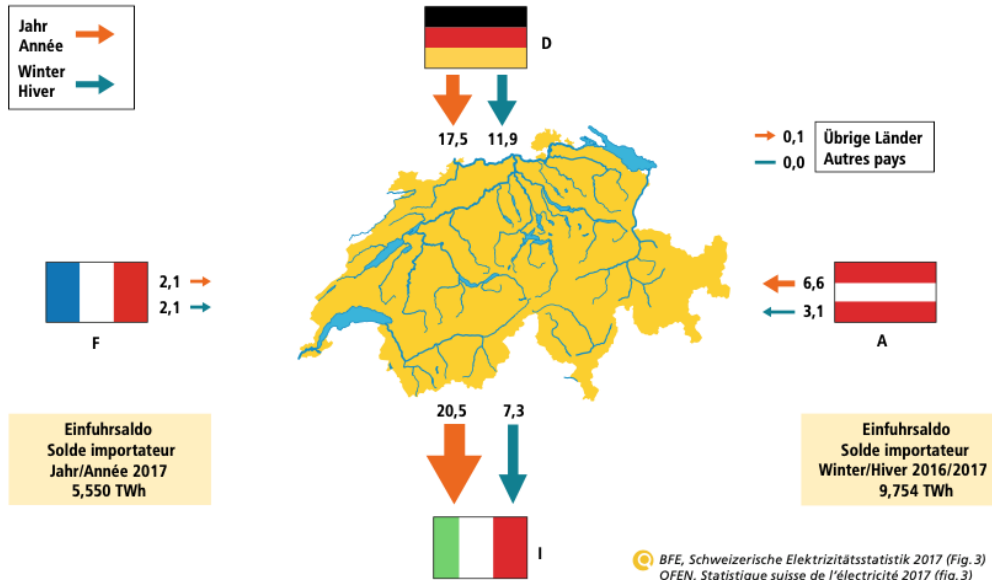


Horocarbon : CO₂ emissions of Swiss electricity in high temporal resolution

Dr. Elliot Romano – 85th LCA Forum

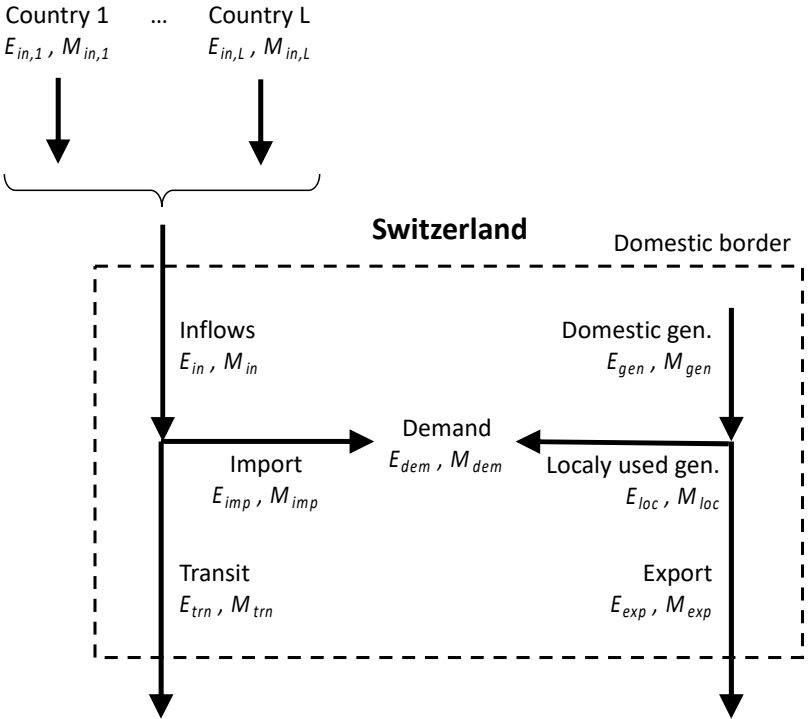
Zurich, 9th November 2023

Context



- Switzerland is highly dependent (in winter) on electricity imports from neighbouring countries.
- Some surrounding countries (i.e D) relies on electricity generation stemming out of fossil fuel power plants.
- Assessment of CO₂ embedded in consumed electricity at a high-temporal resolution is relevant to assess the environmental impacts of new electricity usages, such as Heat-Pumps or Battery Electric Vehicles.

