85th LCA Discussion Forum
Zürich, 9 November 2023

Harmonising the electricity model for buildings in Switzerland

Intermediate results from the ongoing project
“Net zero whole life GHG emissions related to buildings”
on behalf of the Swiss Federal Office of Energy
which is gratefully acknowledged

Martin Jakob, TEP Energy, Zurich

Goal of the project *Netto-Null THGE Gebäudebereich*

TEP Energy and Carbotech on behalf of the Swiss Federal Office of Energy

Elaboration of a **common definition** of «**Net-Zero** GHG emissions related to **buildings**» for Switzerland

Accepted by **all actors**

EnDK Konferenz Kantonaler Energiedirektoren
Conférence des directeurs cantonaux de l'énergie
Conferenza dei direttori cantonali dell'energia
Conferenza dals directurs chantunals d'energia

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
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sia

NNBS

MINERGIE®

Stadt Zürich

F0: Methodological issues

F1: Top down

Need, compatibility

Techn./econ. potentials

F2: Bottom-up

Massnahmen

Techn./ökon. Potenziale

F3: Policy implementation

Feasibility, acceptance

Need

F4: Limits and targets

Research questions F0: Methodological questions

Overview

- F0.1: Emissions budget
- F0.2: Balancing principle: moment of investment vs. pay-off (at which life-time/service life)?
- F0.3: Negative Emission Technologies (NET)
- F0.4:
  - Re-use and recycling of materials at the end of the service life
  - feed-in of electricity produced on buildings to the grid
- *F05: Impact of F0.4 measures on decarbonisation pathway and net zero goal*
- **F0.6: Boundary conditions and methods operational phase**

  a) Accounting of supply contracts and certificates of orgin vs. system-analytical determination of the electricity mix and the emission coefficient of electricity

  b) How to model the Swiss electricity mix?

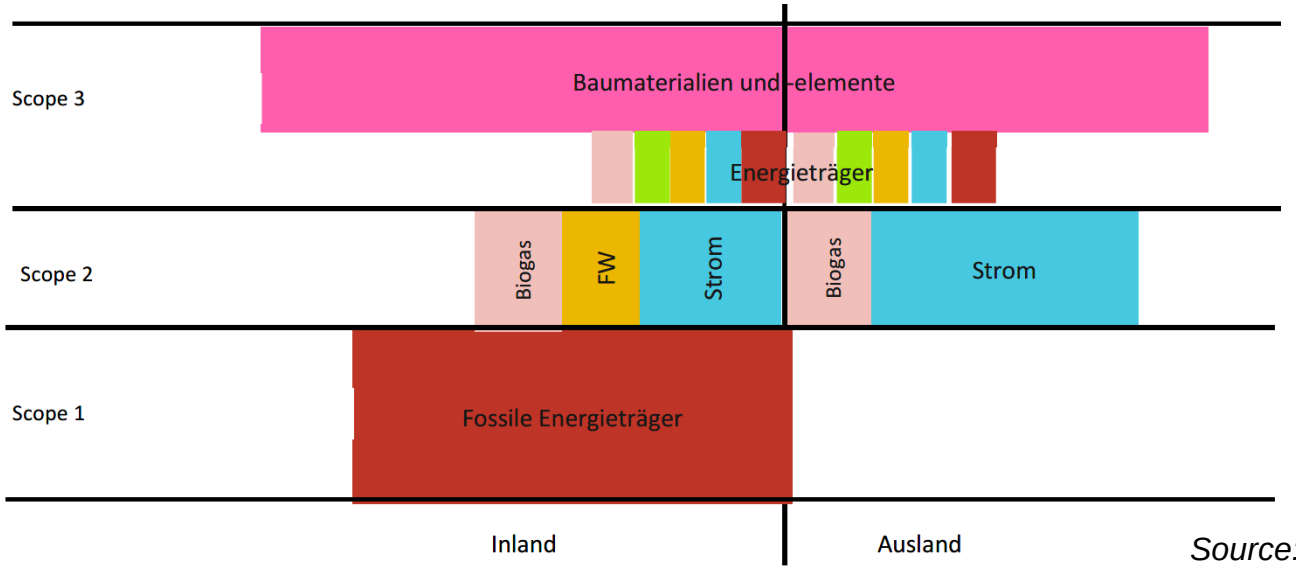
  c) Taking future developments into account or not?

Electricity model in building related LCA

Situation and relevance today

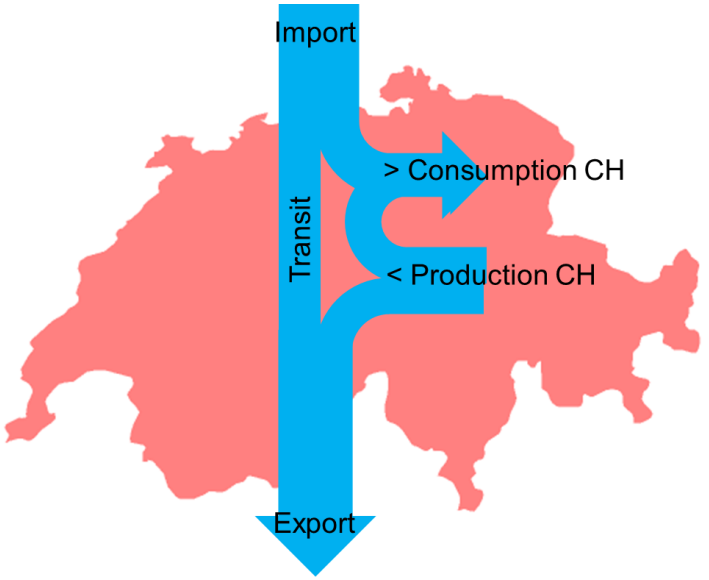
- Electricity related emissions are relevant at (all) different building phases
- Electricity is heavily traded btw. Switzerland and Europe

