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Combined Heat and Power (CHP) plants fuelled by natural gas as a power generation solution for the energy transition - impact on the hourly carbon footprint of the electricity consumed in Switzerland



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Introduction:

Switzerland has committed to a transition to a low-carbon energy system

Energy Strategy 2050

- Promotion of new renewable energy
- Hydraulic power

- Nuclear phase-out

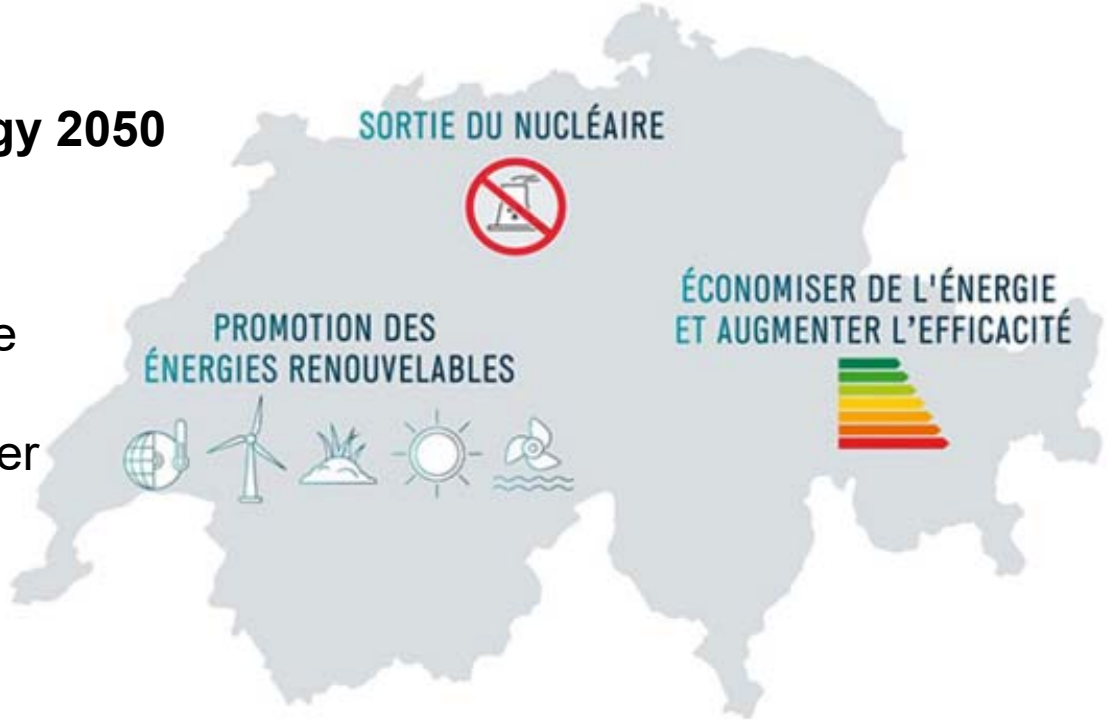

Figure 1: Energy Strategy 2050 (OFEN, 2013)

Saving energy and increasing efficiency

- Buildings
- Mobility
- Industry
- Appliances

Introduction:

Switzerland will have to replace 35% of its electricity production

- Nuclear phase-out : replacement of 35% of domestic power production
- Long-run: compensated by development of RE and reduction in consumption
- Short-run: importation ?
- Elcom: dangerous winter dependency :
    - threat to the security of supply
    - majority of imports are of fossil origin
        - → a substantial part of this missing winter production continues to be produced in Switzerland

→Need a temporary solution to produce electricity during winter in Switzerland

Combined heat power-plant (CHP) fuelled with natural gas can be a short-term solution ?

Research questions

1) What is the impact of the electricity inflows from neighbouring countries on the hourly carbon footprint of the electricity consumed in Switzerland ?
2) How the replacement of a part of the inflows from neighbouring countries by Combined Heat and Power (CHP) fuelled with natural gas impacts the hourly carbon footprint of the electricity consumed in Switzerland ?

