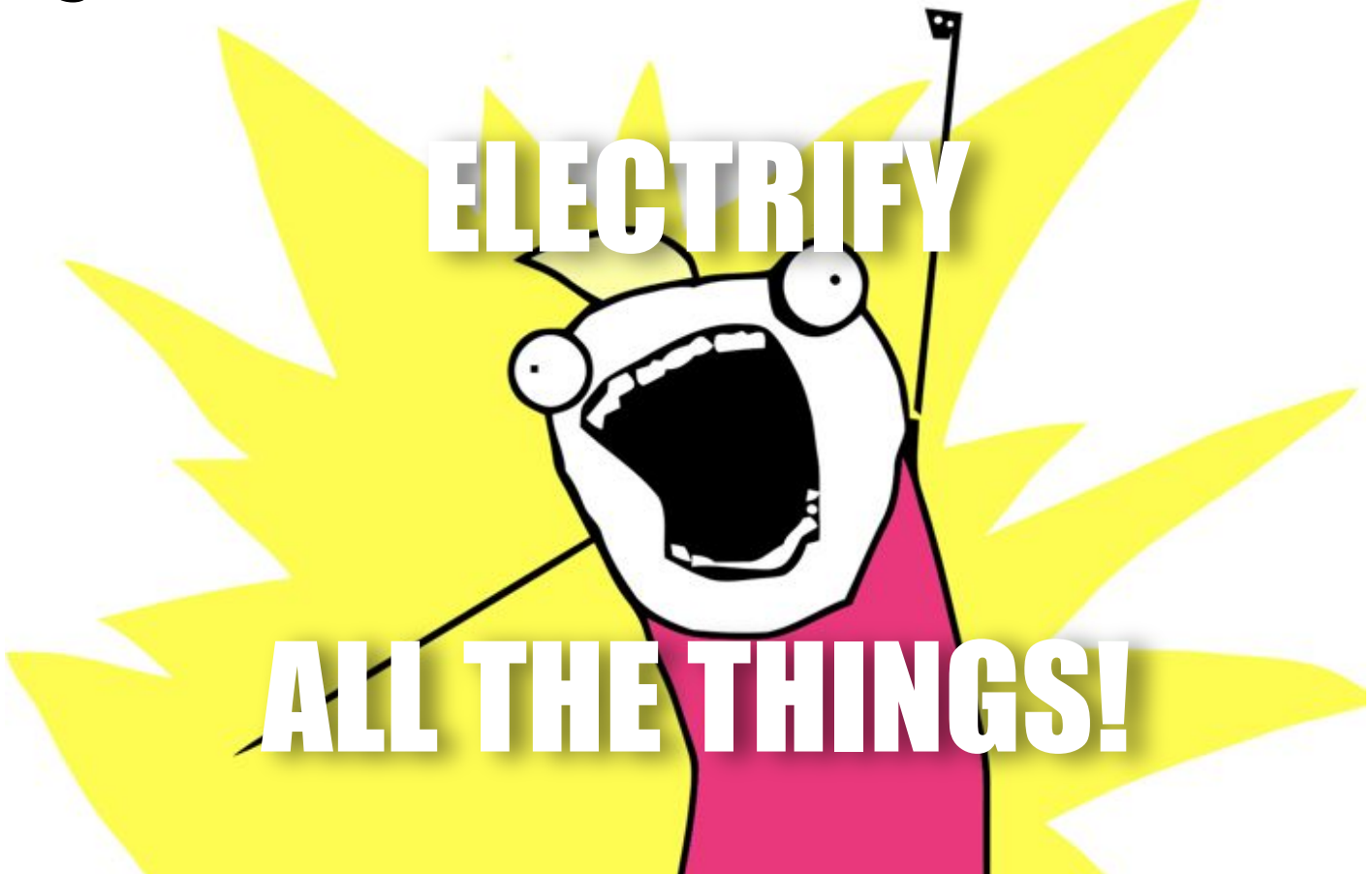
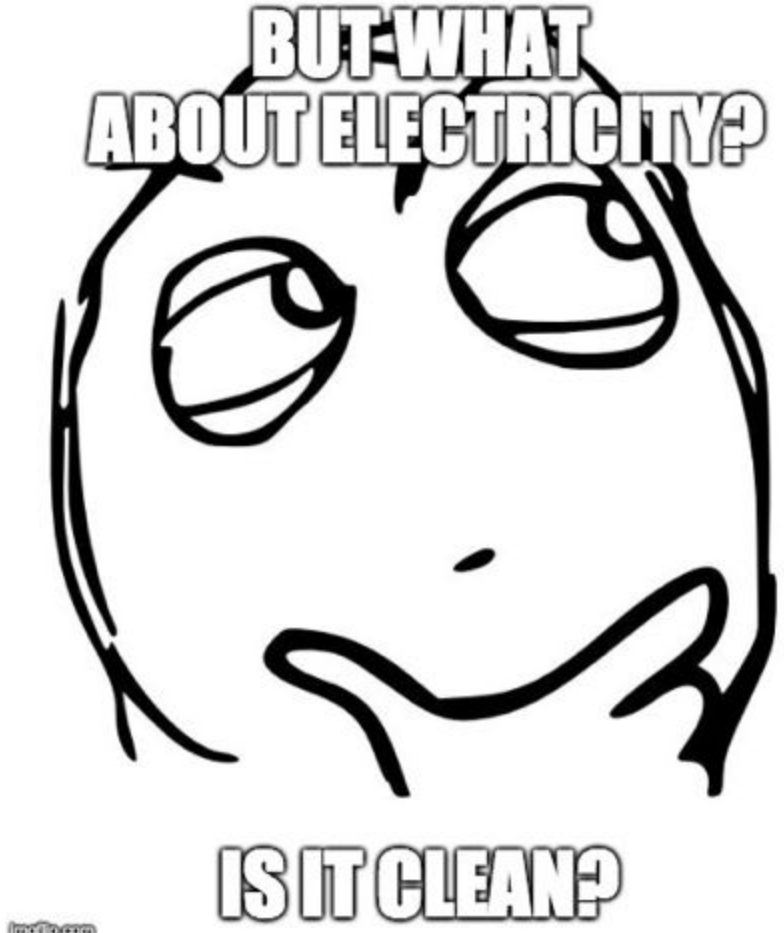
# Getting rid of fossil fuels..




