Spacial and temporal disaggregation of energy consumption

Fraunhofer IEE

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Contents

Disaggregator

The original DamandRegio project aims to disaggregate the final energy consumption of the sectors:

- Industry
- Commercial, Trade and Services (CTS)
- Private Household into a high spacial and temporal resolution.

The original repository was concluded some years ago and since then the api was changed, and the repository became outdated.
For that I created a new version from it to work with the new api. Pitfall:

- industry specific branch load profiles (BLP) to calculate the temporal disaggreation, could not be found in the new api.

Updated version

The presentation today focuses on another version based on a master thesis of this year that was done at TUB by Florian Baumann. This version was supposed to work with the new api, and provide some improvements. This version does not provide disaggregation for private households.

The presentation focuses on electricity consumption. Gas and petrol are not included.

Spatial Disaggregation

1. The raw consumption per industry is taken from GENESIS.
2. If the year is beyond the end year (2020), a growth factor is applied for each industry (wz) and year (until 2050). The factors are taken from data/raw/temporal/Activity_drivers.xlsx;
3. The number of employees per industry and region is taken from opendata. The table provides values from 2008 and 2018. For years above 2018, another table from opendata is used where predicted values are calculated until 2035.
4. The number of employees per industry and region is normalized to get the share of employees per region and industry. The consumption per industry is then distributed to the regions using this share.
5. A proportion of self generated electricity per industry is loaded from data/raw/dimensionless/decomposition_factors.xlsx. This is based on literature from AGEB (Arbeitsgemeinschaft Energiebilanzen) and VDI (Verein Deutscher Ingenieure)

Spatial Disaggregation

1. So far the energy consumption is based only on the share of employees. Another table from opendata is used to get the raw values of electricity consumption per region von JEVI (Jahreserhebung über die Energieverwendung der Betriebe des Verarbeitenden Gewerbes, im Bergbau und der Gewinnung von Steinen und Erden). This applies only to industries of the manufacturing sector (wz 05-33).
2. The problem: *Given total consumption per industry and total consumption per region, how much does each industry consume in each region?*

   For CTS industries the disagregation is only based on the share of employees.
   For manufacturing industries a biproportional fitting approach is used to satisfy constraints on both dimensions - industries (rows) regions (columns) with a minimum constraint of 10MGh per worker.

Temporal Disaggregation

1. Consumption data is disaggregated as before and filtered for WZ in "industries" or "CTS".
2. Efficiency rates are applied.

   For "industry" the rate of efficiency is calculated base on two rates for different phases: Phase 1 (2019-2035) and Phase 2 (>2036).

industry_sector	5	6	7	8	9	10	11	12
2035	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
2045	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013

Table: Efficiency rates for industries 5-33.

   For a given year, a compound efficiency factor is calculated by the number of years in Phase 1 and the number of years in Phase 2.

Temporal Disaggregation

For "CTS" the rate of efficiency is calculated base on specific application rates. First the consumption is disaggregate between aplications using the table data/raw/dimensionless/decomposition_factors.xlsx:

industry_sectors	lighting	information_communication_technology
1	0.255814	0.046512

Table: Lighting and ICT data for industry sectors 1 and 2.

And for each application, specific efficiency rates are applied, on which the compound efficiency factor is calculated as before:

until_year	lighting	information_communication_technology
2035	0.0210	0.0070
2050	0.0105	0.0035

Table: Data for lighting, ICT, and space cooling until 2035 and 2050.

Temporal Disaggregation - Industry

3. The consumption data is then disaggregated differently for industry and CTS sectors:

   For **"industry"** (wz 5-33) the consumption is disaggregated using ***shift load profiles***.

   - First, shifts are predefined as s1 (08:00-16:30), s2 (06:00-23:00), and s3 (00:00-24:00)
   - During the shifts the energy consumption is fully allocated, outside the shifts zero. A parameter "low" can be changed from 0 to 1 to allocate a small share of consumption outside the shifts (here low is 0.5)
   - For each of this shifts, 3 categories are defined: workdays, workdays + saturday, workdays + saturday + sunday
   - What differentiates the shift load profiles among states is the occurrence of holydays, which are treated as sundays.

Temporal Disaggregation - Industry

- E.g., for Hessen in 2020, the load shift profiles at 14:00:00 are:

Timestamp	S1_WT	S1_WT_SA	S1_WT_SA_SO	S2_WT	S2_WT_SA	S2_WT_SA_SO
2020-01-03 14:00:00	0.000046	0.000044	0.000042	0.000038	0.000036	0.000033

Table: Shift load profiles

- Each industry in the "industry" sector is assigned to one of the 9 shift load profiles types based on its working hours.
- Every state has 9 shift load profiles.
- Finally, for each region, the shift load profiles of the according state is used and each industry's consumption is multipllied by the appropriated shift profile.

Temporal Disaggregation - CTS

For **"CTS"** the disaggregation is done using ***standard load profiles***, and the disaggregation is done by states as follows:

Every industry in the "CTS" sector is assigned to one standar load profile (e.g., 'H0', 'L0', 'G3', etc.).

Filtering by each state, we get a dataframe like below:

industry_sector	1001	1002	SLP
1	249.669997	969.018490	L0
2	0.000000	89.470945	L0
3	0.000000	0.000000	G3
36	0.000000	14579.634018	G3
37	1563.897832	244.854069	G3

Table: Data filtered by state with SLP assignment.

Temporal Disaggregation - CTS

The profiles specify power consumption in 15 minutes intervals for a typical day, be it in winter, summer, or transition period; and for saturday, sunday, or weekday.

Hour	SA_WIZ	SU_WIZ	WD_WIZ	SA_SOZ	SU_SOZ	WD_SOZ	SA_UEZ	SU_UEZ	WD_U
00:00:00	94.1	73.2	74.9	109	91.6	96.5	101.5	80.7	86.6

Table: Standard load profile example.

SA: Saturday, SU: Sunday, WD: Weekday; WIZ: winter, SOZ: summer, UEZ: transition period

Temporal Disaggregation - CTS

These profiles are then used to create a yearly state-specific profiles by accounting holydays as sundays, and the values are then normalized to sum up to 1.

Date	Day	Hour	DayOfYear	WD	SA	SU	WIZ	SOZ	UEZ	H0	L0
2020-01-01	2020-01-01	00:00:00	1	False	False	True	True	False	False	0.000018	0.0000

Table: Hourly data for 2020-01-01.

The dataframe above is used to map every 15-minutes in a year to a specif day type and season, and its according profile value. All value are normalized.

The consumption is then multipled by these values to get the disaggregated consumption.

Thank you for your attention!

Questions?