GHG emissions related to buildings (schematic)



Source: TEP Energy

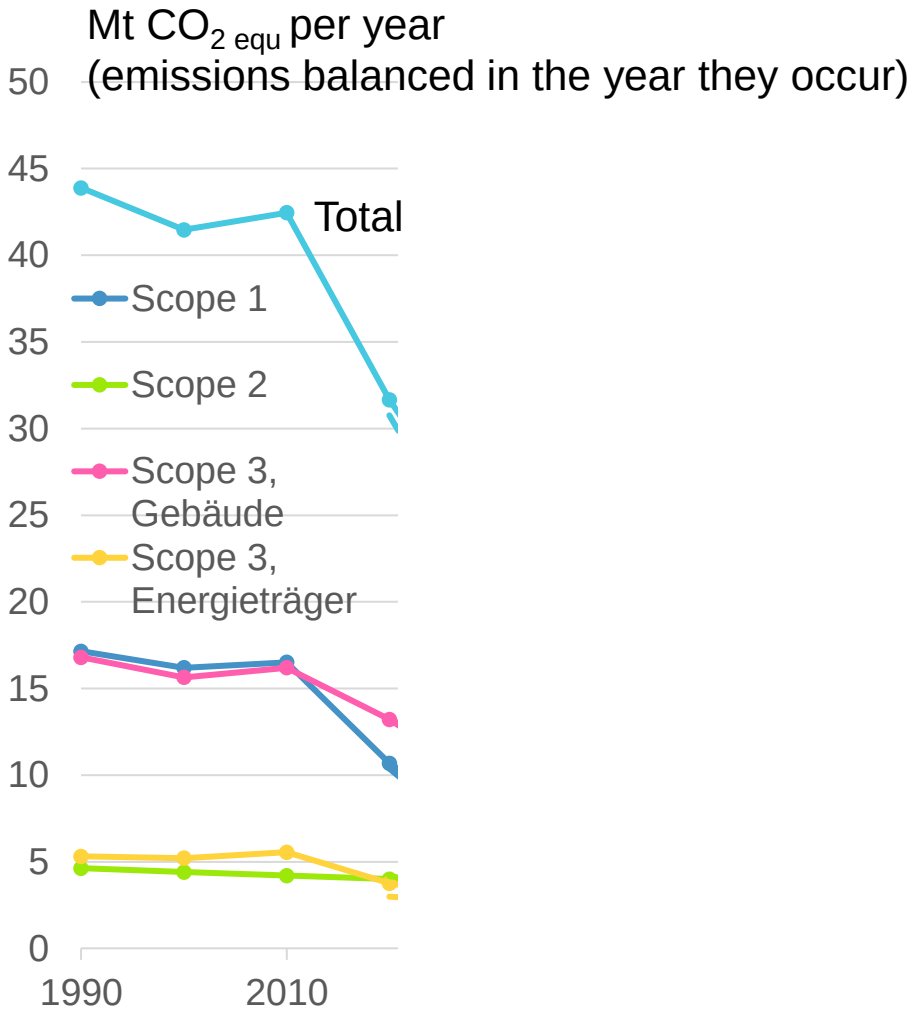
Electricity production, trading, and consumption



Electricity model in building related LCA

Situation and relevance today

- Relevant shares of energy consumption and GHG emissions are attributed to
  - buildings and
  - the related energy system (transmission sector & conversion sector)
- GHG emissions are stemming from the following relevant sources
  - direct emissions from fossil energy use (scope 1)
  - upstream emissions e.g. from the electricity and district heating generation and from primary energy carrier extraction and processing (scopes 2 und 3)
  - embodied emissions from the production and processing of construction materials (scope 3)

