Hourly emission due to electricity consumption - Providing new information on electricity footprint in real-time

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6 November 2019

Group of Experts on Cleaner Electricity Systems

15th session

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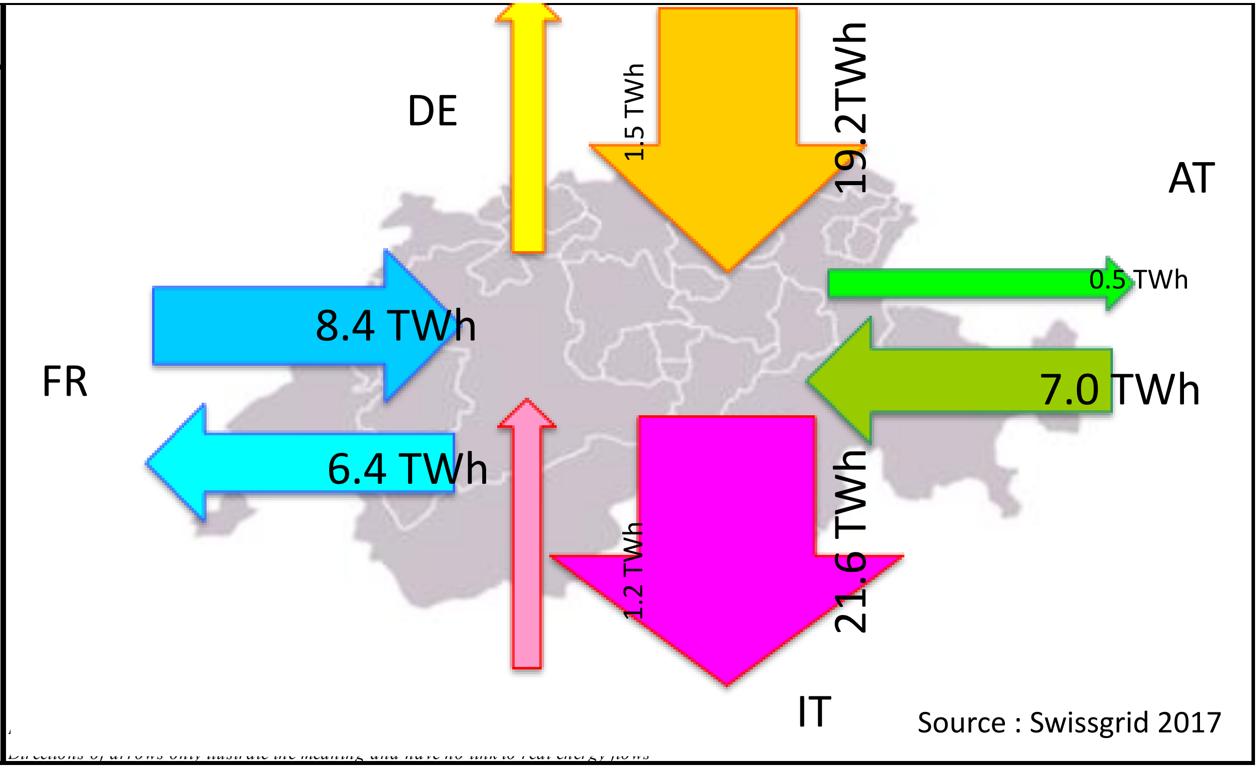
Switzerland : a country at the heart of the European grid

Verbundaustausch
Cross Border Exchange

CH→AT	E	457 774	MWh
	Pmax	1 092	MW
AT→CH	E	7 053 956	MWh
	Pmax	2 233	MW
CH→DE	E	1 558 591	MWh
	Pmax	2 845	MW
DE→CH	E	19 284 034	MWh
	Pmax	5 440	MW
CH→FR	E	6 363 545	MWh
	Pmax	2 987	MW
FR→CH	E	8 438 037	MWh
	Pmax	2 845	MW
CH→IT	E	21 615 970	MWh
	Pmax	5 360	MW
IT→CH	E	1 262 485	MWh
	Pmax	2 344	MW



Source : Swissgrid 2017

- Electricity consumption (2017) : 58.5 TWh
- Electricity generation (2017) : 61. 5TWh
- Total of exchanges (Imports 36.5 TWh / Exports : 30.9 TWh)