BUT WHAT
ABOUT ELECTRICITY?
IS IT CLEAN?
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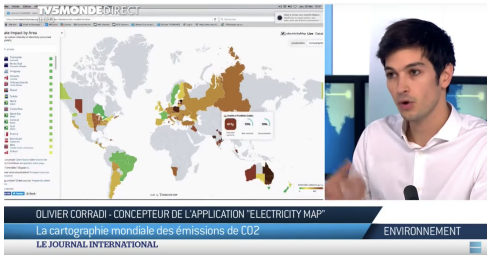
# In 2016, we built electricitymap.org

to map the world's electricity emissions, **in real-time**

- 5000 daily active users, 100% organic
- >1300 github contributions with >90 country integrations
- Used in TV debates, classrooms, universities, by policy makers..



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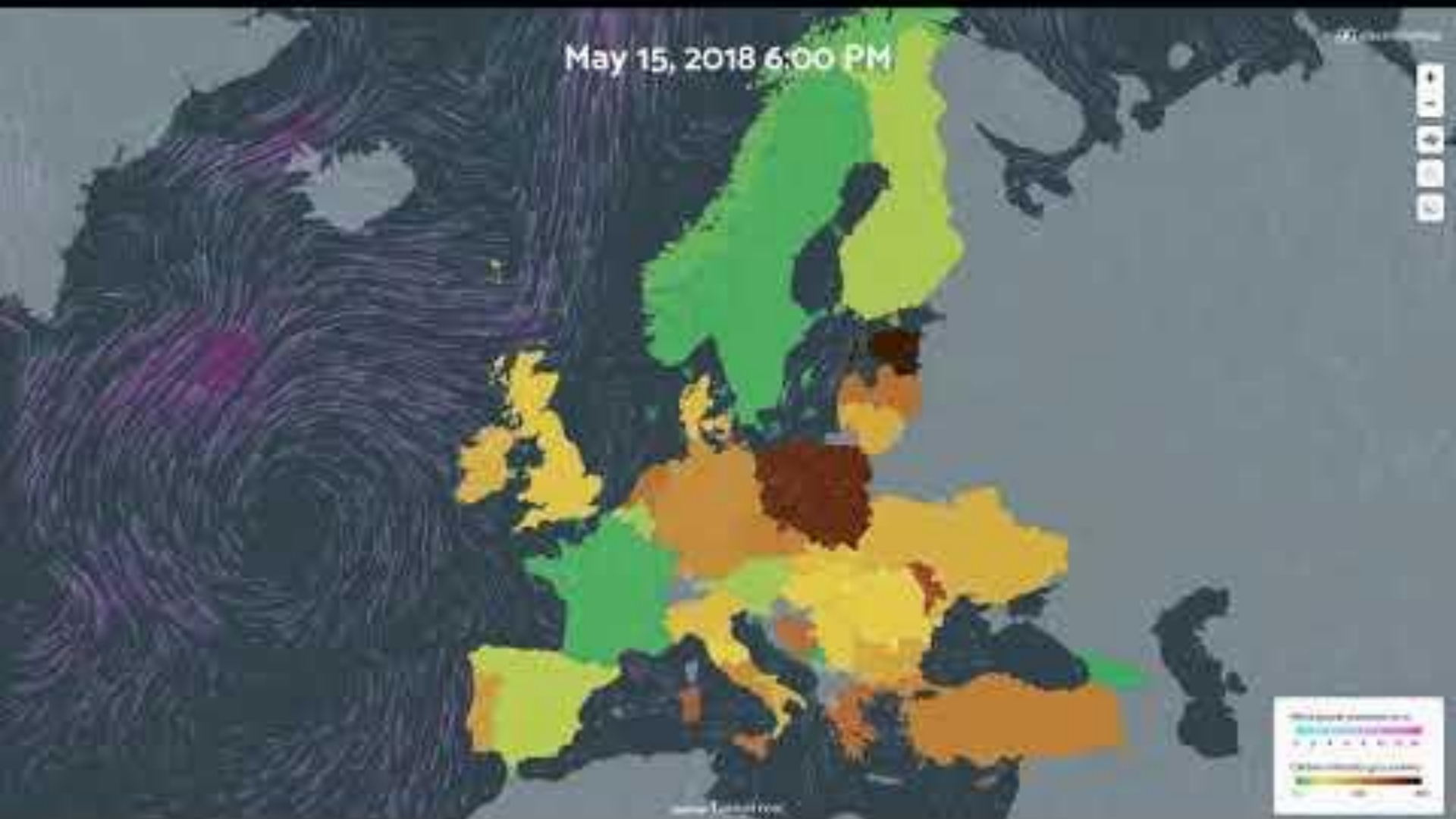

May 15, 2018 6:00 PM

# CITIES research: computing the marginal origin of electricity

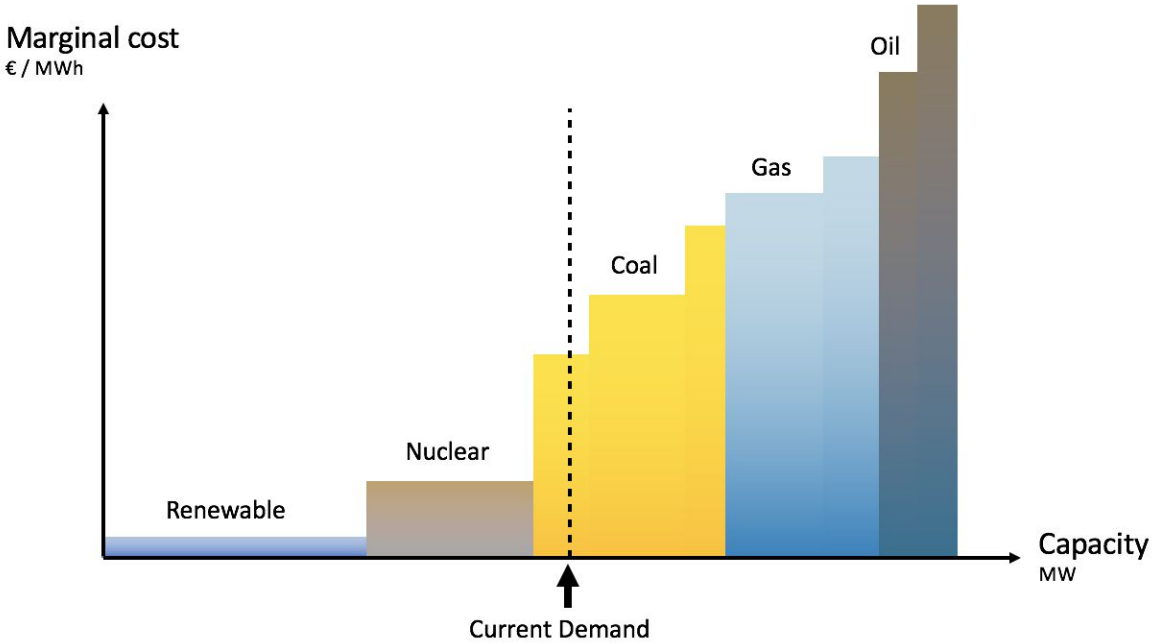
**Use case**: when I charge my EV, where does that electricity come from?