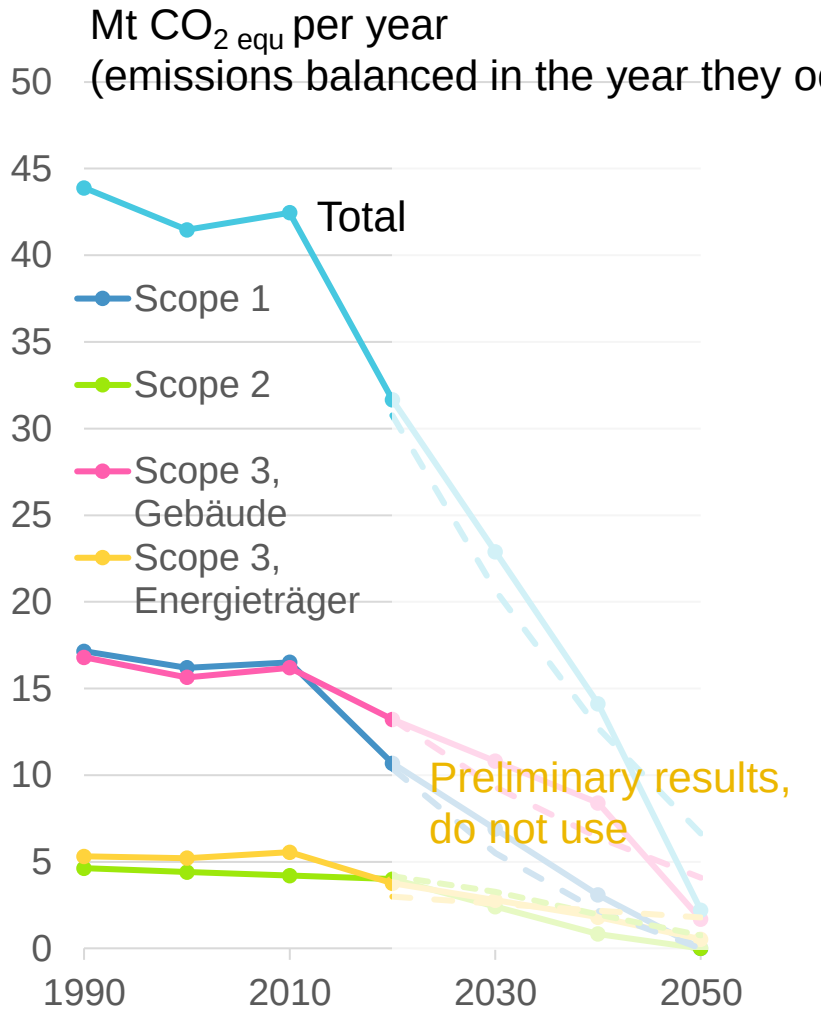


Source: GHG inventory of Switzerland, complementary estimates by TEP Energy

Electricity model in building related LCA

Situation and relevance in the future

- **Net zero GHG emissions** from buildings and the related energy and the construction sectors:
  - Reduction down to close to zero
  - Remaining emissions need to be extracted from the atmosphere (and from the hydrosphere
- **High dynamics** by 2050:
  - direct emissions from fossil energy use <u>to be avoided completely</u>
  - upstream emissions e.g. from the electricity and district heating generation , <u>to be avoided (almost) completely</u>
  - embodied emissions from the production and processing of construction materials <u>to be avoided to a large extent</u>



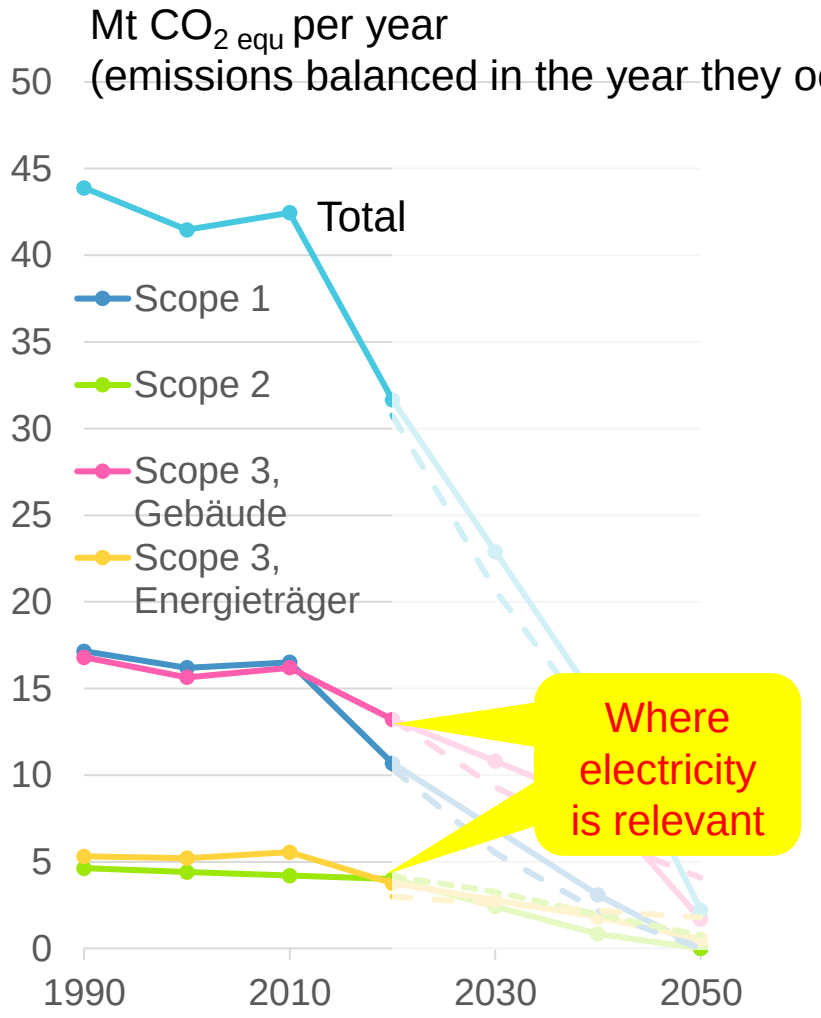
Source: GHG inventory of Switzerland, complementary estimates by TEP Energy

Electricity model in building related LCA

Situation and relevance today

Electricity is a key factor in the transition process, namely, to displace GHG emissions:

- from the buildings‘ **operational phase**
  (individual and large-scale heat pumps, perhaps production of synthetic fuels and gases)
- from the **buildings’ construction and end of life phases**
  (large-scale heat pumps, electric motors, synthetic fuels and gases, and others
  to process materials and building elements and to drive the construction process)



Source: GHG inventory of Switzerland, complementary estimates by TEP Energy

Electricity model in building related LCA

Given the **current situation** and **expected / needed developments**,
the following issues need to be addressed:

1. Purchased quality (certificates of origin (CO), HKN) vs. relevant production (incl. trading)?
2. Which balance model for the Swiss electricity mix?
    a) BM1 to BM4 (see separate slide)?
    b) Commercial trade or physical cross-border electricity flow?
3. Consider future development of electricity mix for building LCA (individual buildings, sites) or not?
4. Average mix or marginal effect?