Neibourghing countries : Installed capacity

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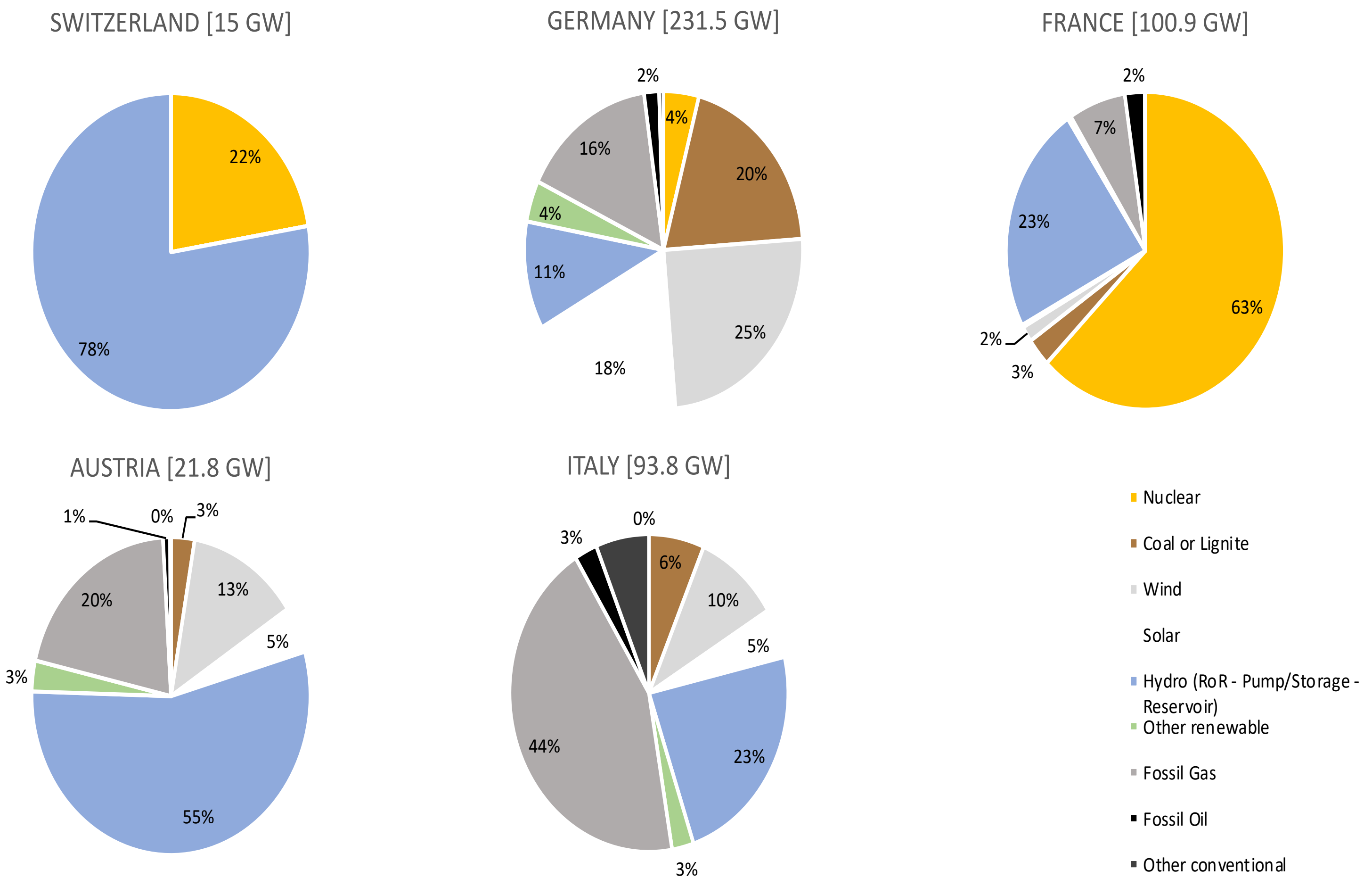


- Some neighbouring countries rely on a high-share of fossils fuels technologies.
- In DE, a small share of the installed capacity (2%) represents other conventional plants, which used blast furnace gases and coke gases for electricity generation.

Data : ENTSO 2017 / UNIGE

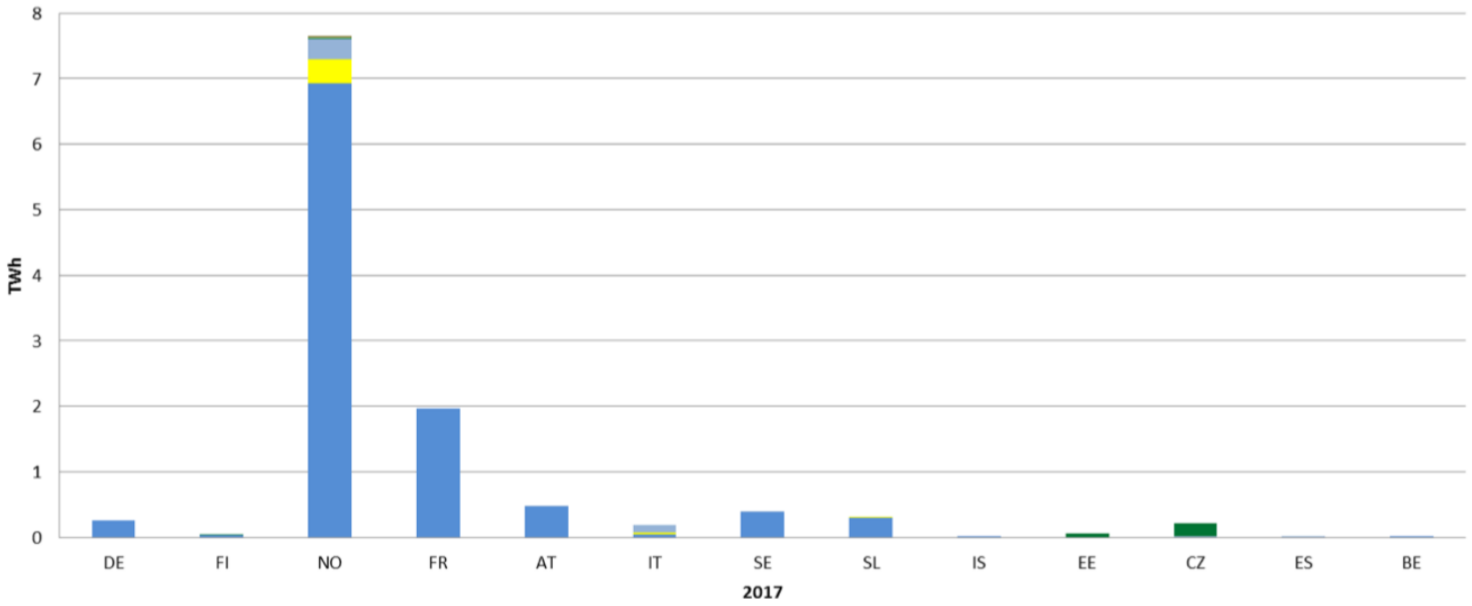
Existing approaches for accounting CO_2 emissions