Swiss consumption mix



Swiss consumption mix

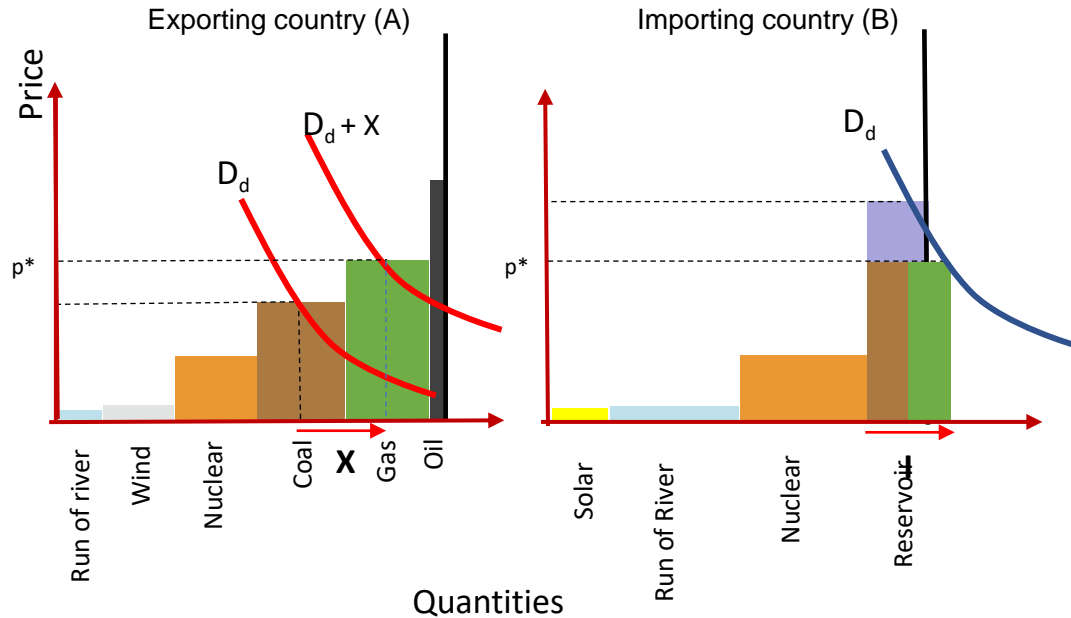


electricity mixes of imports (traded-mix)
(excluding transits)



electricity mixes of domestic generation
(excluding exports)

Traded-mix methodology



D_d : Domestic demand

Exports (X) = Imports (I)

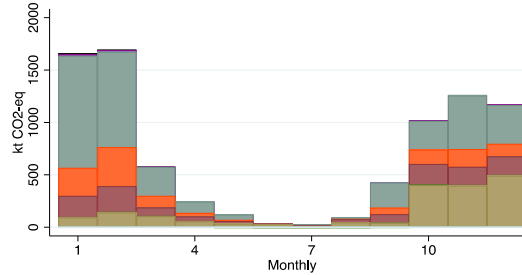
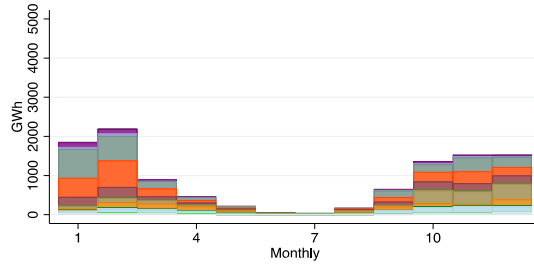
- relies on the **merit-order principle** and electricity cross-border trade mechanisms.
- considers the **impact** of a country imports on the neighbours' generation fleets.
- differs from the most commonly-applied method (**global-mix**), considering the mix of imported electricity with the same structure as the generation mix of the exporting country.