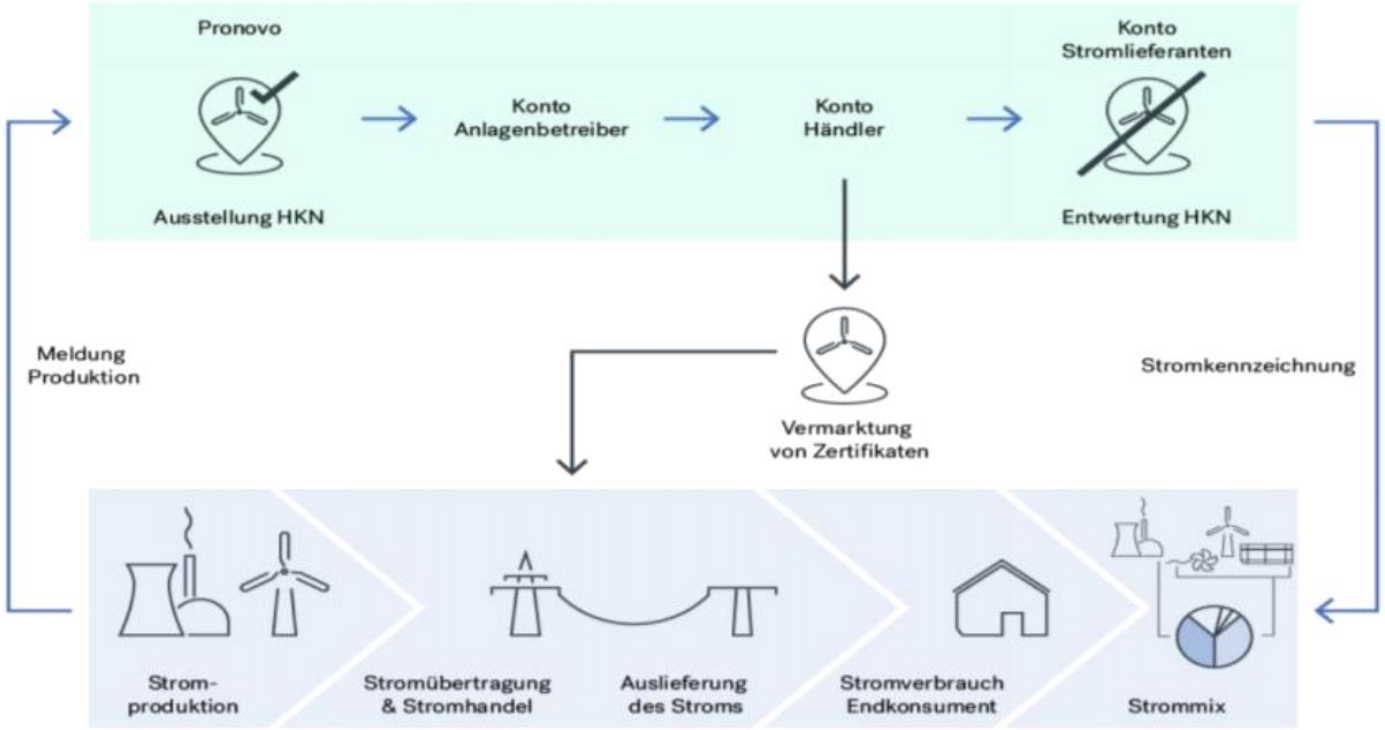
Certifactes of origin (CO) or not?

Purchased quality (CO) vs. relevant production?

RQ F06.A

Purchased quality (certificates of origin (CO)) vs. relevant production (incl. trading)?

- CO are decoupled too much from electricity related commercial activities
- Swiss CO are no longer accepted in the EU, EU CO are accepted in Switzerland
  - Imports of CO, e.g. from Norway
  - Availability (too) high at (too) low costs
- CO provide (too) little incentive for investment decisions in favour of renewables
- CO are not available for (long-term) future electricity consumption