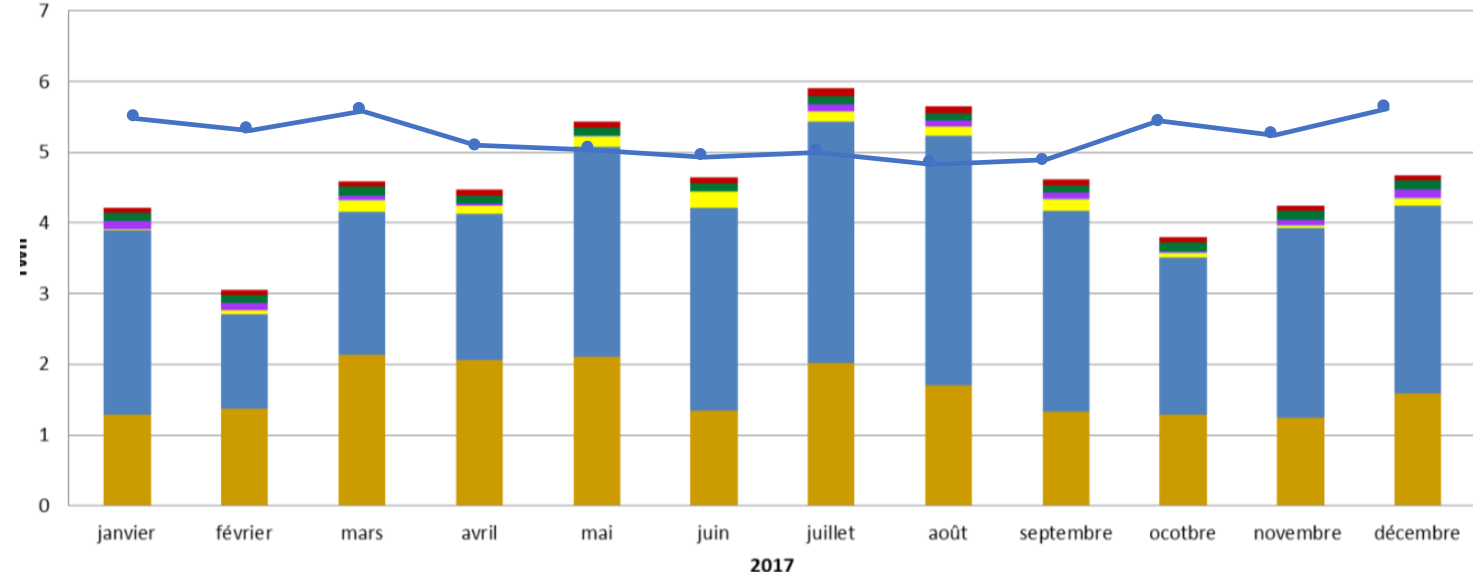
	Emissions responsibility	Domestic generation mix	Imports generation mix	Computational period
Approach A	Production	Average Mix	-	Yearly
Approach B	Consumer	Certified Mix	Certified or European Residual mix	Yearly
Approach C	Consumer	Average Mix	Average Mix for Direct or Indirect flows	Yearly – daily - hourly
Approach D	Consumer	Marginal	Assumptions on imports mix	Hourly
UNGE Approach:	Consumer	Marginal	Marginal	Hourly