Results

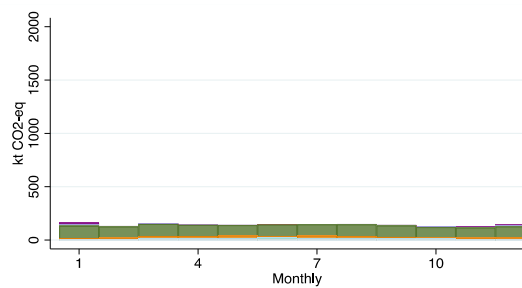
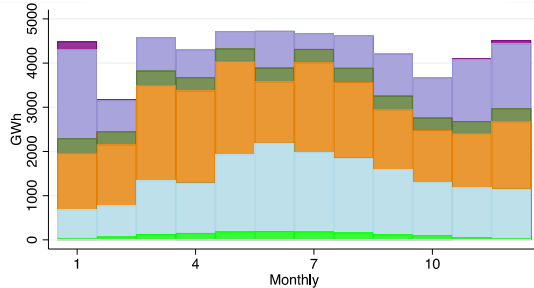
Energy mixes

GHG emissions

Imports

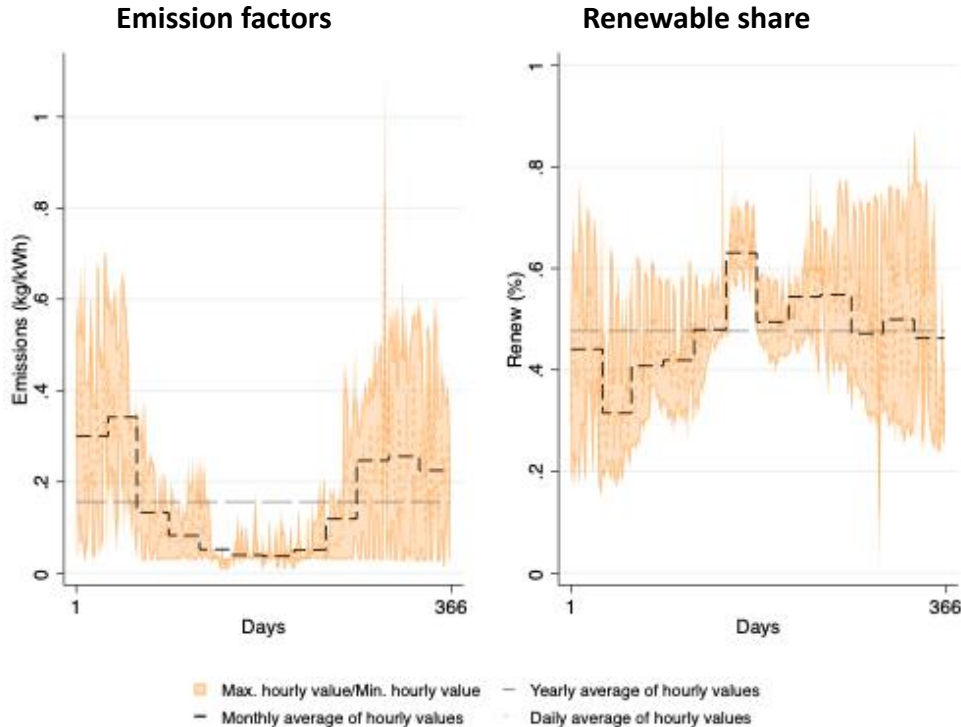


Domestic



- identification of the energy mixes and embedded GHG emissions of imports and domestic generation.