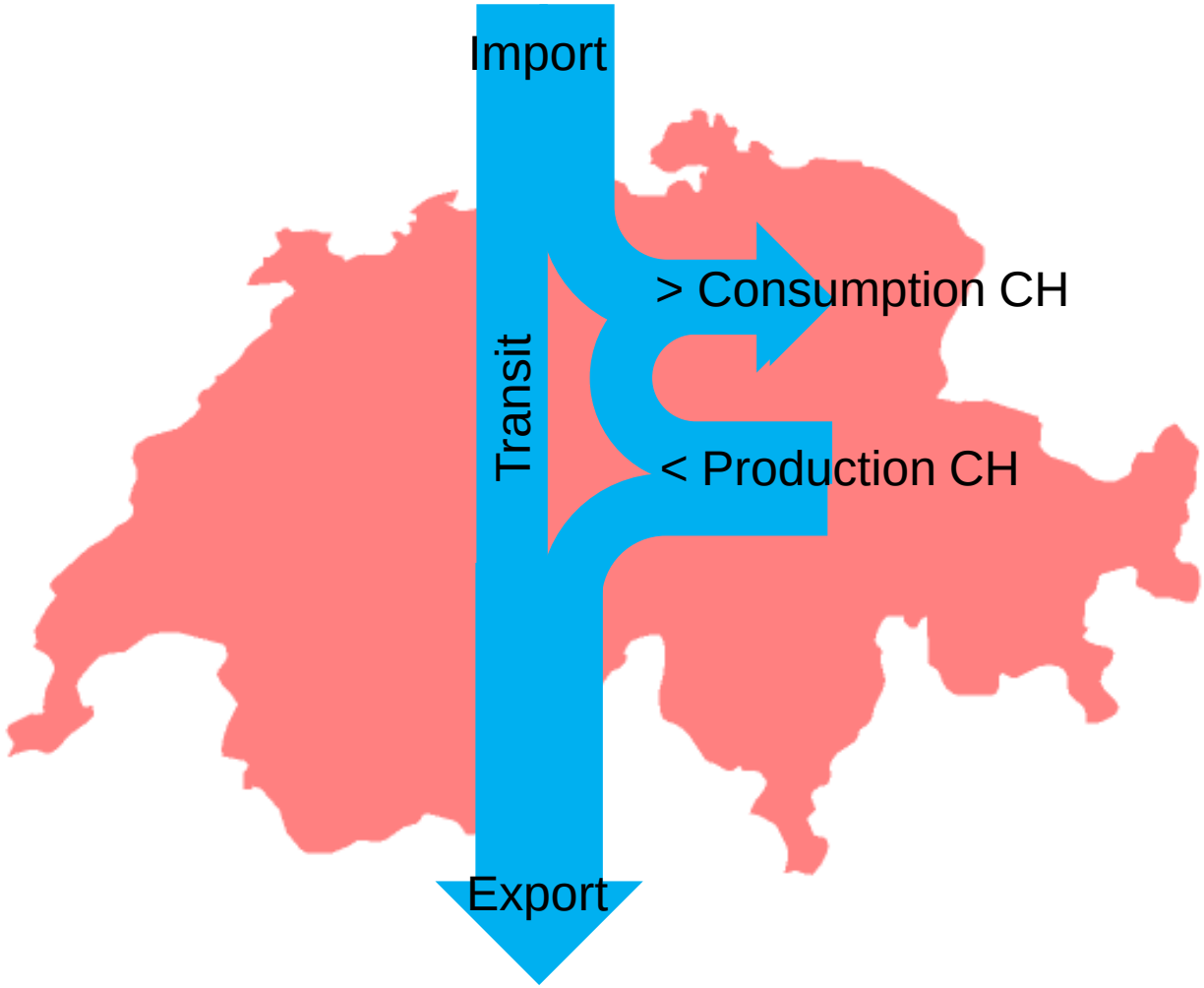


https://pronovo.ch/de/herkunftsnachweise/information/informationen-zu-hkn/

Modelling of the current electricity mix

Modelling of the electricity mix relevant for Switzerland

RQ F06.B



- Large amounts of net import and export at hourly time scale
- Strong fluctuation (seasonally, hourly)
- Questions:
  - Which part of the imported electricity is used in Switzerland, which part of transit?
  - Which part of the Swiss production is used domestically, which part is exported?
  - Relevance of transit

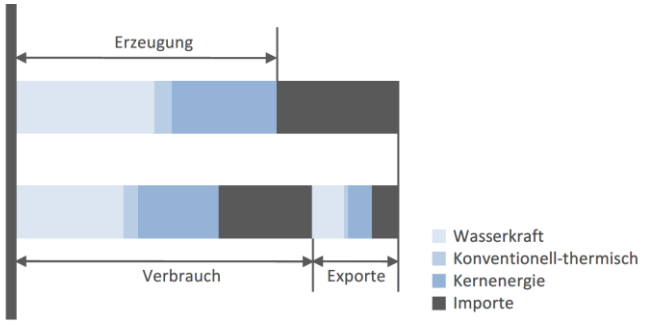
F0.6A Modellierung Strommix Schweiz, Ist-Zustand

4 possible balance methods (BM), yearly, monthly or hourly

BM1: Consumer mix = Production mix

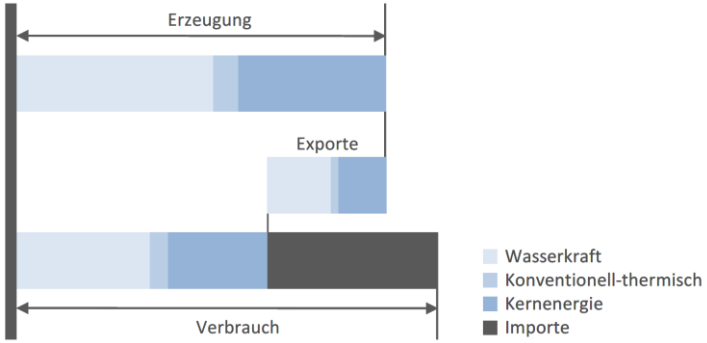
BM2: Mix of production + imports

Consumer mix
= Production mix
+ imports



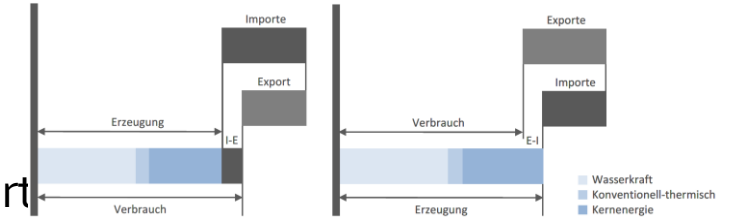
BM3: First Export, then imports

Consumer mix
= Domestic production
– gross exports
+ gross imports



BM4: Net imports and export, rest is transit

Consumer mix
= Domestic production
– hourly net export
+ hourly net import



Quelle: Ménard et al. 1998, representation TEP Energy

Electricity balance model for Switzerland

Assessment of the stakeholder group

Methodological variants	Suitability for net zero target: Climate policy 2050 Climate impact long-term	Incentives for actors (to increase el. efficiency)	Discussion / input steering group
BM1: Consumption mix = Production mix Switzerland	No, too much simplification	• Low incentive for electricity efficiency, as CH mix has low GHG. • High incentive for the substitution of fossil fuels with electricity-based applications.	Consens: No to pursue any further
BM2: Consumption mix = Mix Production +imports	Yes (yet endowed with uncertainties)	Medium to high (btw. BM3 and BM4)	Uncertainties in «both directions» (as opposed to BM3 and BM4) => useful compromise
BM3: Consumption mix = Domestic production minus exports plus imports (Model for building LCA according to KBOB-Empfehlung 2009/1)	Yes (yet endowed with uncertainties)	High incentive to use electricity wisely and efficiently, as the consumer mix has relatively high GHG emissions	Maximal variant. Fazit: BM3 as reference method for further research modules
BM4: Consumption mix = domecstic production – hourly export balance + hourly import balance	Yes (yet endowed with uncertainties)	• Medium-low for electricity efficiency • Medium for substitution of fossil fuels with electricity-based applications, as GHG-EF medium-low	Minimal variant

