Carbon intensity data

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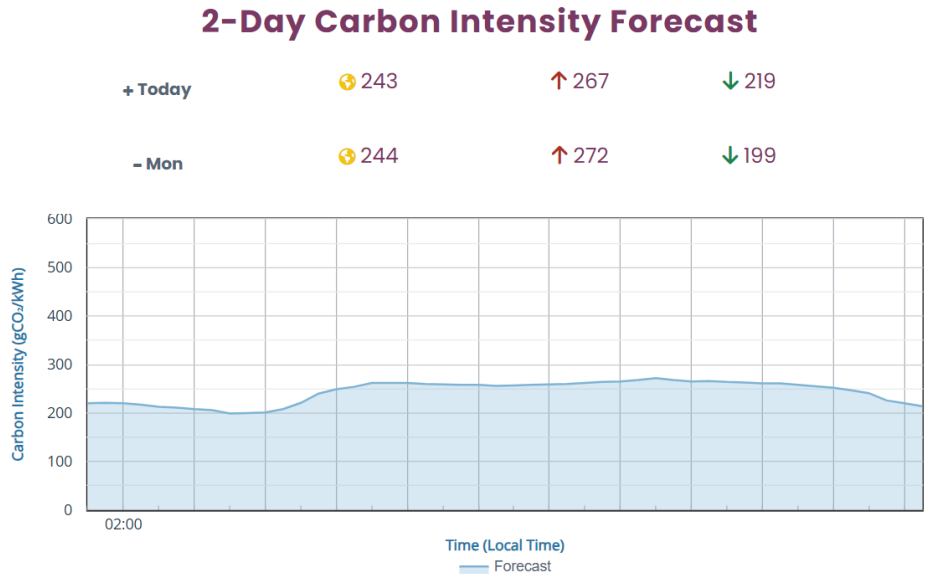
Carbon intensity data availability

- Primary sources
  - Covering one country/region
  - Power grid operators or flexibility providers
  - TSO (Transmission System Operator)
    - UK - National Energy System Operator (NESO)
    - CZ – ČEPS (Czech TSO)
    - ES – REE (Spanish TSO)
- ENTSO-E European Association of TSO
  - All EU, focus on TSO role (generation mix)
  - Free access
  - Note: in US EPA CAMPD (Clean Air Markets Program Data), EIA (Energy Information Administration)
- Aggregation platforms
  - All regions, history, derived products (forecast)
  - Focus on reporting emissions and load shifting
  - Electricity Maps, WattTime
  - Freemium model



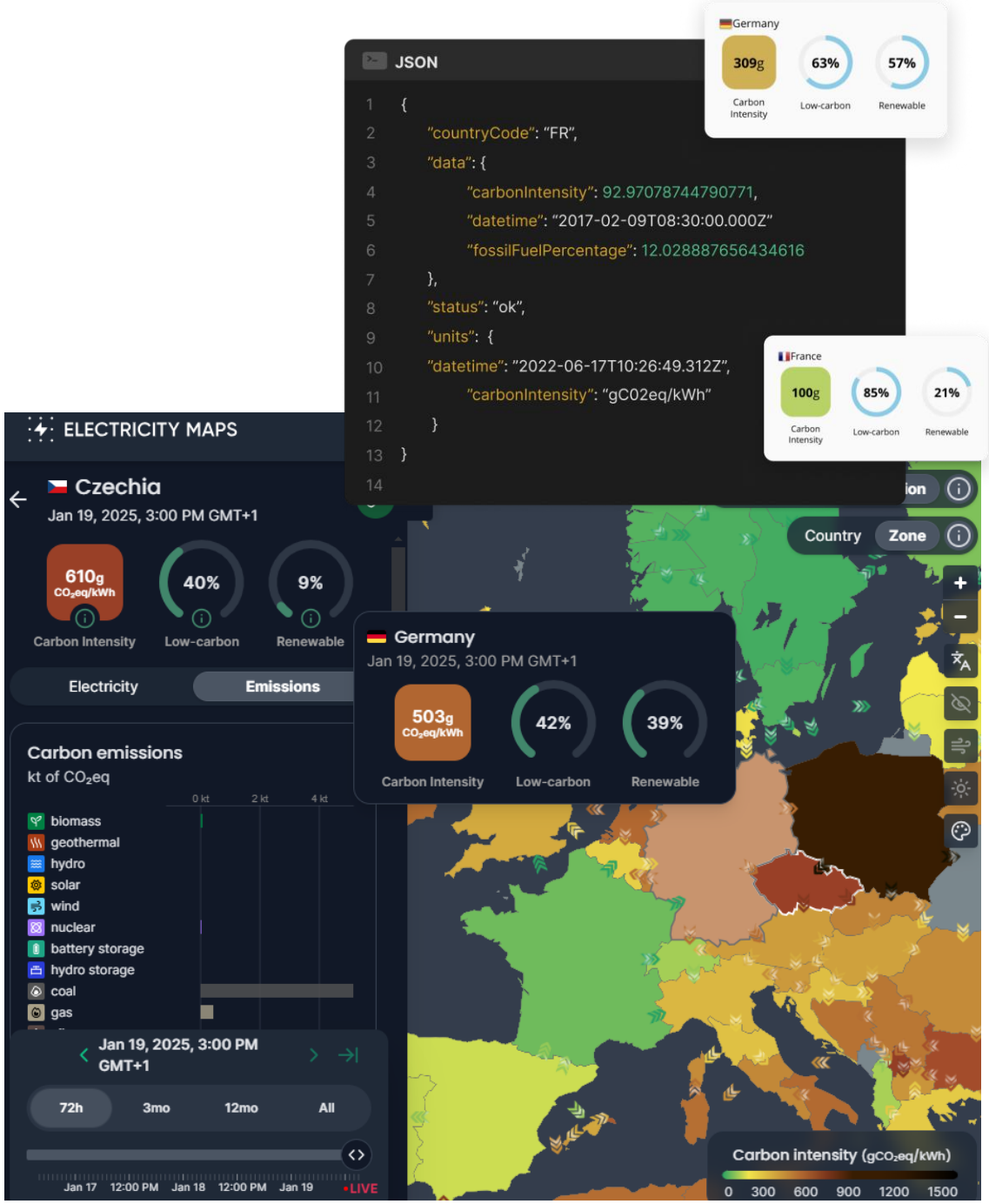
Credits: https://carbonintensity.org.uk/ data UK only