Power plants are dispatched by increasing cost

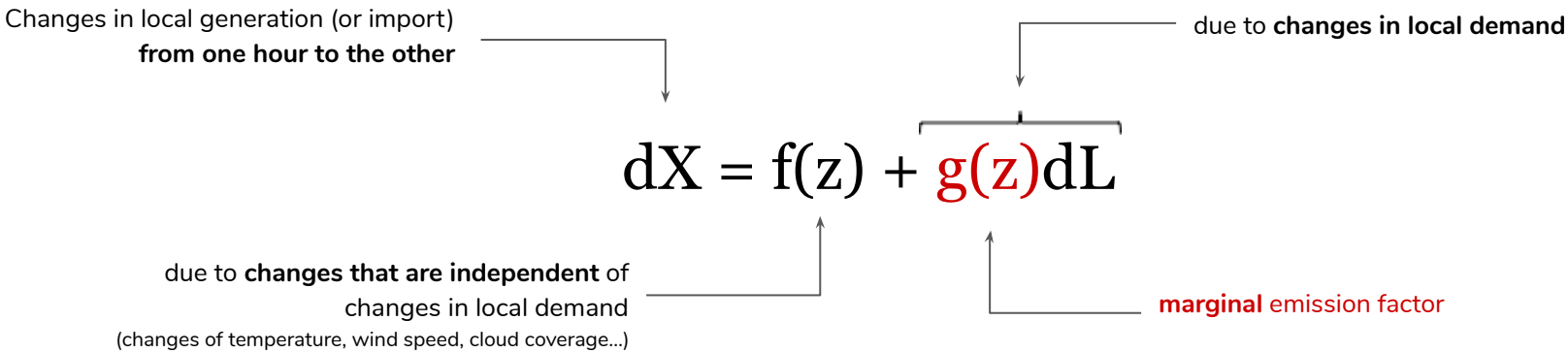
When electricity demand is increased, the first power plant to increase its production is cheapest that has spare capacity

We call that power plant the **marginal power plant**.

**Problem**: the dispatch order is **secret**



# Computing the *marginal* origin of electricity




1/ Create a **linear** model to reconstruct changes over time dX

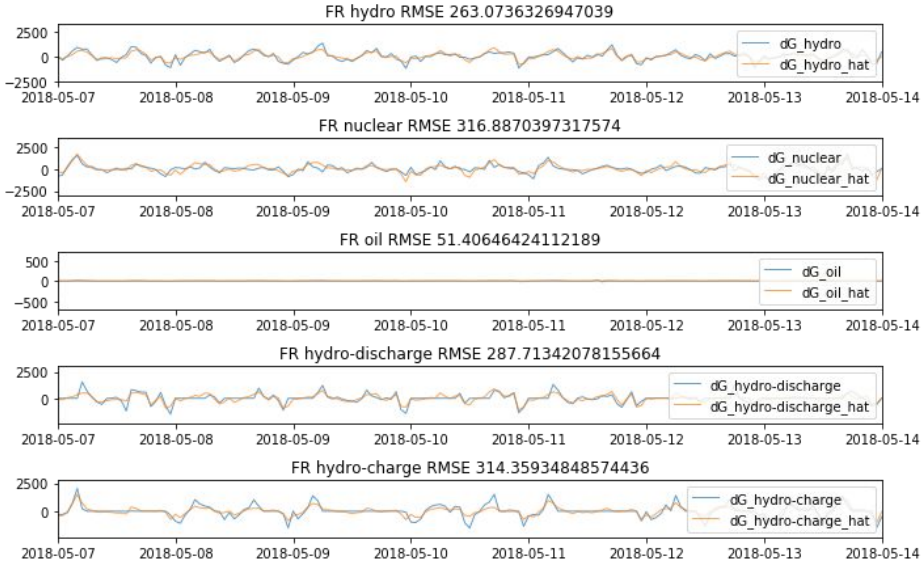
Use $\mathbf{Z}$ as a feature vector (wind speed in each area, market prices in each area, etc..).