Methods

The four parts of the research process

Methods:
Consumption accounting principle (C=Prod+Imp-Exp)
Attributional Life Cycle Analysis (ACLA)

Data :
- Ecoivent version 3.7.1
- ENTSO-E Transparency platform

Scope :
Only exchanges with first ring countries (direct neighbours i.e. Germany, Austria, Italy, France)

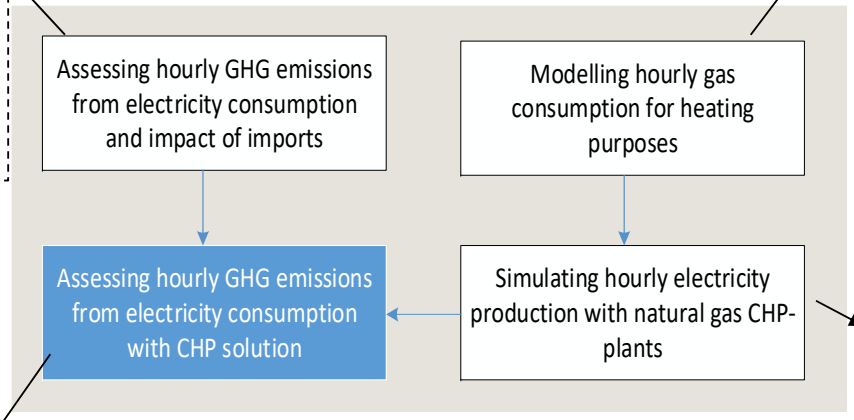

Figure 2 : The four parts of the research process

Methods:
Top-down econometric approach using heating degree hours according to the Swiss SIA standard 381/3

Data :
Data made available by the company which supplies and transport high-pressure natural gas to Western Switzerland

Methods:
- Top-down approach
- Heating demand had to be covered by thermal output
- CHP plant considered as linear-model : an energy converter with fixed electrical and thermal efficiencies

CHP Parametrization:
- From Ecoinvent 3.7.1 (electricity generation with CHP in Switzerland)

Methods:
Conditional attribution :
Electricity produced replace first imports (independently from the country of origin)

Results

Imports from Germany impacts strongly the carbon footprint of the electricity consumed in CH

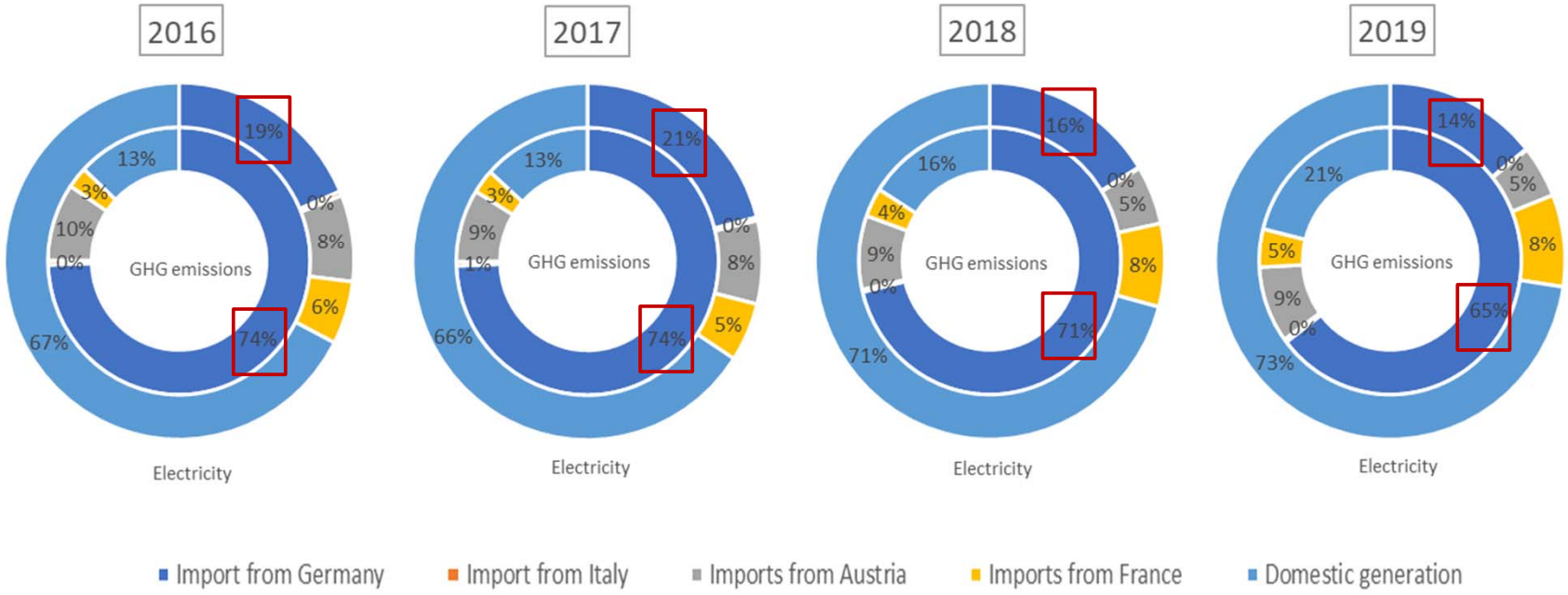

Figure 3: Source of the electricity consumed in Switzerland and its related GHG content