Hourly emissions factors

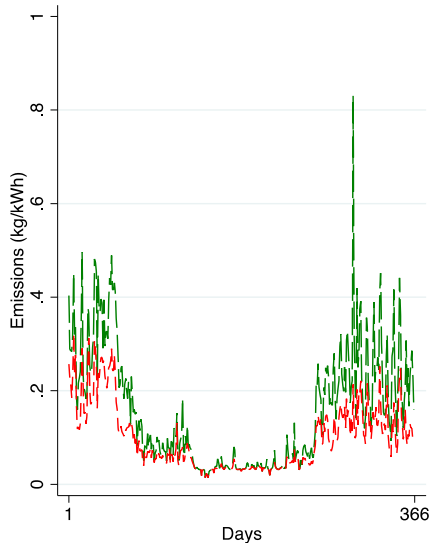


- important **seasonality** of emissions factors.
 - correlation of emission factor with Swiss electricity imports.
- ➔ relevancy of hourly granularity of emissions factors to assess GHG footprint of electricity usages with seasonal profiles (HP, BEV).

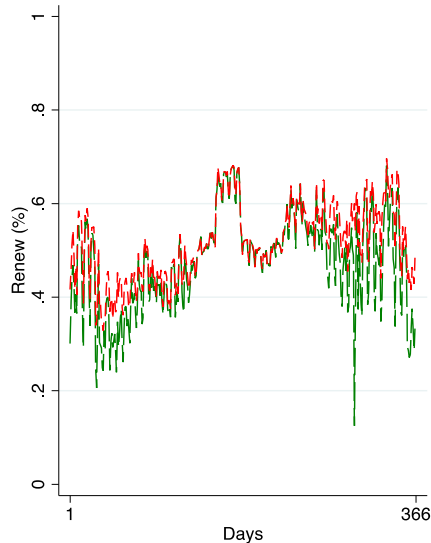
Hourly, daily and monthly profiles of the Swiss 2017 electricity consumer mix, in terms of the GHG emission factor (left) and the renewable energy fraction (right).

Traded vs Global mix

Emission factors



Renewable share

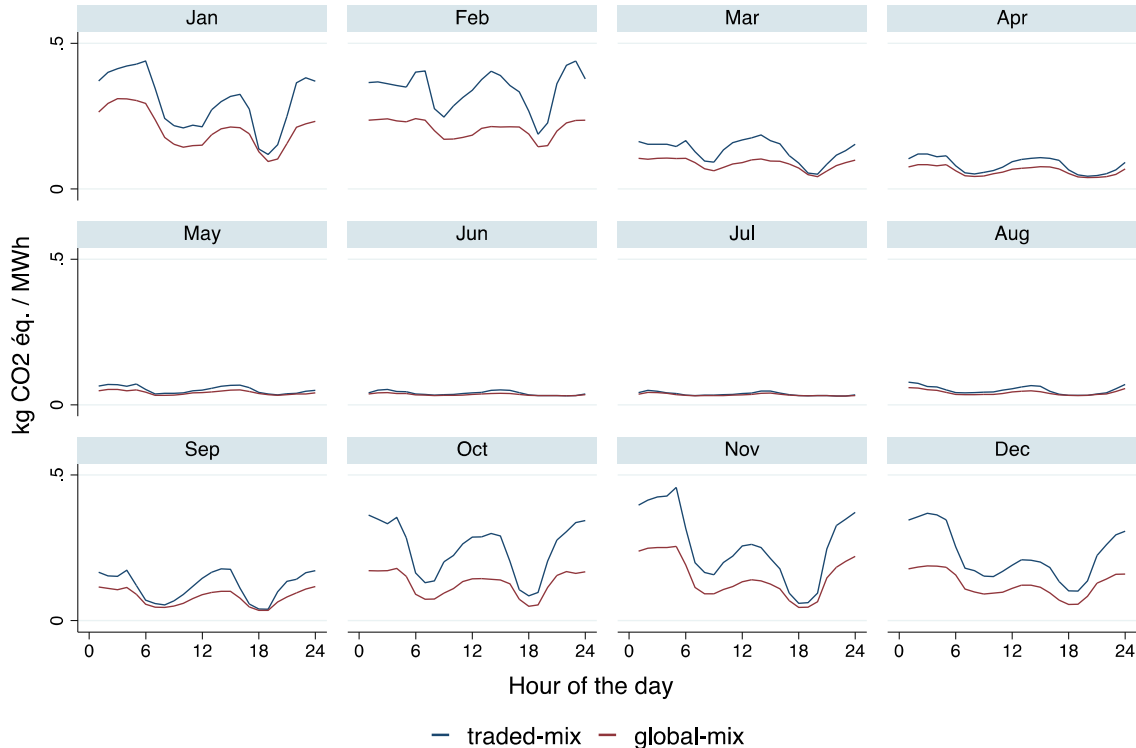


— Daily average 2017 Traded-mix
— Daily average 2017 Global-mix

• Comparison :