Accounting for CO2 emissions is complex

Existing approaches tackle only a specific problem

Limits of the certified mix approach



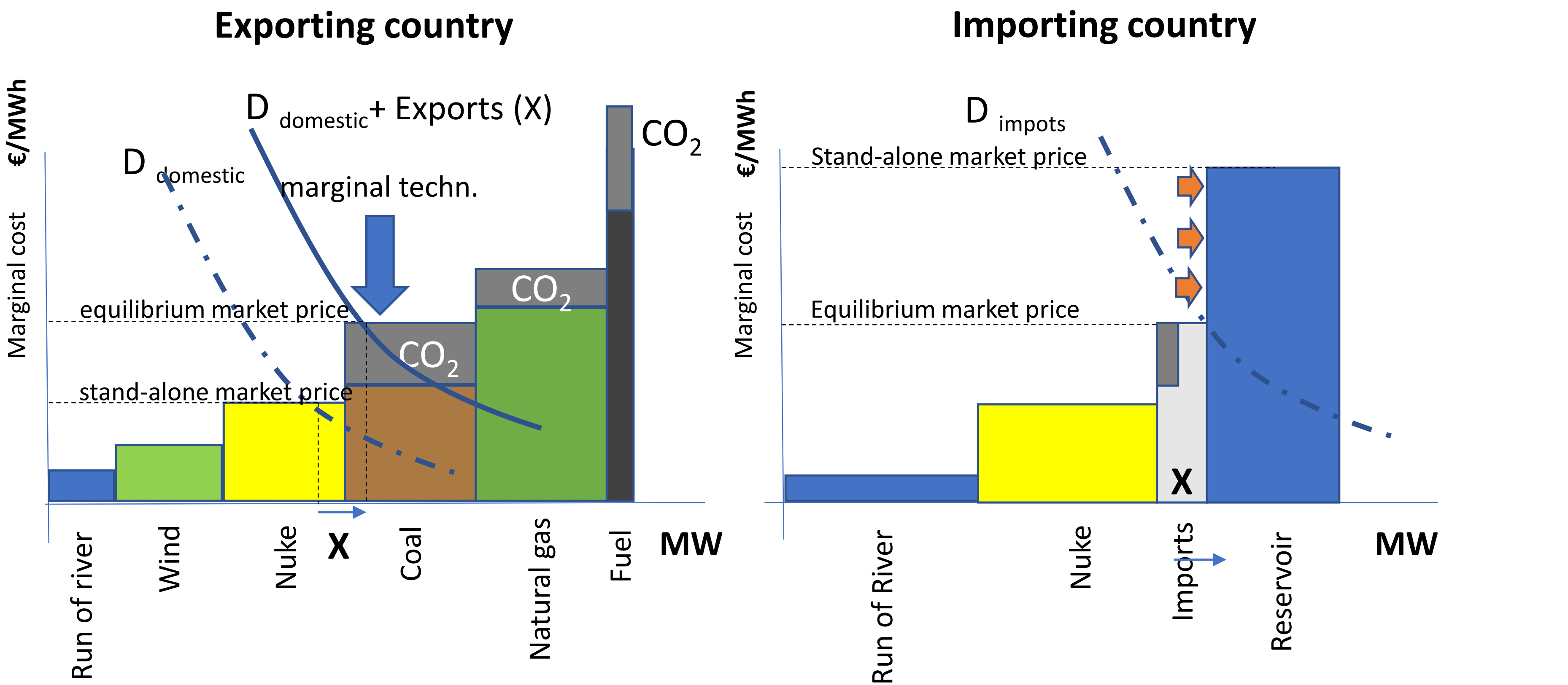


Source : Pronovo 2017

- Some certificates are imported from Norway, or ENTSO-E countries which have no interconnections with CH.

- Guarantees of origin in CH are generated over the summer when consumption (blue line) profile is at the lowest.

Method : Marginal impact of imports on CO_2 emissions



- Electricity is dispatched according to merit order based on the marginal cost of each technology (including CO_2 price)
- Prices and exchanges between countries are defined according to supply and demand for each hour.
- Generation costs in a country are minimized, to satisfy demand, thanks to the optimisation of the power plant program (vs. market prices) and through power exchanges over transmission capacities.
- When imports occurs, the **marginal impact of imports** on the merit order of neighbouring countries could be estimated.

New Data are available at the hourly granularity

- EU Regulation EU N° 1227/2011 & EU N°2013/543, the following data are made available :
    - **Load data**
    - **Network and congestion management data**
    - **Transmission data**
    - **Installed aggregated capacity**
    - **Generation data (dispatch data)**
    - **Market price**
- The data granularity is hourly.

GHG emissions by technologies

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- Values are issued from *ecoivent* database per country
- Life-cycle assesment (kg CO2-eq/kWh) for each technology (including dismantling)

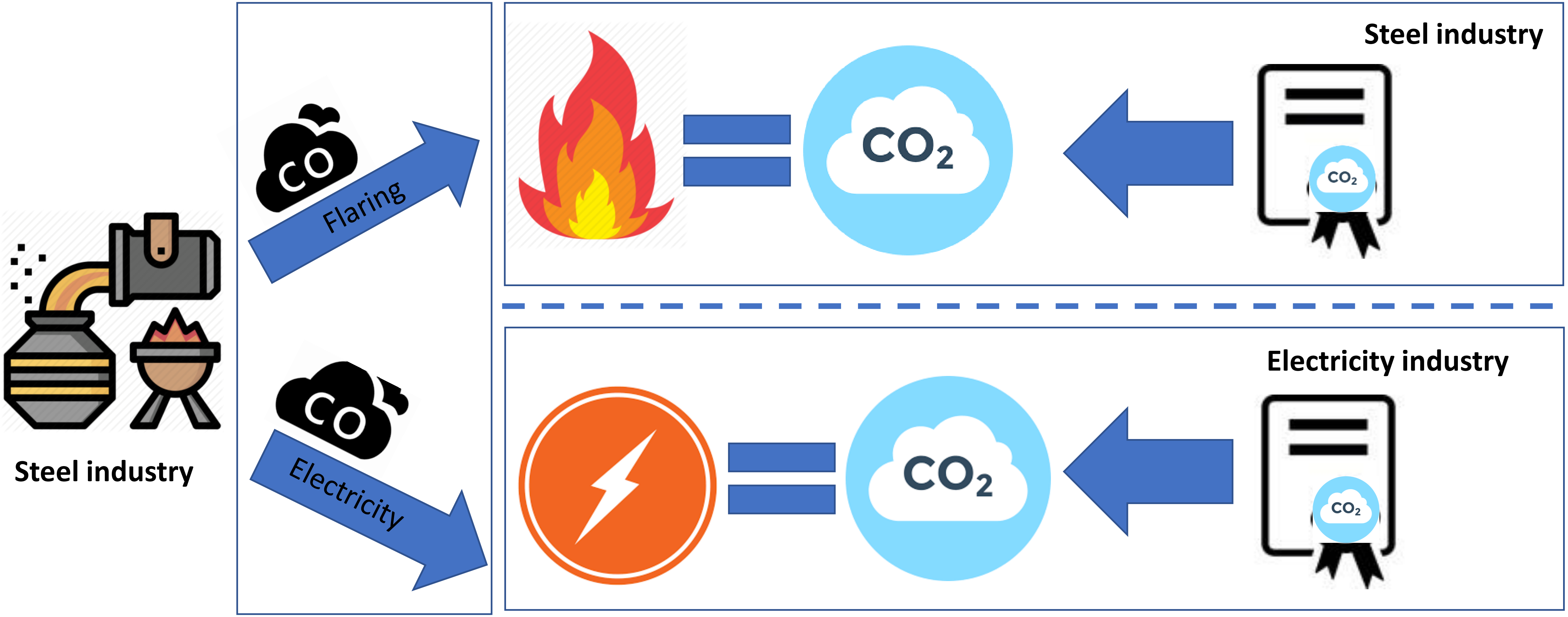
Technology	Life cycle emissions kg CO_2-eq/kWh	Technology	Life cycle emissions kg CO_2-eq/kWh
Wind-on-Shore	0.02-0.04	Municipal waste	0.347-0.568
Wind-off-Shore	0.02-0.03	Coke	0.94-0.96
Solar	0.09-0.12	Combined coal and gas	0.90
Run-of-River	0.005	Gas	0.368-0.701
Geothermal	0.08-0.09	Other conventional	0 (1) -2.9 (2)
Biomass	0.06	Storage hydroelectricity	0.01
Other renew.	0.04	Pumped-storage hydro.	0.42
Nuclear	0.01	Oil	0.864-0.932
Lignite	1.21		