2/ Fit for both changes of local generation and import/exports for each zone

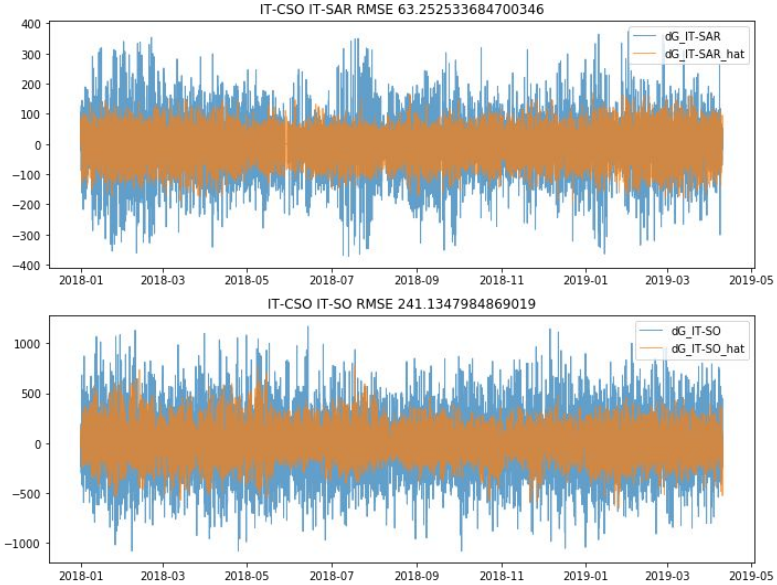
L1 regularization is used to select only the relevant features in $\mathbf{Z}$ (we have >500 features)