- **Traded mix** : higher emissions factor (green) & lower renewable share in the mix.
- **Global mix** : lower emissions factor & higher renewable share in the mix.
- Reminder : Global-mix imports mix have the same structure as the generation mix of the exporting country.

Hourly profiles



- **Winter & nights :**

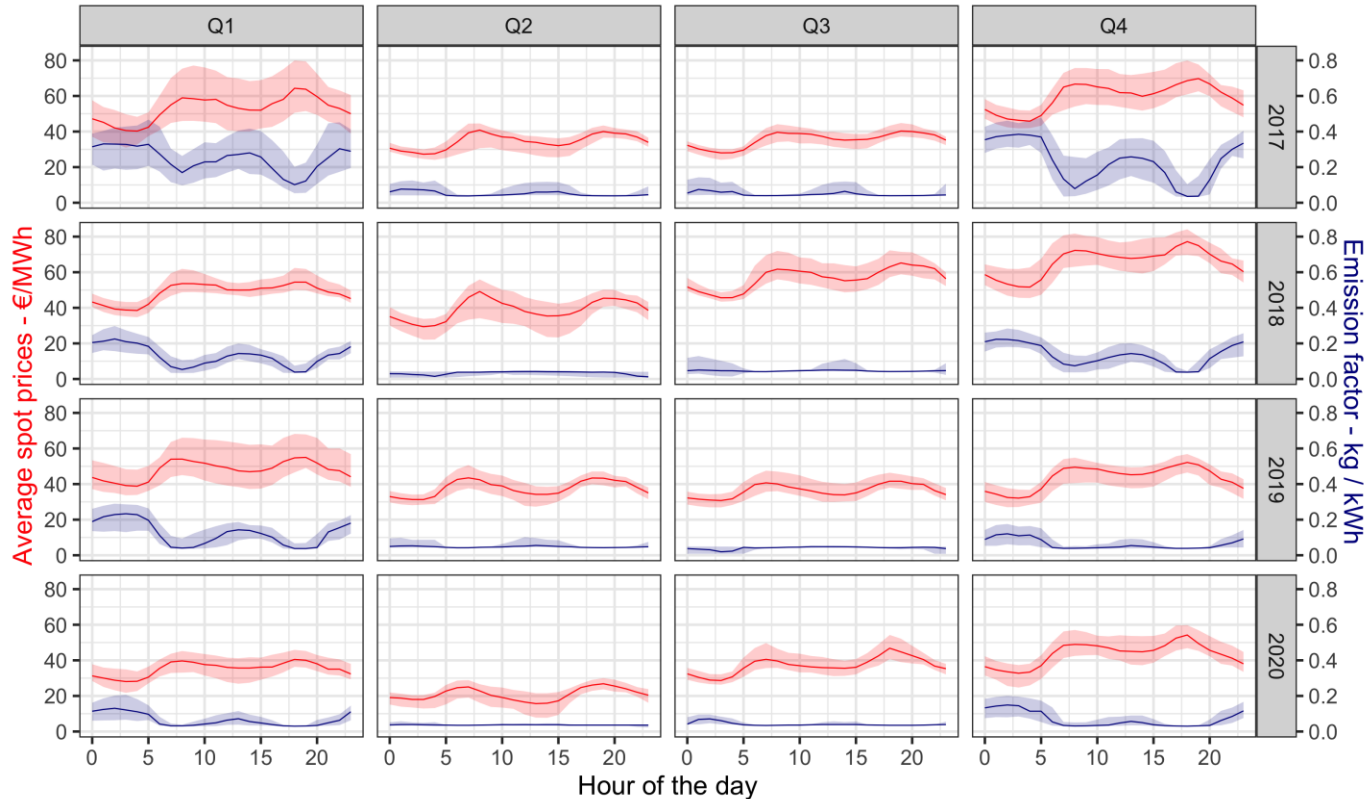
- traded-mix depicts higher emission factors than global-mix, specially at nights and early afternoon hours in winter.

