Environmental impact of utilities

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With the recent focus on sustainability and net-zero by 2024, important business decisions have to be made. To make these decisions, we need to know our current environmental impact. This report models the enivronmental impact of utilities, assuming gas, power and solar. The numbers are based on typical residential building, but numbers for an office can easily be plugged in.

Utility consumption

Assuming the following usage pattern:

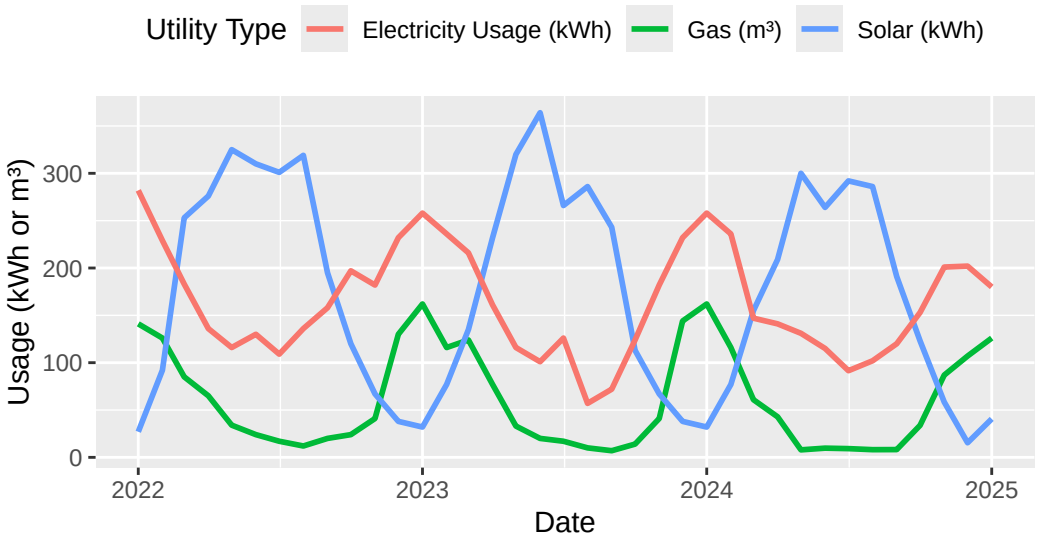

Figure 1: Assumed utility usage. Note that energy meters measure net flow, and thus gross solar and power might differ.

Details

Date	Gas (m^3)	Electricity Usage (kWh)	Solar (kWh)
2025-01-01	126.0	180.0	40.6
2024-12-01	107.0	202.0	15.4
2024-11-01	86.9	201.0	58.4
2024-10-01	33.8	153.0	123.0
2024-09-01	8.2	120.0	191.0
2024-08-01	8.1	102.0	286.0
2024-07-01	9.2	91.5	292.0
2024-06-01	9.7	115.0	264.0
2024-05-01	7.9	131.0	300.0
2024-04-01	42.8	141.0	209.0
2024-03-01	60.9	147.0	155.0
2024-02-01	116.0	236.0	77.0
2024-01-01	162.0	258.0	32.0
2023-12-01	144.0	232.0	38.0
2023-11-01	41.0	182.0	67.0
2023-10-01	14.0	124.0	113.0
2023-09-01	7.0	72.0	243.0
2023-08-01	10.0	57.0	286.0
2023-07-01	17.0	126.0	266.0
2023-06-01	20.0	101.0	364.0
2023-05-01	33.0	116.0	320.0
2023-04-01	77.0	161.0	232.0
2023-03-01	124.0	216.0	135.0
2023-02-01	116.0	236.0	77.0
2023-01-01	162.0	258.0	32.0
2022-12-01	130.0	232.0	38.0
2022-11-01	41.0	182.0	67.0
2022-10-01	24.0	197.0	120.0
2022-09-01	20.0	158.0	195.0
2022-08-01	12.0	136.0	319.0
2022-07-01	17.0	109.0	301.0
2022-06-01	24.0	130.0	310.0
2022-05-01	34.0	116.0	325.0
2022-04-01	65.0	136.0	276.0
2022-03-01	85.0	183.0	253.0
2022-02-01	126.0	229.0	92.0
2022-01-01	141.0	282.0	27.0

Emissions of energy production

To quantify and compare the warming effects of different kind of emissions, the IPPC proposes using the Global Warming Potential (GWP), which can be used to express the warming effect of different emissions to that of CO . To calculate our total emissions, we must first determine the emissions caused by the energy production.