Understanding the data

- Marginal Operating Emissions Rate (MOER) CO_2/MWh
  - The emissions of power plant needed in response to a change in consumption
  - Used as input signal for load shifting and indicates *how much can be avoided*
  - Controversy: Determining the marginal power plant is complex, problems with auditing, reporting and can represent overstated signal [alternatives by electricity maps, support for marginal rates by WattTime]
- Average Operating Emissions Rate (AOER) CO_2/MWh
  - The average of all power sources operating at a particular time
  - Good for: Current carbon impact of a particular site/datacenter
- Relative realtime marginal emissions intensity index
  - Current CO2 intensity index relative to values observed in the past month.
  - A higher index indicates current carbon intensity is higher.
  - Goal: Free tier available signal for deciding if use electricity just now in local region (WattTime).

Electricity Maps

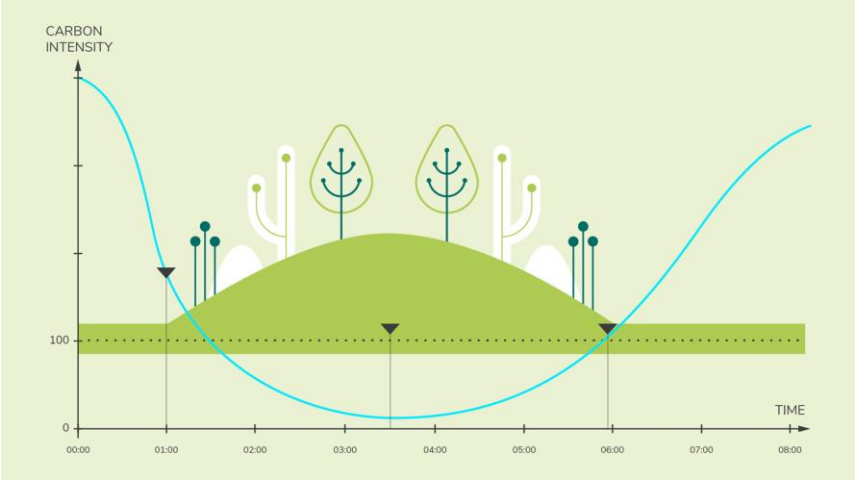
- Focused and cooked data
  - Realtime data from whole world, forecasts, metodology
  - Use cases with Google and more for calculating emmisions and load shifting
- Commercial (API) [docs]
  - Free tier limited to one region and actual data (no forecast and history)
- Other option: WattTime.org
  - Similar, US origin, nonprofit
  - Provides the carbon index for free [watttime API]