Source: adopted from Jakob and Stettler (2023)

Legend

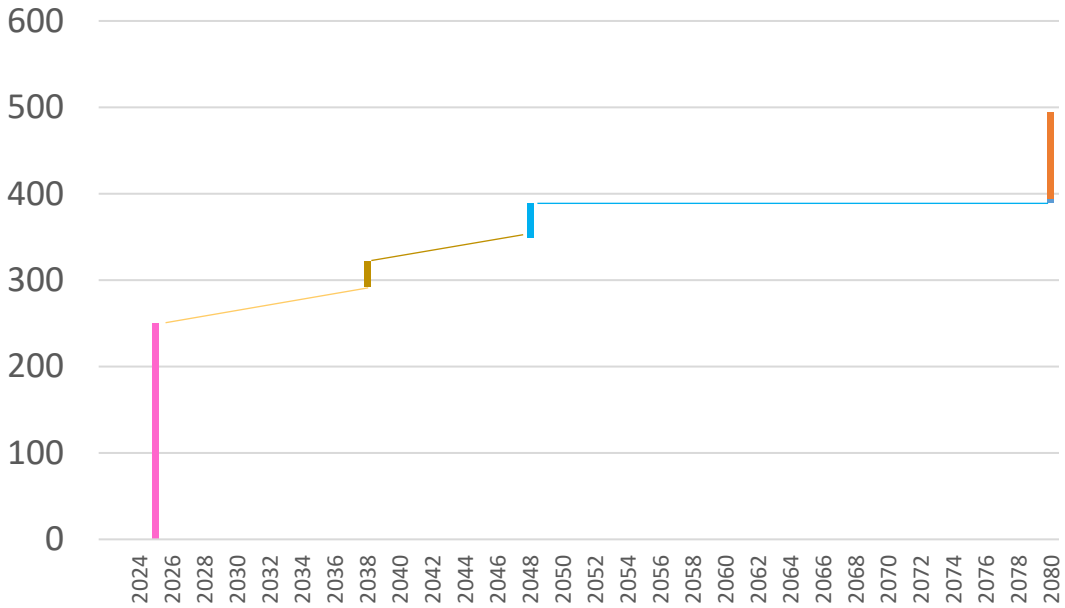
Pursue further in any case	Pursue further (at least in the upcoming research modules, to explore effects and consequences)	No to pursue any further

Current or future electricity mix?