Electricity

The emissions of electricity production depends on the source of the energy, which changes minute-by-minute. During day, a lot of green solar power is generated, and during peaks, gas turbines kick in. Exact information on the current national energy mix is publicly available. Ember-energy calculates the CO emissions based on the energy mix, and has an API (email required) which provides the following numbers:

See also: https://www.cbs.nl/-/media/_excel/2023/06/1-co2-emissie-energieverbruik-rendementen-elektriciteit-2021.xls

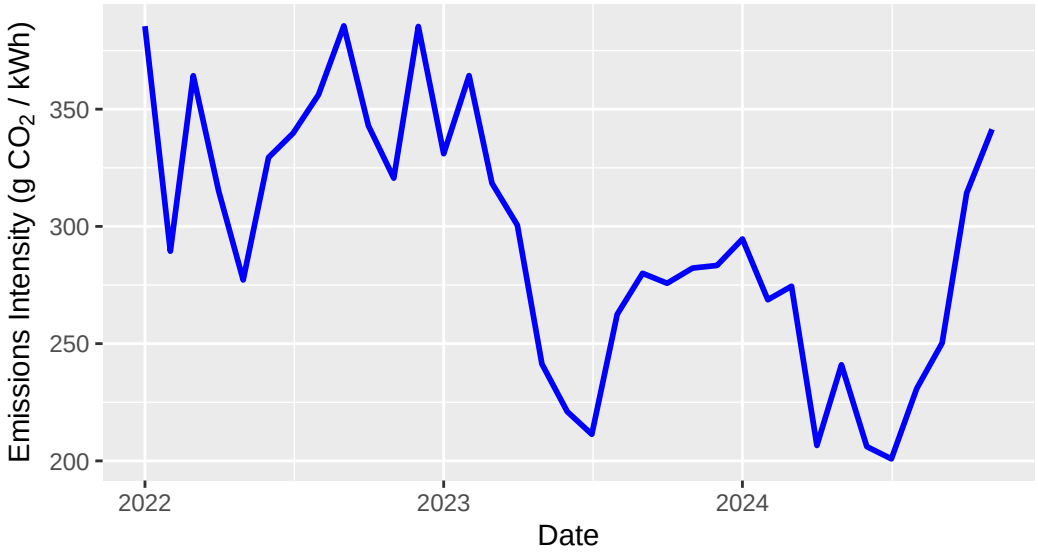

Figure 2: CO emissions of the dutch energy production over time

To calculate the emissions caused by our energy consumption, we should account for the differing CO emissions as follows:

$$\mathrm{CO}_2 = \sum_{i=1}^{n} E_i \times F_i$$

With CO_2 is the total produced CO in grams,
E_i the electricity usage for month i in kWh,
F_i the emissions intensity in gCO_2/kWh for that specific month i.

Gas

Calculating the exact emissions caused by gas production is somewhat more complex as gas distributors measure the gas-usage as volume (m^3) which is dependent on the temperature, pressure and gas mix, all of which are subject to change. Gas distributors solve this by multiply the measured volume with a correction value to determine the caloric value of the consumed gas (also see wobbe index). These corrections can be found on the final invoice.

The Netherlands Enterprise Agency (RVO) has calculated the emission factor for natural gas to be **56.34 kg CO per GJ** of energy. This only includes the emissions caused by burning the gas, not from producing it. The exact number differs by ±2% per year due to differences in the national gas mix, for instance through higher LNG imports.

The CBS reports that **1 GJ of natural gas corresponds to 31.6 m^3**, thus we can calculate the emissions per m^3 as follows:

$$\frac{56.34 \text{ kg}}{\text{GJ}}$$

Since

$$1 \text{ GJ} = 31.6 \text{ m}^3$$

we can compute:

$$\frac{56.34}{31.6} \text{ kg/m}^3$$

which simplifies to:

$$1.78 \text{ kg } CO_2 \text{ per m}^3$$

As the deviations for the emissions of the gas mix are ~2%, we simplify the calculation by not accounting for them.

Calculations

From the emission factors per energy type the final formula can be determined:

$$\mathrm{CO}_2 = \left(\sum_{i=1}^{n} E_i \times F_i \right) + (G \times 1,78)$$

With CO_2 as the total produced CO in grams,
E_i the electricity usage for month i in kWh,
F_i the emissions intensity in $kgCO_2/kWh$ for that specific month i. G the total gas usage in m^3

Plugging our usage data into this formula gives us the following emissions:

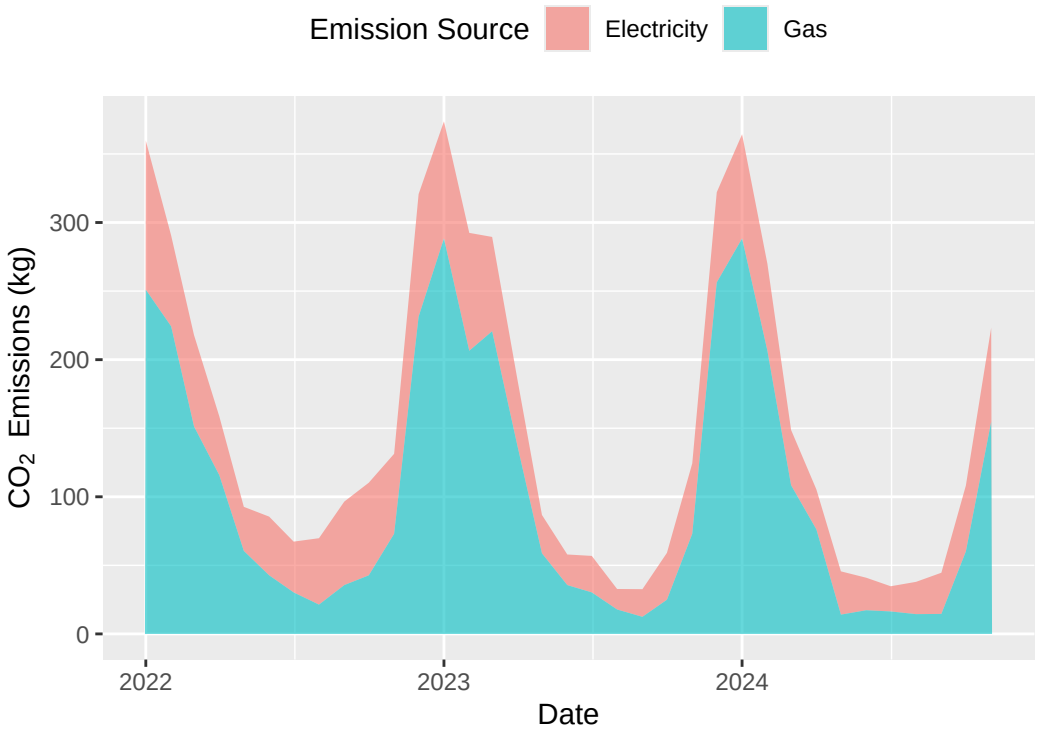

Figure 3: Monthly CO Emissions from Energy and Gas

year	Gas emissions (kg CO)	Electricity emissions (kg CO)	Total emissions (kg CO)
2022	1279.82	721.12	2000.94
2023	1361.70	551.89	1913.59
2024	970.99	452.84	1423.83

year	Gas emissions (kg CO)	Electricity emissions (kg CO)	Total emissions (kg CO)

Details

date	Electricity	Gas	total	year
2024-11-01	68.62542	154.682	223.30742	2024
2024-10-01	48.07719	60.164	108.24119	2024
2024-09-01	30.03240	14.596	44.62840	2024
2024-08-01	23.54670	14.418	37.96470	2024
2024-07-01	18.37869	16.376	34.75469	2024
2024-06-01	23.69920	17.266	40.96520	2024
2024-05-01	31.56969	14.062	45.63169	2024
2024-04-01	29.12778	76.184	105.31178	2024
2024-03-01	40.34709	108.402	148.74909	2024
2024-02-01	63.42028	206.480	269.90028	2024
2024-01-01	76.01712	288.360	364.37712	2024
2023-12-01	65.73720	256.320	322.05720	2023
2023-11-01	51.36404	72.980	124.34404	2023
2023-10-01	34.19300	24.920	59.11300	2023
2023-09-01	20.16000	12.460	32.62000	2023
2023-08-01	14.96307	17.800	32.76307	2023
2023-07-01	26.62884	30.260	56.88884	2023
2023-06-01	22.32100	35.600	57.92100	2023
2023-05-01	27.99544	58.740	86.73544	2023
2023-04-01	48.38694	137.060	185.44694	2023
2023-03-01	68.77440	220.720	289.49440	2023
2023-02-01	85.97480	206.480	292.45480	2023
2023-01-01	85.39542	288.360	373.75542	2023
2022-12-01	89.38264	231.400	320.78264	2022
2022-11-01	58.34738	72.980	131.32738	2022
2022-10-01	67.56115	42.720	110.28115	2022
2022-09-01	60.91374	35.600	96.51374	2022
2022-08-01	48.43504	21.360	69.79504	2022
2022-07-01	37.03166	30.260	67.29166	2022
2022-06-01	42.82070	42.720	85.54070	2022
2022-05-01	32.15056	60.520	92.67056	2022
2022-04-01	42.86040	115.700	158.56040	2022
2022-03-01	66.65775	151.300	217.95775	2022
2022-02-01	66.27718	224.280	290.55718	2022
2022-01-01	108.68562	250.980	359.66562	2022

If real estate occupancy rate, area or any other measure is known, calculating the carbon footprint per person, workspace or area is trivial.

Concerns

Clearly, the current calculations only accounts for the direct emissions caused by burning gas, or from producing electricity. (scope 1&2 emissions). Producing and transporting gas and electricity also has a significant impact on the environment.

Furthermore, solar panels return electricity into the grid. How should they be accounted for?