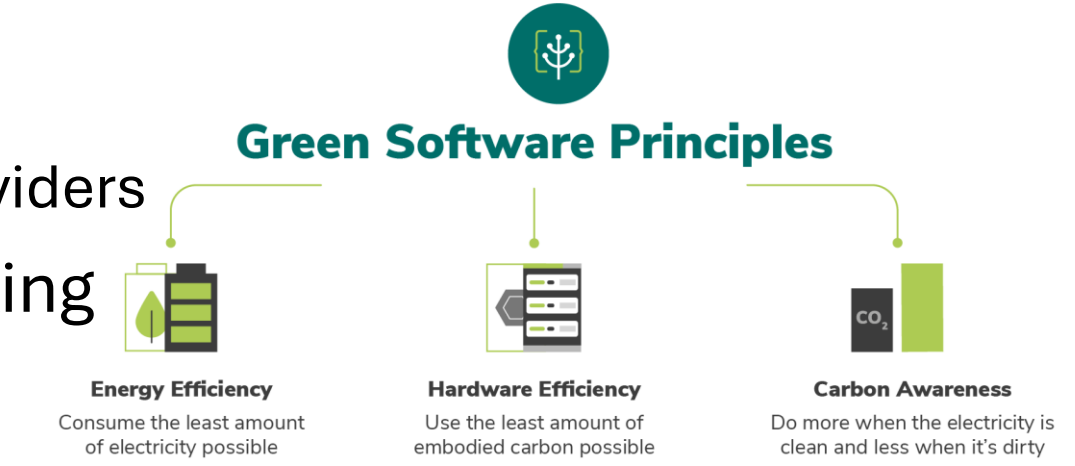


Credits: Electricity Maps

Carbon Aware SDK

- Goal: abstraction layer decoupling from particular data source
  - Standardization (gCO_2/kWh)
  - Data provider agnostic
  - Possibility to aggregate from multiple providers
- Open source with strong industry backing (lead: Microsoft, .NET)
- Connection with Green Software Foundation

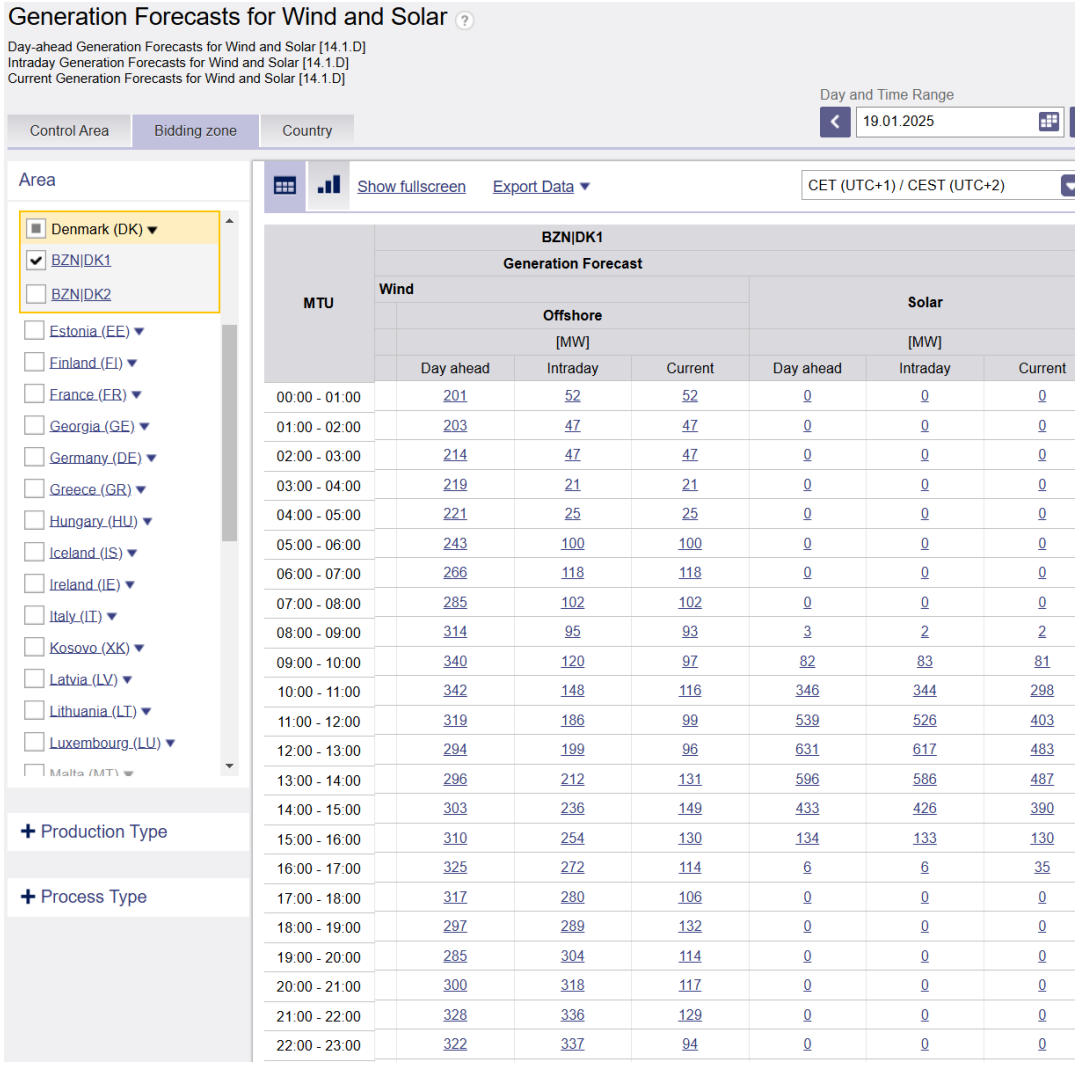




Credits: Green Software Foundation, 10 best tools to green your software, The Green Web Foundation