Source : ECOINVENT

- To deal with the issue from blast furnaces gases, two scenarios are considered.
  - **Scenario 1** : Emissions from the blast furnace gases are considered as waste thus zero emissions level
  - **Scenario 2** : Emissions from the blast furnace gases s are accounted on behalf of the electricity sector.

The specific case of furnace German furnace blast

- **CO** is a waste gas from the steel industry. Not direct emissions is allowed (flaring or electricity generation is required)
- Flaring or generation decisions depend on the comparison of the electricity spot prices and the opportunity cost of the CO2 certificates (i.e resell on market).
- Carbon emission are accounted on behalf of the sector who surrender the certificate



Inflows (imports & transits) by border

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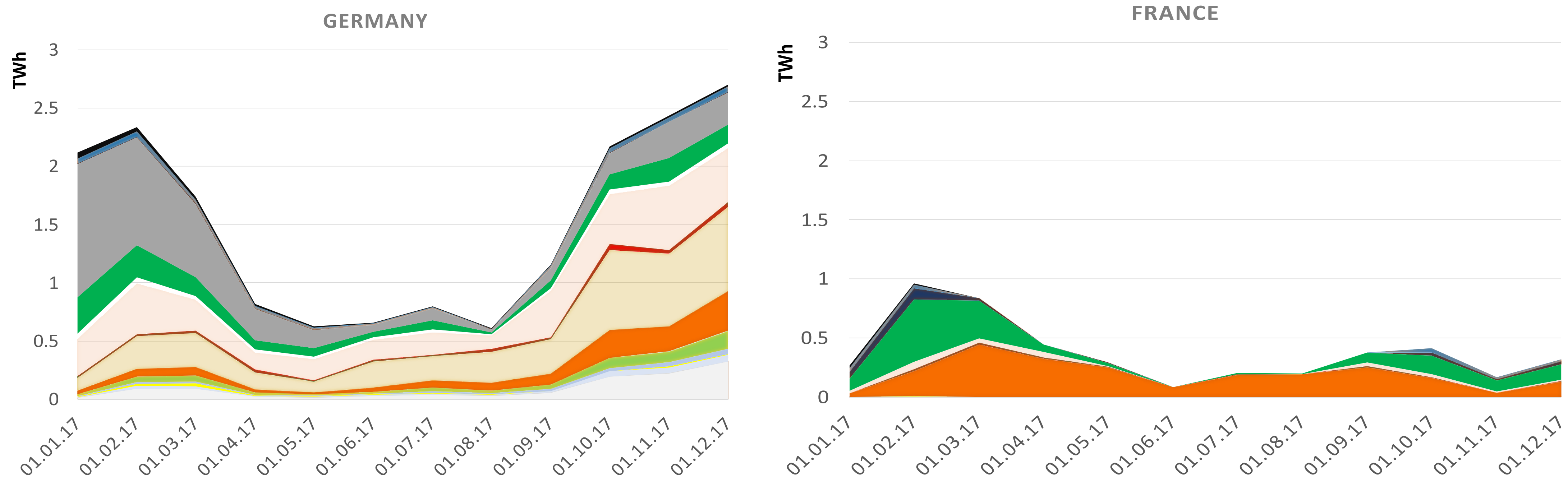
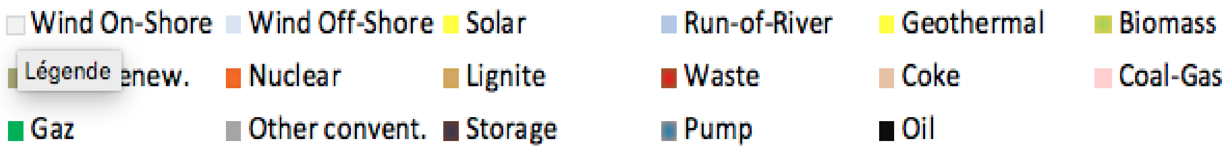