# Trying to reconstruct the past (examples)

## generation



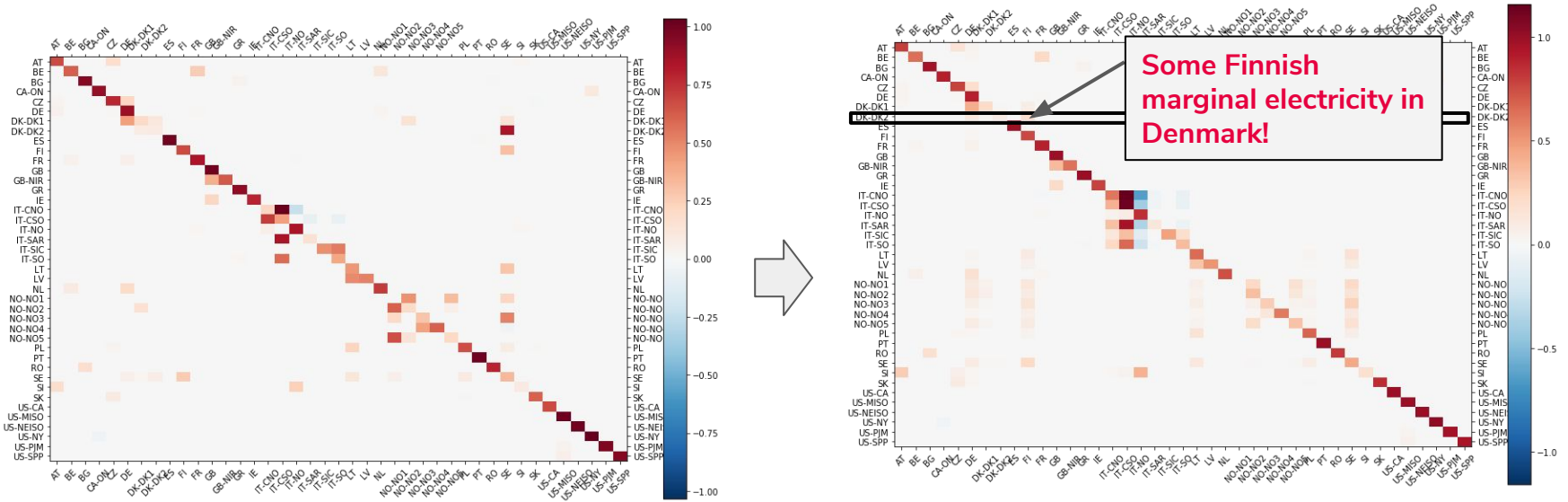

## interconnectors



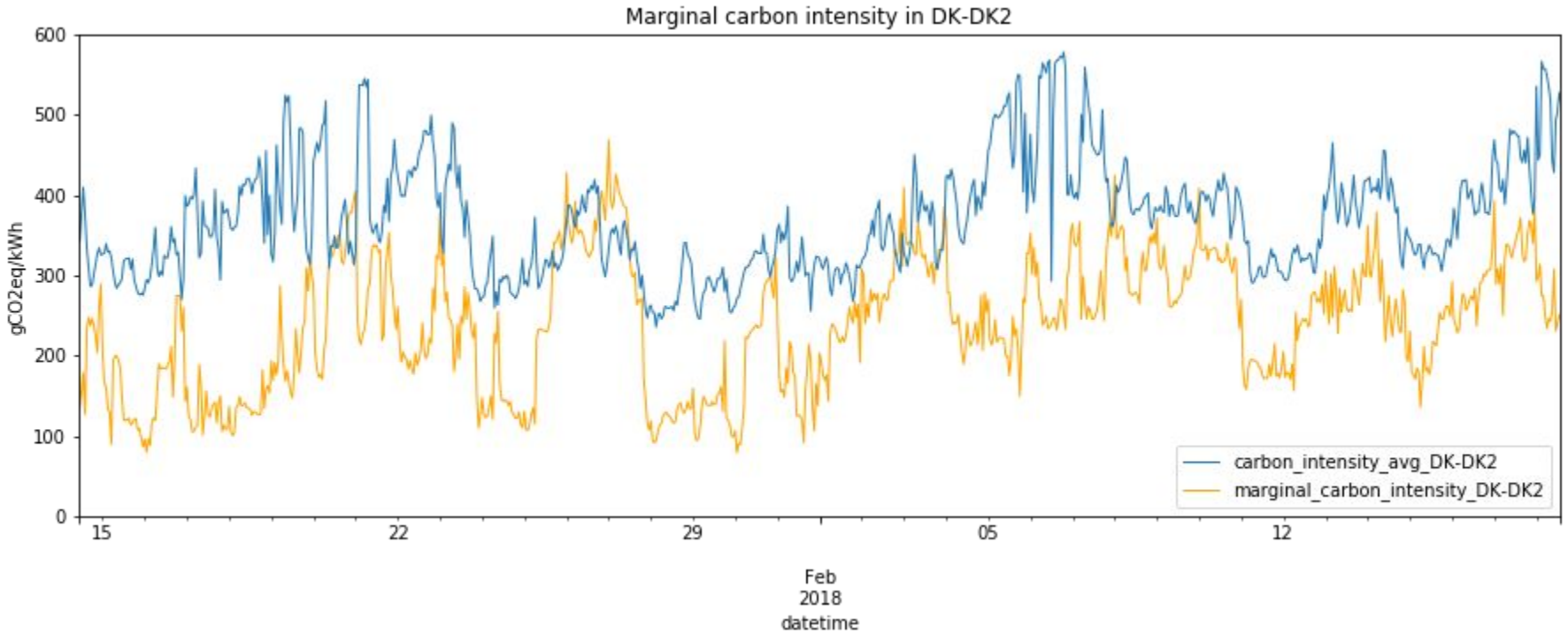
# N-th order correlations

**Assumption:** an increase in