ENTSO-E

- Free TSO data at one site/API
- Forecasts available
- Focused on controlling the grids, control flexibility, prices
  - No products like carbon intensity
  - Detailed (complex) data



Generation Forecasts for Wind and Solar

Day-ahead Generation Forecasts for Wind and Solar [14.1.D]
Intraday Generation Forecasts for Wind and Solar [14.1.D]
Current Generation Forecasts for Wind and Solar [14.1.D]

Day and Time Range: 19.01.2025

Control Area | Bidding zone | Country

Area

Denmark (DK)
BZN|DK1
BZN|DK2
Estonia (EE)
Finland (FI)
France (FR)
Georgia (GE)
Germany (DE)
Greece (GR)
Hungary (HU)
Iceland (IS)
Ireland (IE)
Italy (IT)
Kosovo (XK)
Latvia (LV)
Lithuania (LT)
Luxembourg (LU)
Malta (MT)

+ Production Type

+ Process Type

Show fullscreen | Export Data | CET (UTC+1) / CEST (UTC+2)

MTU	BZN|DK1 Generation Forecast					
	Wind Offshore [MW]			Solar [MW]		
	Day ahead	Intraday	Current	Day ahead	Intraday	Current
00:00 - 01:00	201	52	52	0	0	0
01:00 - 02:00	203	47	47	0	0	0
02:00 - 03:00	214	47	47	0	0	0
03:00 - 04:00	219	21	21	0	0	0
04:00 - 05:00	221	25	25	0	0	0
05:00 - 06:00	243	100	100	0	0	0
06:00 - 07:00	266	118	118	0	0	0
07:00 - 08:00	285	102	102	0	0	0
08:00 - 09:00	314	95	93	3	2	2
09:00 - 10:00	340	120	97	82	83	81
10:00 - 11:00	342	148	116	346	344	298
11:00 - 12:00	319	186	99	539	526	403
12:00 - 13:00	294	199	96	631	617	483
13:00 - 14:00	296	212	131	596	586	487
14:00 - 15:00	303	236	149	433	426	390
15:00 - 16:00	310	254	130	134	133	130
16:00 - 17:00	325	272	114	6	6	35
17:00 - 18:00	317	280	106	0	0	0
18:00 - 19:00	297	289	132	0	0	0
19:00 - 20:00	285	304	114	0	0	0
20:00 - 21:00	300	318	117	0	0	0
21:00 - 22:00	328	336	129	0	0	0
22:00 - 23:00	322	337	94	0	0	0

Credits: ENTSO-E transparency portal (link, docs)

Calculate data from free sources

- Carbon intensity
  - Multiplying power sources production mix with emmision factors of sources in the mix
  - Electricity Maps contrib provides open source code and methodology
  - Data sources, emmision factors
- Solar+wind ratio as a signal for load shifting?
  - Simple and easy to understand
  - ENTSO-E provides free 24h forecasts of solar/wind generation

Credits: Electricity Maps, carbon intensity calculations, emmision factors

Mode	Emission factor (gCO2eq/kWh)	Category	Source
battery discharge	301	Renewable (default)	World average intensity by Electricity Maps
biomass	230	Renewable	IPCC 2014
coal	820	Fossil	IPCC 2014
gas	490	Fossil	IPCC 2014
geothermal	38	Renewable	IPCC 2014
hydro	24	Renewable	IPCC 2014
hydro discharge	301	Renewable (default)	World average intensity by Electricity Maps
nuclear	12	Low-carbon	IPCC 2014
oil	650	Fossil	UK Parliamentary Office of Science and Technology
solar	45	Renewable	IPCC 2014
unknown	700	Fossil	Assumes thermal (coal, gas, oil)
wind	11	Renewable	IPCC 2014

Proposal: Carbon intensity data in GreenDIGIT

- Use ENTSO-E data, calculate products
  - Common component where details are changeable and transparent
- Alternative: partner with Electricity Maps or WattTime
  - Get curated data, „pay“ with our partnership
  - Get Electricity Maps (free tier) separately by each partner
- Agree what data we need
  - Granularity, frequency, history, forecast, etc.
  - Is current carbon intensity of european countries enough?
  - Is enough signal for load shifting based on the ratio of solar+wind in the power generation mix (this day/next day forecast)?