Emission balancing: Annualized per year or cumulated

New buildings

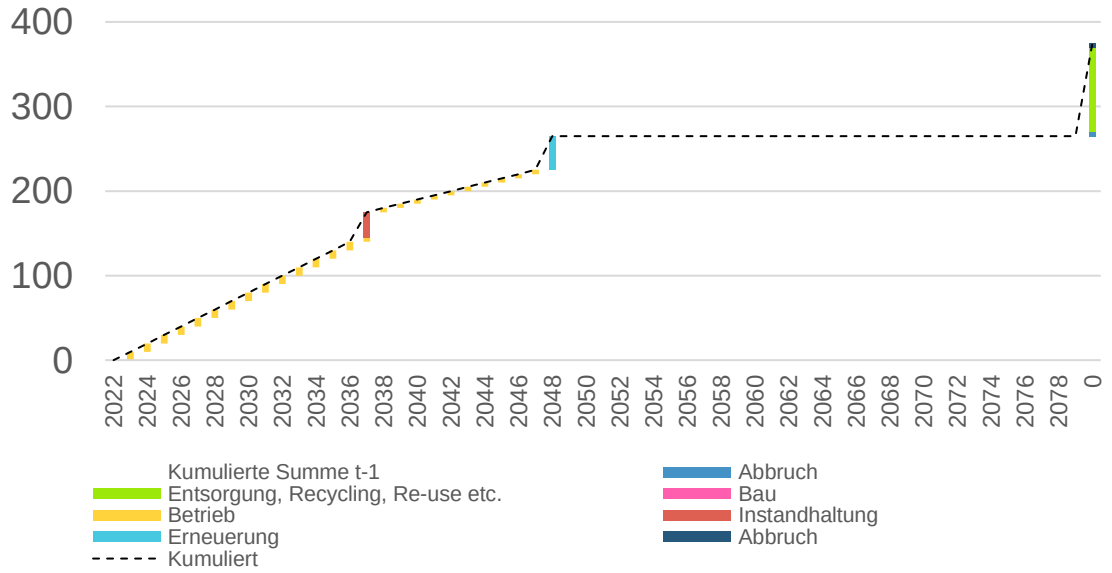
Cumulative: kg/m²



Source: Schematic representation TEP Energy

Existing buildings

Cumulative: kg/m²

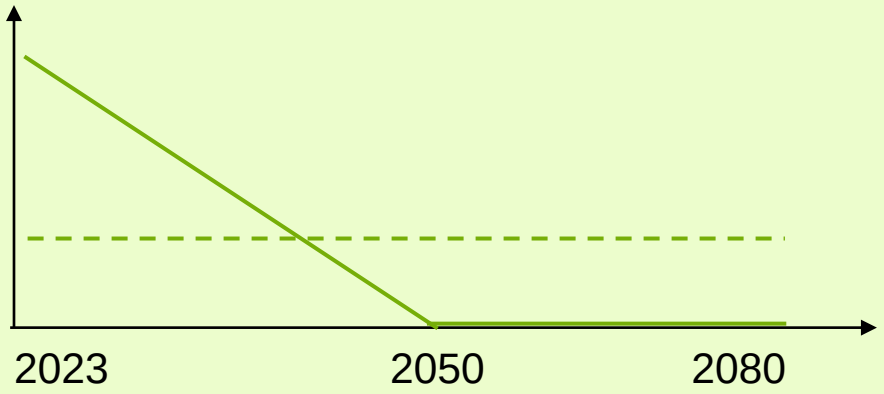


Electricity model in building related LCA: current situation or future development

F0.6B

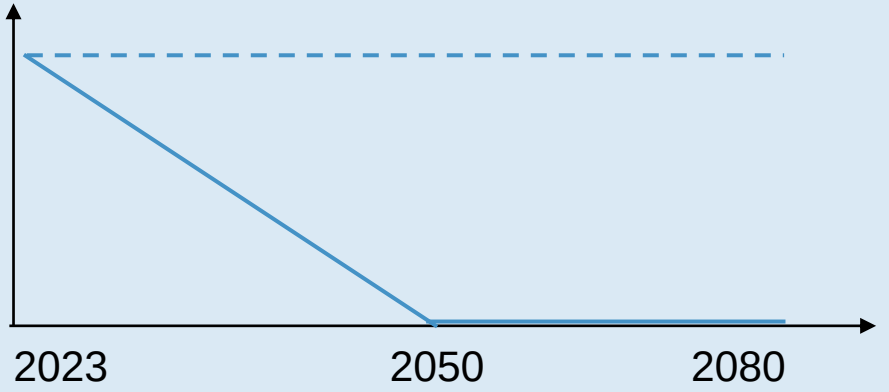
Proposal: dynamic

Use average between today and future (e.g. 2050 or depending on assumed service life)



Alternative: static

Static: current mix for the whole operational phase



Reasoning for the proposal: Electricity using building technologies (incl. HP) do have a relatively long service life (up to 2050 or beyond) and electricity generation in Switzerland and in Europa must and will change

Source: TEP Energy

Electricity model: static vs. dynamic

Assessment of the stakeholder group

Methodological variants	Suitability for net zero target: Climate policy 2050 Climate impact long-term	Incentives for actors (to increase el. efficiency)	Discussion / input steering group
M1: Static analysis: Current situation of electricity mix and power plants for the entire operating phase, ditto for all other energy sources	Not compatible with EP 2050+ scenarios. GHG can be greatly overestimated (which may require expensive additional reduction measures)	Yes, incentive for el. efficiency higher than with M2	Yes, Pursue further. The building phases must be distinguished: • Construction phase: present and, if applicable, past-orientated • Operation phase: present- and, if applicable, future-orientated. Matrix to be created together with the selection of the BM
M2: Dynamic consideration of environmental parameters for electricity averaged between the situation today and 2050 (possibly beyond). To be based on a 2050 NZ GHGE 2050 compatible scenario.	Yes, close to unbiased (true) emissions, best guess	Yes, • Lower compared to M1 with regard to el. efficiency • Higher with regard to the substitution of fossil technologies by el. ones (because of decreasing emissions in a NZ scenario.	Time from today to 2050 corresponds approximately to the service life of the technical systems. Important as a variant to assess the consequences.

Legende:

Pursue further in any case	Pursue further (at least in the upcoming research modules, to explore effects and consequences)	No to pursue any further

Conclusions

Preliminary conclusion

The choice of electricity model has a large impact on specific and aggregated building related GHG emissions

Guidance for that choice:

1. Certificates of origin currently have to many drawbacks and should not be used for consequential LCA modelling
2. Further research is needed to determine the role of domestic production, its export share, and the role of imports in domestic consumption
3. To calculate the impact of current construction and retrofit activity, choose
   - a current electricity mix for the LCA of materials and construction processes
   - a future (prospective) electricity mix for the LCA of the operational phase of buildings
4. Modelling of marginal effects is (also) an interesting approach, although some challenges are to be solved ("who" is consuming at the margin)

Further reading

Jakob, M., & Stettler, C. (2023). Netto-Null Treibhausgasemissionen im Gebäudebereich - Zwischenbericht - Methodische Fragen. i.A. BFE.

Jakob, M., Widmer, D., & Volkart, K. (2009). CO2-Intensität des Stromabsatzes an Schweizer Endkunden. FOGA, FEV.

Ménard M., Dones R., Gantner U. (1998). Strommix in Ökobilanzen – Auswirkungen der Strommodellwahl für die Produkt- und Betriebs-Ökobilanzen. Unterstützt von INFEL/VSE. PSI-Bericht Nr. 98-17., Villigen, Dezember.