import from zone A is equivalent to an increase in demand in zone A

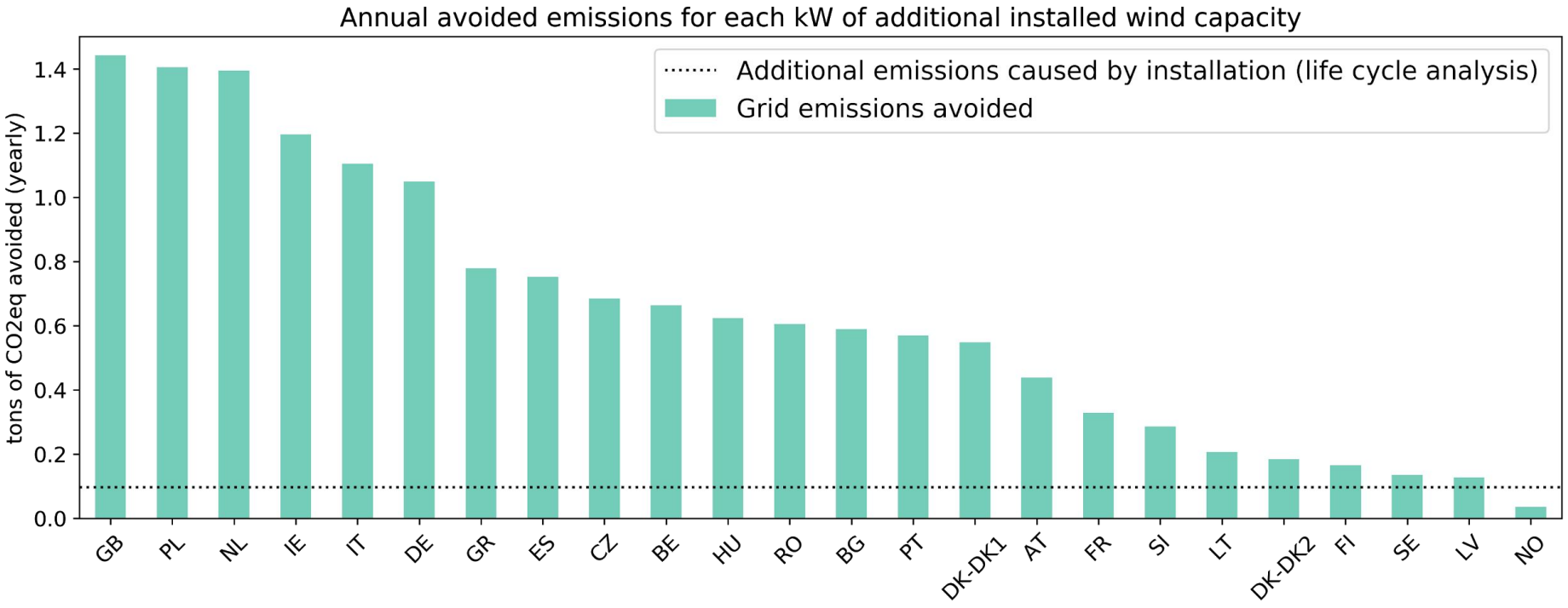
Using a slightly adjusted **flow-tracing** method (not explained here), one can compute the nth-order matrix.