- during those hours, a share of the Swiss consumption is satisfied by imports stemming out of fossil fuel power plants abroad, as imports are less costly.

- **Summer :**

- traded-mix and global-mix emissions factor aligns to each other in summer
- during the summer period, Switzerland is a net-exporter.

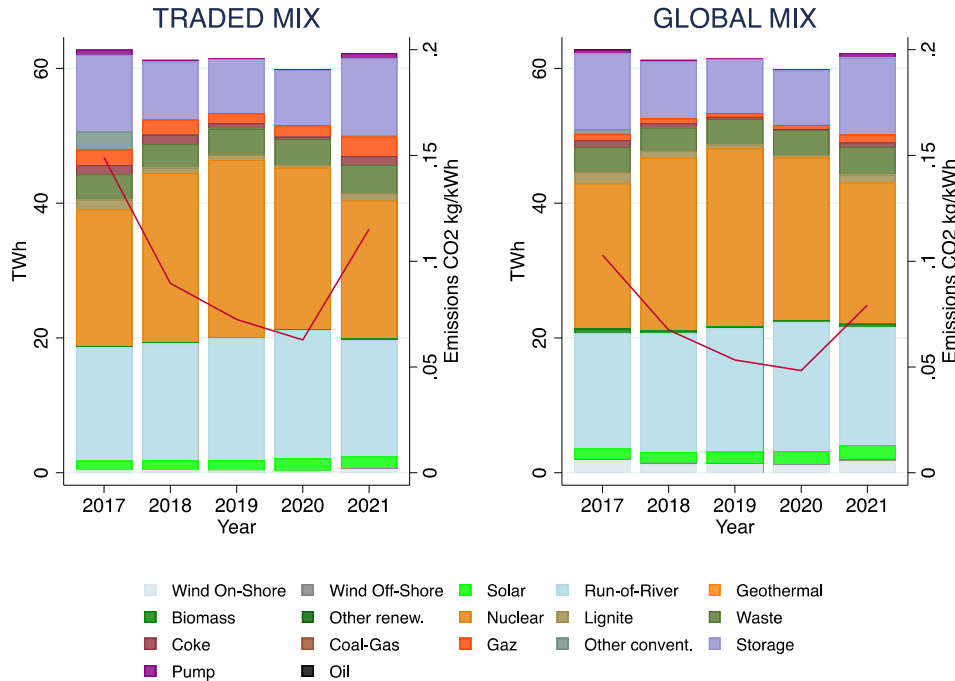
Correlation price vs GHG



Source : EPEX, Horocarbon.ch

- negative correlation between emission factors and electricity market prices.

Multi-annual comparison



- **Global-mix method**

- over-estimates renewables (located at the left-hand side of the exporting countries) in the imports mix.
- characterized by lower emission factors across the year.

- **Traded-mix method**

- reinforces the fossil-fuels power plants (located at the right-hand side of the merit-order) in the import mix
- depicts the substitution by fossil fuel power plants, when domestic nuclear generation is unavailable due to outages (e.g. 2017 or 2021)

Conclusions

- relies on the merit-order principle and cross-border trade as observed on the electricity markets.
- provides emissions factor ranging from 62g CO₂ eq./kWh in 2020 to 160g CO₂ eq./kWh in 2017 , with an updated value around 109 CO₂ eq./kWh in 2022.
- provides emission factors at hourly granularity and depicts the importance of considering their seasonality for assessing environmental impact of electricity usages (HP, BEV).

More info



horocarbon.ch

Thank you for attention

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More information :

E.Romano, P. Hollmuller, M. Patel (2023) : «Applying trade mechanisms to measure quantify GHG emissions of electricity consumption in an open economy - the case of Switzerland », submitted