Hourly values aggregated by months



From	Inflows (TWh)
Austria	6.6
France	4.6
Germany	18.2
Italy	0.6

GHG emissions in inflows by technologies

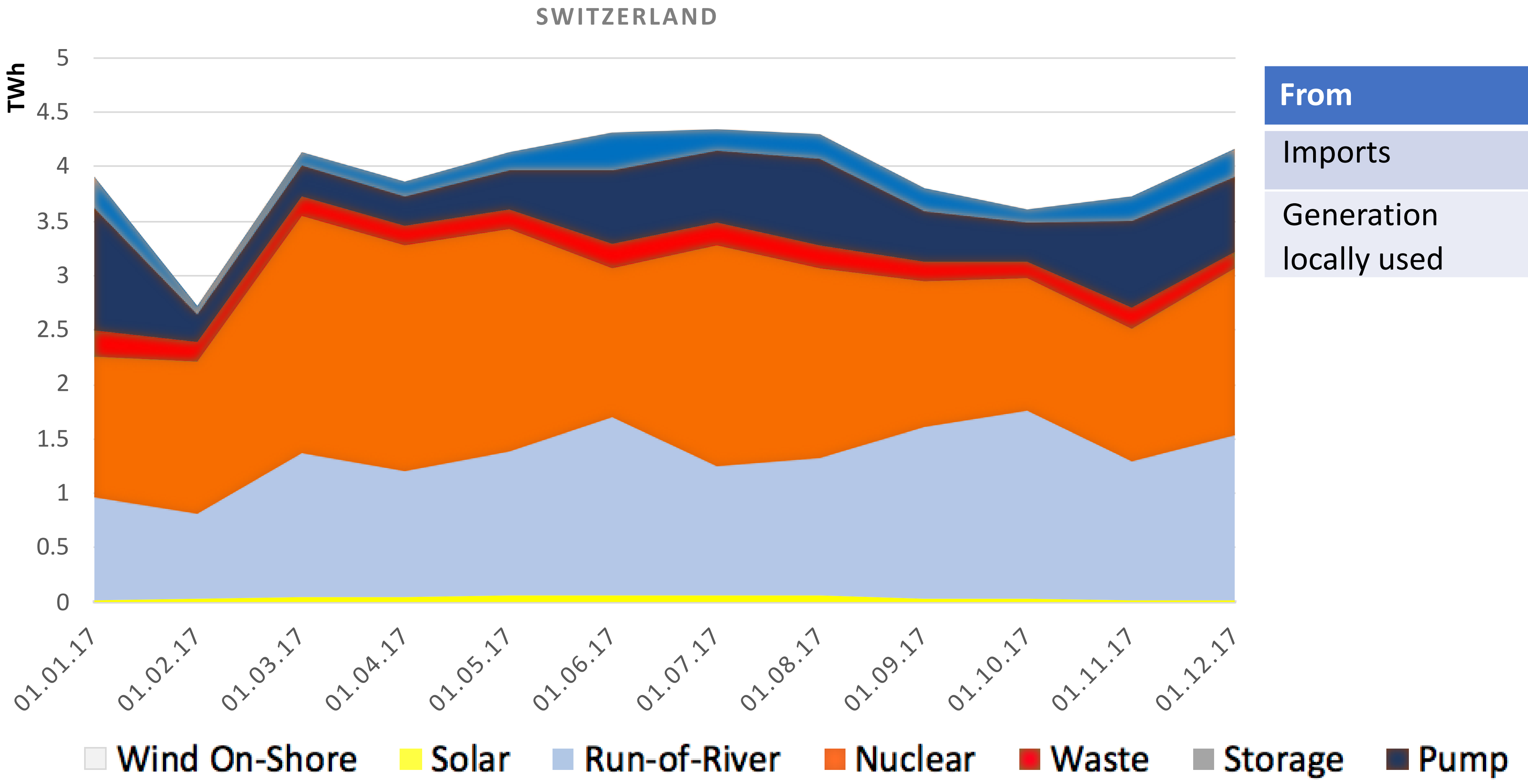
- Emissions tied to the inflows are computed at each border, at an hourly granularity.

Border	Net inflows $E_{in,L}$ TWh	Life cycle emissions (Scenario 1) $M_{in,L}$ M tCO_2-eq	Emissions factor (Scenario 1) $w_{in,L}$ kg CO_2-eq / kWh	Life cycle emissions (Scenario 2) $M_{in,L}$ M tCO_2-eq	Emissions factor, (Scenario 2) $w_{in,L}$ kg CO_2-eq / kWh
Austria	6.6	1.1	0.17	1.3	0.19
France	4.6	1.2	0.26	1.4	0.30
Germany	18.2	9.9	0.54	20.4	1.12
Italy	0.6	0.1	1.20	0.3	1.21
Total / Average	30	12.3	0.41*	23.4	0.78*