Results

Share of coal an lignite in the German generation mix is constantly decreasing

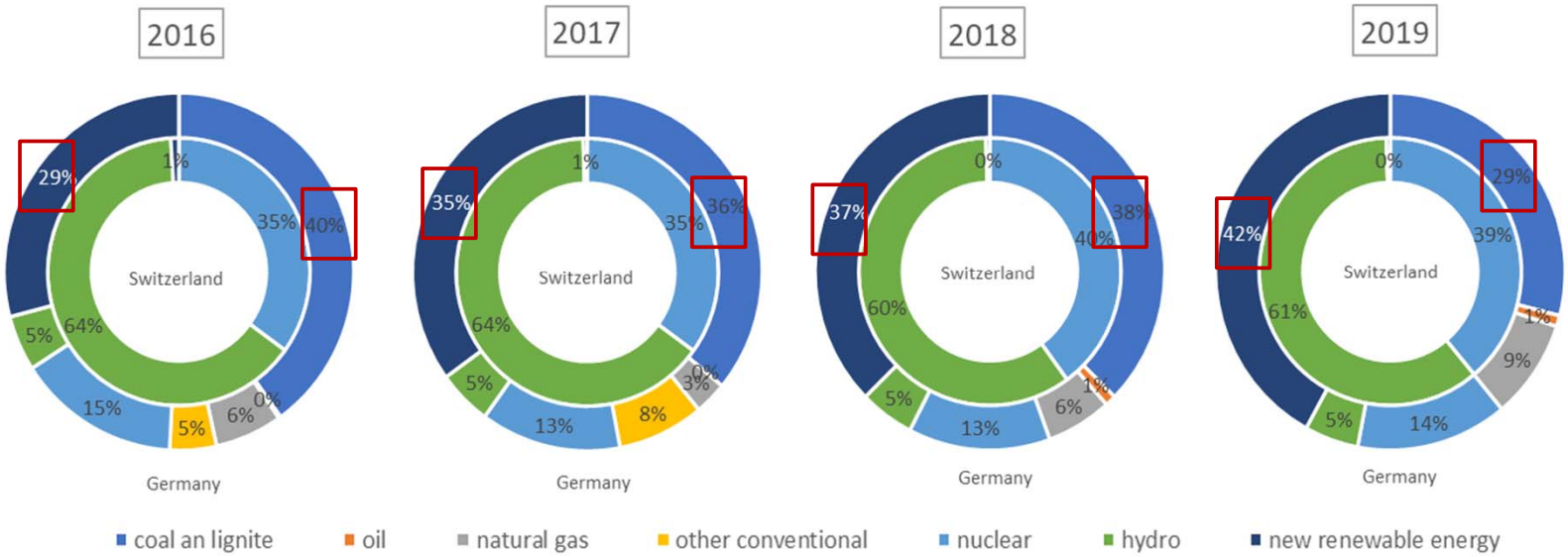

Figure 4: Switzerland and Germany Generation Mix

Results

Variation between summer and winter carbon footprint is really important

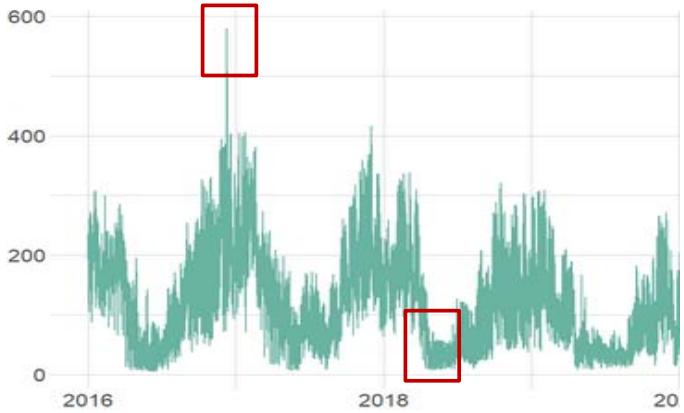

Figure 5: Hourly emission factor of the electricity consumed in Switzerland (in g CO2eq/kWh)