# *Marginal* origin of electricity in East Denmark



# Application1: where to install renewables?



# Application2: optimising time-of-use of electricity

Google The Keyword Latest stories Product updates Company news

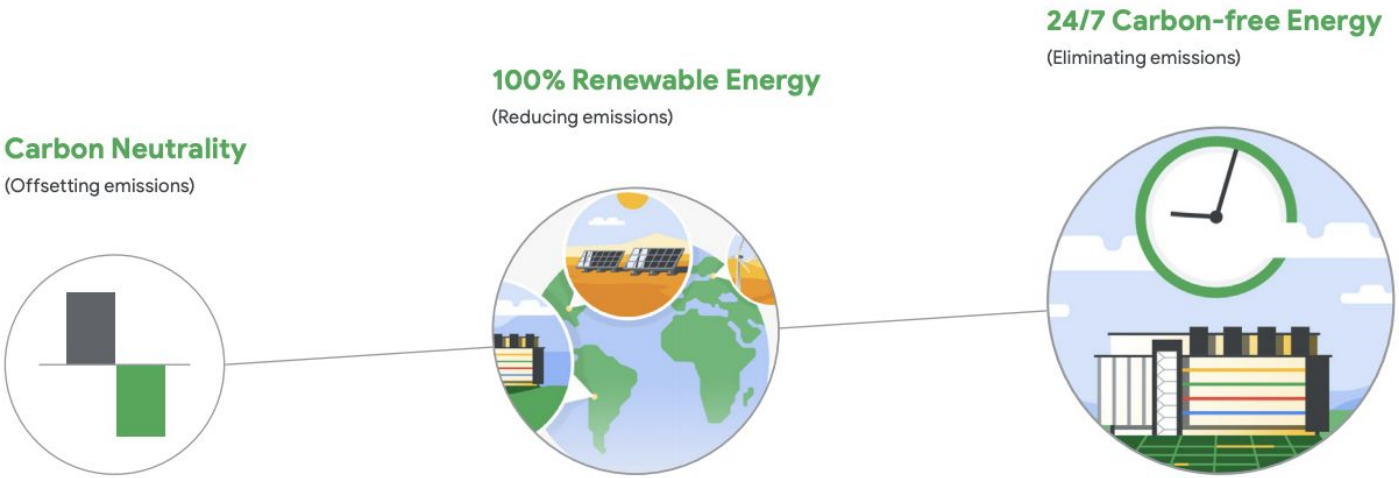
DATA CENTERS AND INFRASTRUCTURE

## Our data centers now work harder when the sun shines and wind blows

**Ana Radovanovic**
Technical Lead for Carbon-Intelligent

Addressing the challenge of climate change demands a transformation in how the world produces and uses energy. Google has been carbon neutral

# Google’s energy journey towards 24/7 carbon-free




### Since 2007

Google has purchased enough high-quality carbon offsets and renewable energy to bring our net operational emissions to zero.

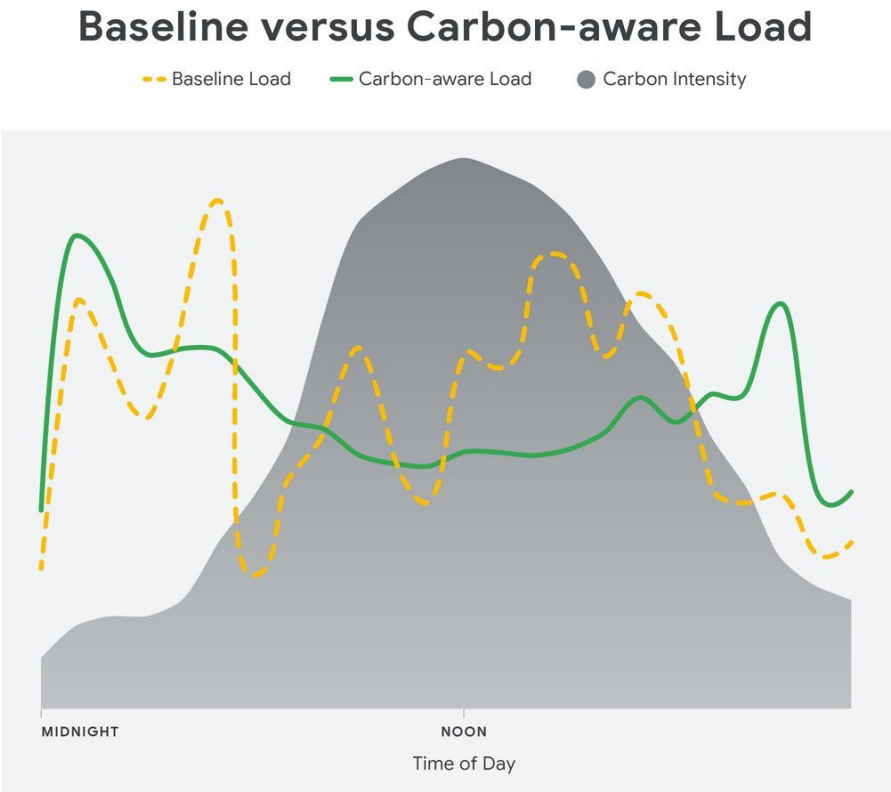
### Since 2017

Google has matched its global, annual electricity use with wind and solar purchases. However, our facilities still rely on carbon-based power in some places and times.

### By 2030

Google intends to match its operational electricity use with nearby (on the same regional grid) carbon-free energy sources in every hour of every year.

# Preliminary results



**Our ambition is to enable a**
**data-driven transition to a low-carbon future**

**What data are *you* using to power your transition?**


Democratising climate action

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