(*)annual average values

Table 5: GHG emissions from surrounding countries in inflows - Year 2017

Generation in Switzerland



From	Consumption (TWh)
Imports	11.0
Generation locally used	47.5

GHG emissions : imported and domestic

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	Domestic Consumption TWh	Life cycle emissions $MtCO_2$-eq		Emission factor kg CO_2-eq / kWh	
		Approach 1	Approach 2	Approach 1	Approach 2
Imports	11.0	4.5	9.9	0.409	0.845
Local gen. for domestic use	51.9	2.3	2.3	0.056	0.056
Total / Average	62.9	6.8	12.2	0.108 *	0.196 *

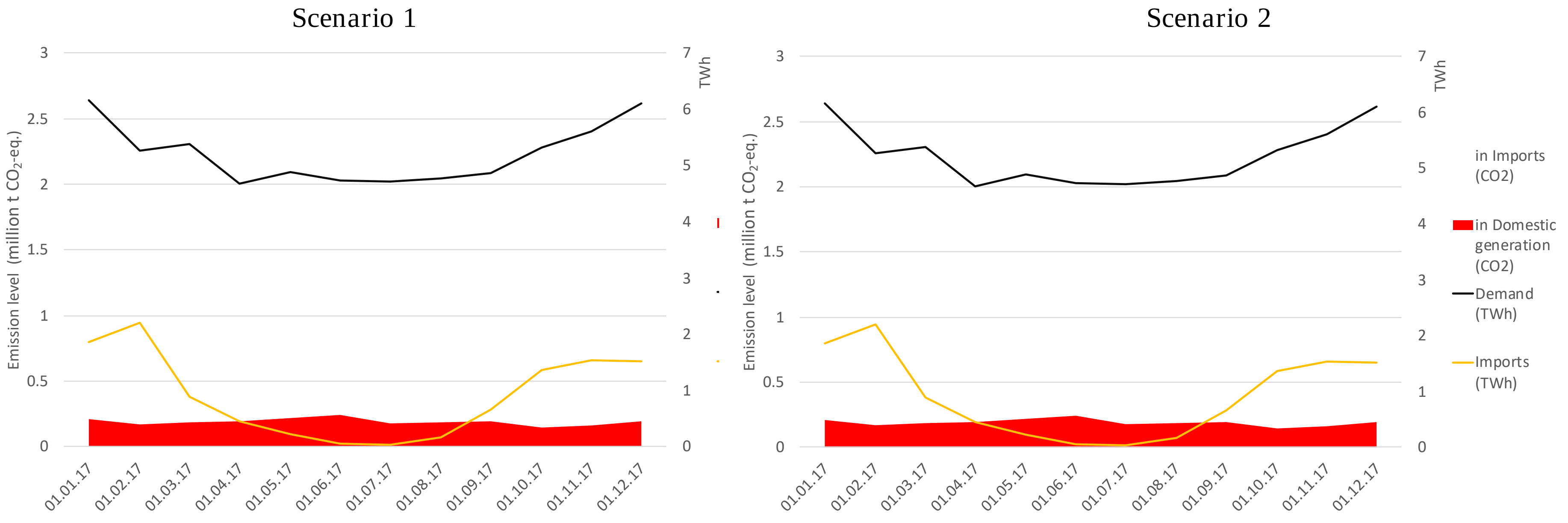
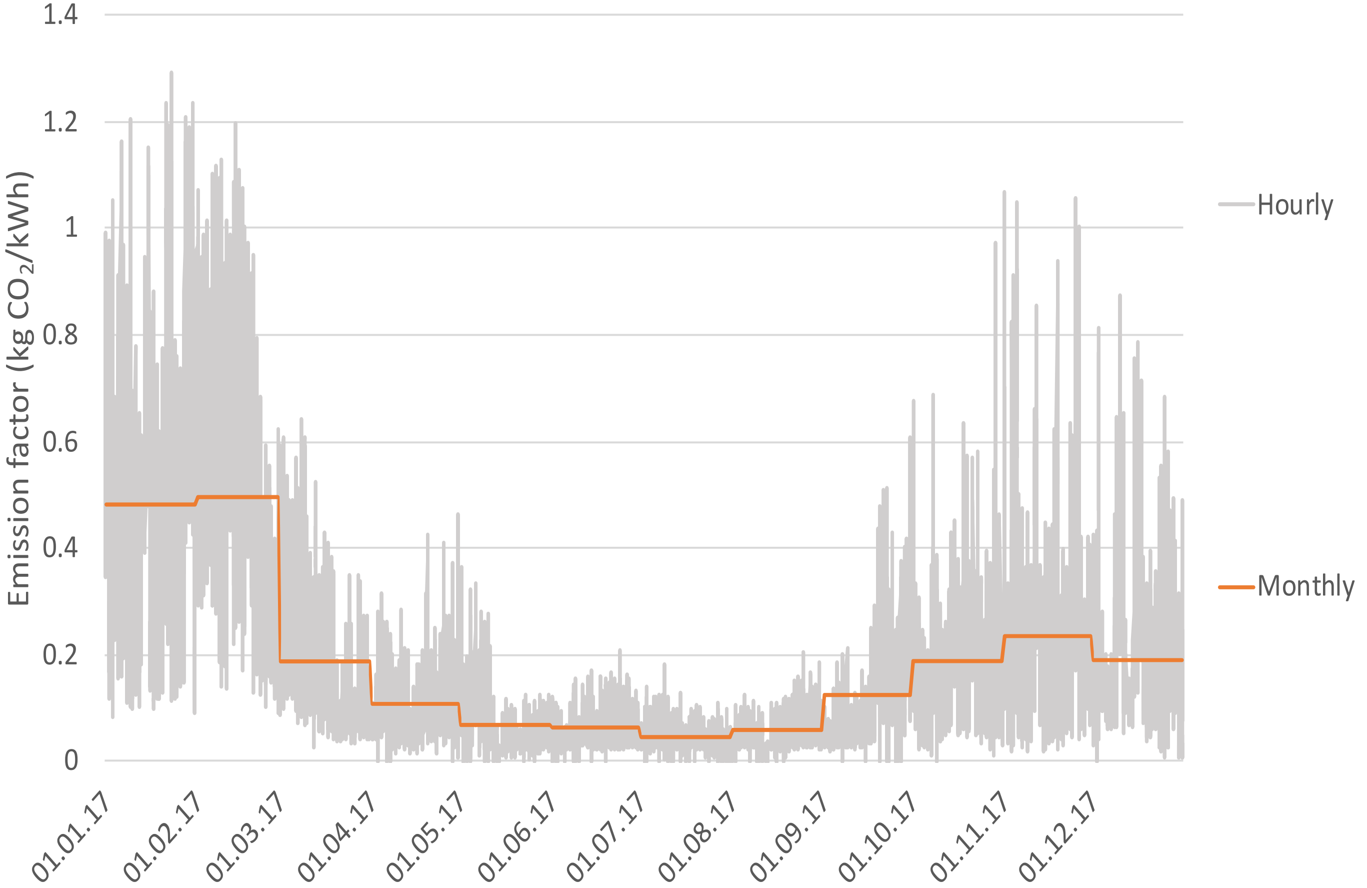