Year	$EFCons_{CH}$ (g CO2eq/kWh)	$EFCons_{CH}^{New}$ (g CO2eq/kWh)	Variation (%)
2016	143,58	133,76	-6.83
2017	150,83	140,84	-6.62
2018	118,18	114,36	-3.23
2019	94,36	95,37	1.07

Table 1: Actual emission factor of the electricity consumed and results of the CHP simulation

Results

CHP could produce nearly 10% of the electricity consumed in Switzerland

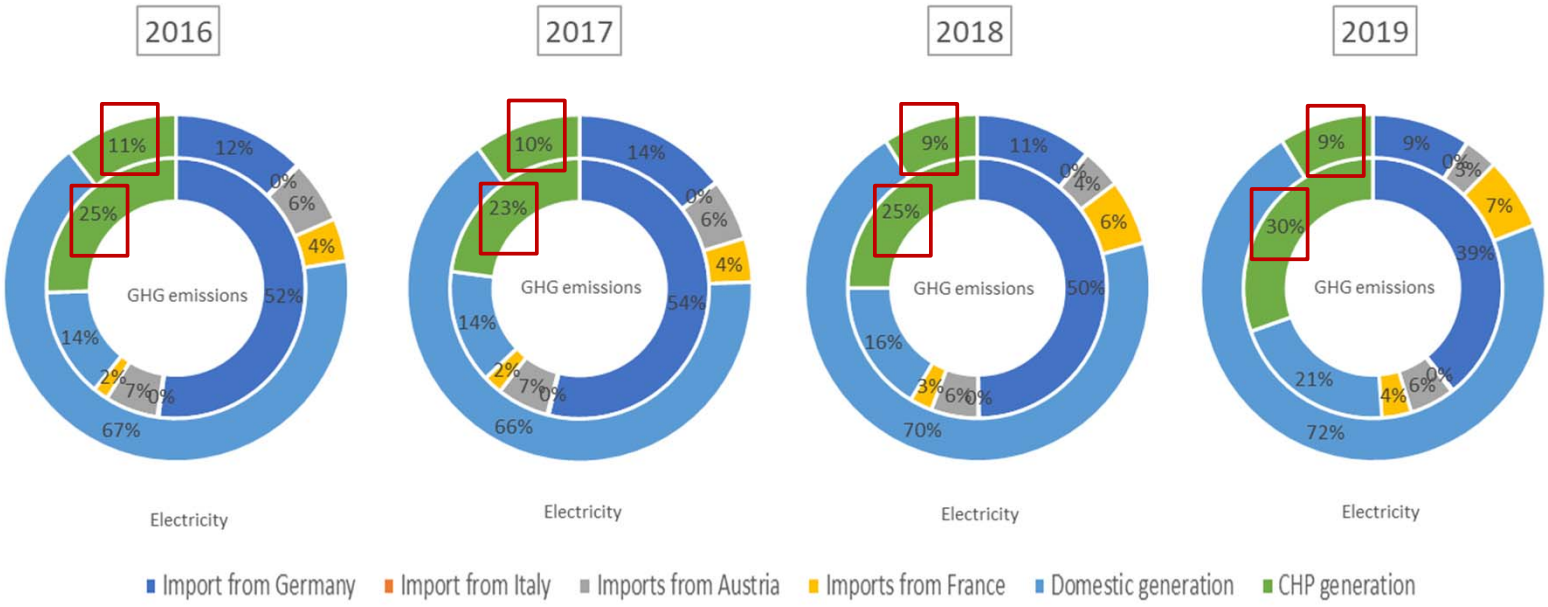

Figure 6: Source of the electricity consumed in Switzerland and its related GHG content after the CHP simulation

Conclusion

What we did:

- Adoption of an hourly approach to evaluate the hourly carbon footprint of the electricity consumed in Switzerland (2016-2019)
- Measurement of the impact of the electricity imports from neighbouring countries (DE, FR, AT, IT)
- Simulation of how the deployment of CHP fuelled with natural gas would impact this carbon footprint

Results:

- Swiss dependency on electricity imports during winter has a non-negligible impact on the environment
- Heavily impacted by imports from Germany and its coal-based power production
- The range between which the carbon footprint varies through time is huge (winter vs summer)
- CHP solution examined in this study could represent a short-term solution to produce power in Winter on the swiss territory

Further research:

- Effect of nuclear phase-out should be further explored
- Cost and feasibility of deployment such a solution

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Questions

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