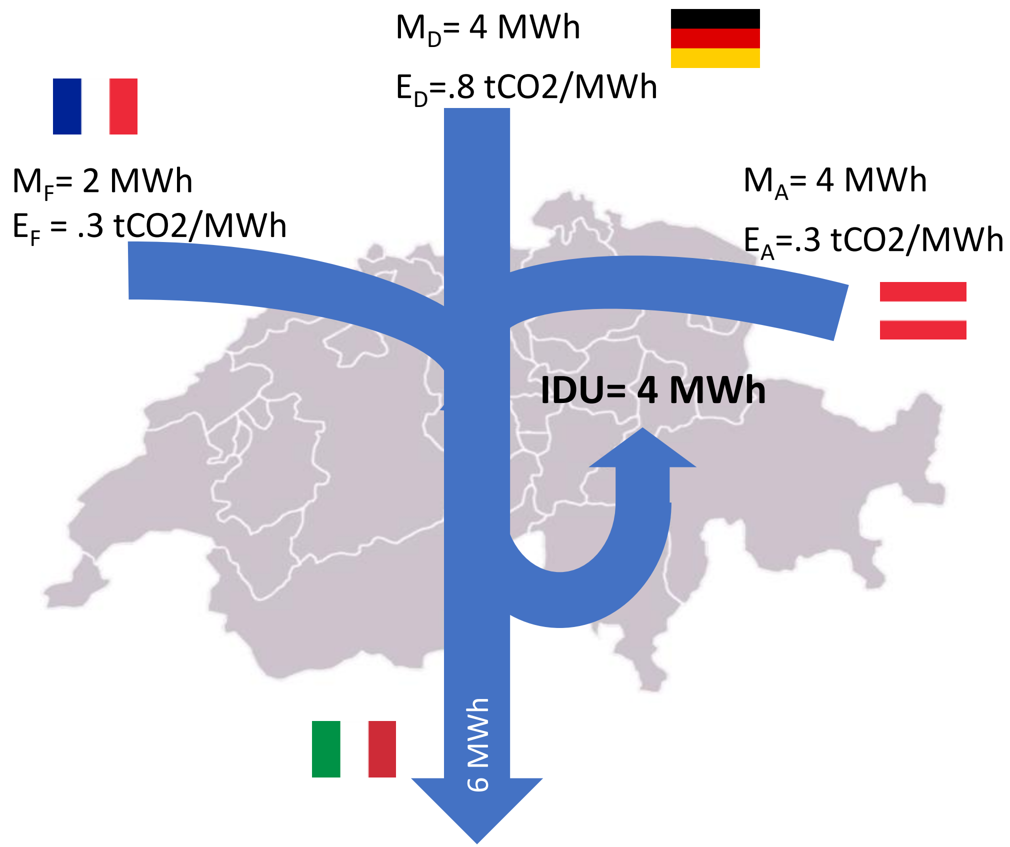
Figure 8: Electricity & CO_2 emissions in Switzerland from netted imports and locally used domestic generation - Year 2017

The GHG emissions differs for both scenarios as furnaces gases played a major role during winter (2016-2017) when European generation capacity were affected by outages (French nuclear) , demand was high, and spikes prices were observed on markets.

CO_2 emissions in Switzerland



Footprint from imports for domestic use at hour h :



Emission factor : 197 g eq CO_2 /kWh
Total emissions : 11.5 Mt eq CO_2

Conclusions

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- Methodology is based on the real time imports and marginal impact of the imports on the generation mix from neighbouring countries
  - → the information could be provided to consumers in real time

- Methodology offers a profile of CO_2 emissions over the year (not only an average value)
  - → Useful for climate policy and energy policy to asses the footprint impact of different electricity process (Heat pumps, Electrical vehicules,…)

  - → useful information to have generation investments in period of time where low-carbon technologies are required

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Thank you for your attention