Back-up slides

F0.4B Einspeisen PV (Überschuss)-Strom

Alternative 1: investieren und verkaufen

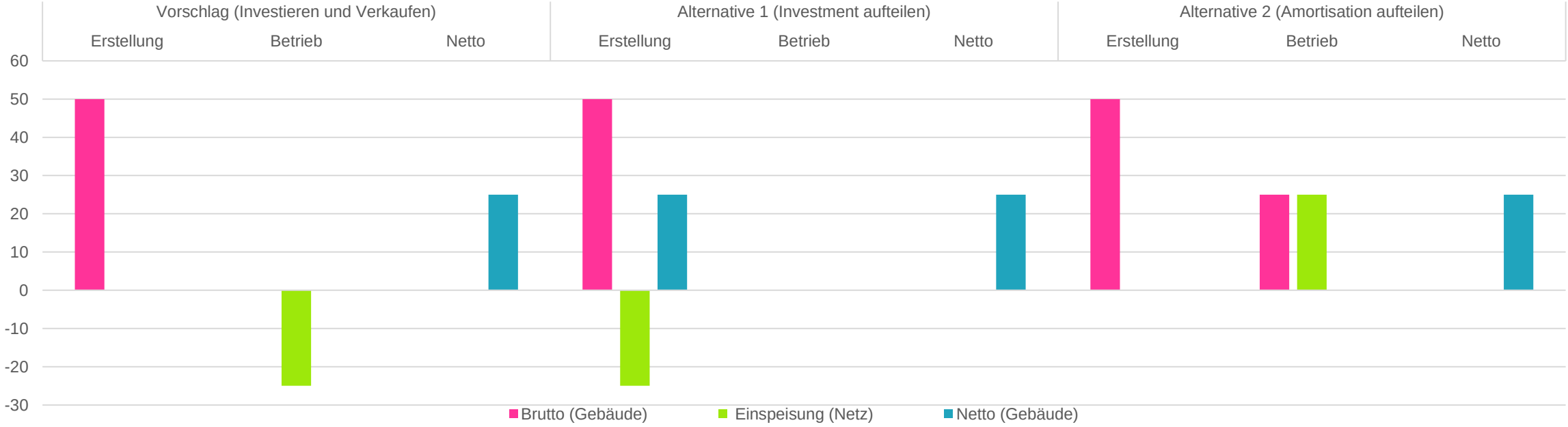
Umweltbelastung des PV Systems bei Errichtung dem Gebäude zuordnen und im Betrieb abziehen (gemäss Rücklieferungsanteil)

Vorschlag: Investition aufteilen

Aufteilen der Umweltbelastung des PV Systems auf Gebäude und Netz (gemäss Eigenverbrauchsanteil).
Kein Abzug in der Phase Betrieb

Alternative 2: Amortisation aufteilen

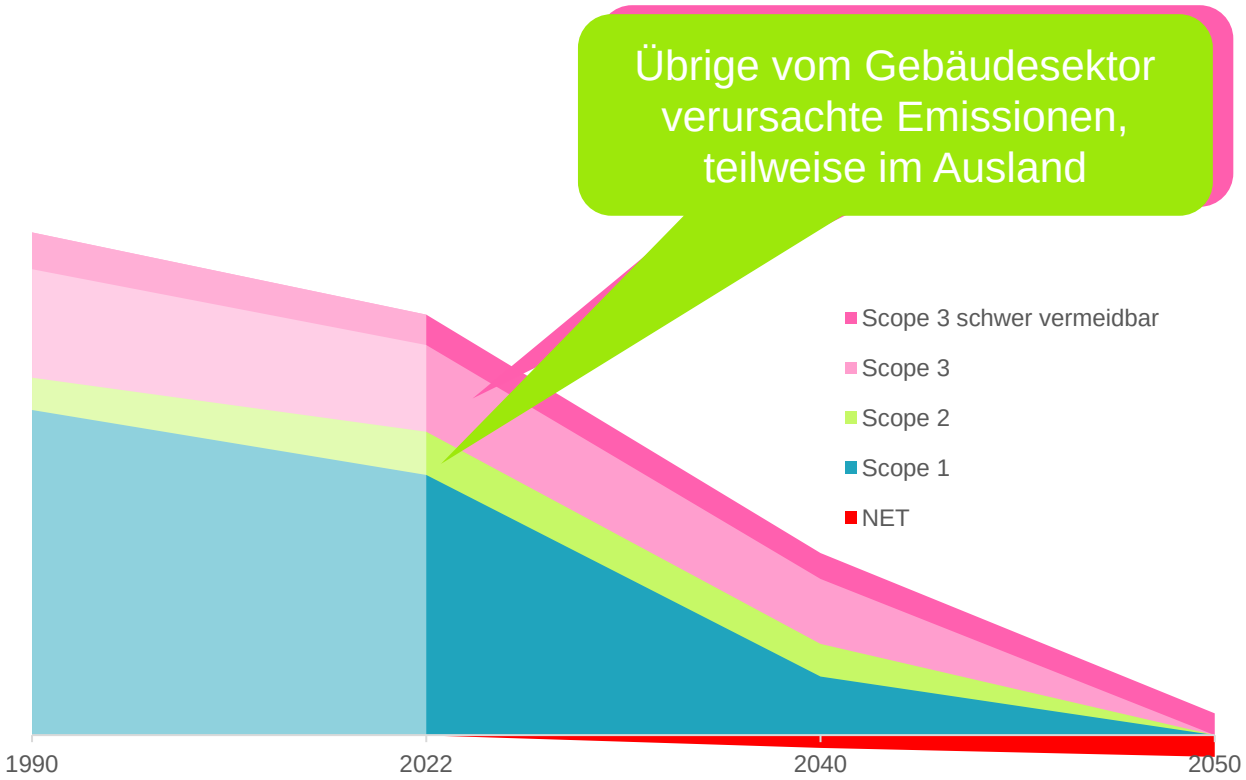
Abschreibung des Erstellungsaufwands auf die Betriebsphase und Aufteilung zwischen Eigenverbrauch (Gebäudes) und Netz bzw. Käufer des PV-Stroms



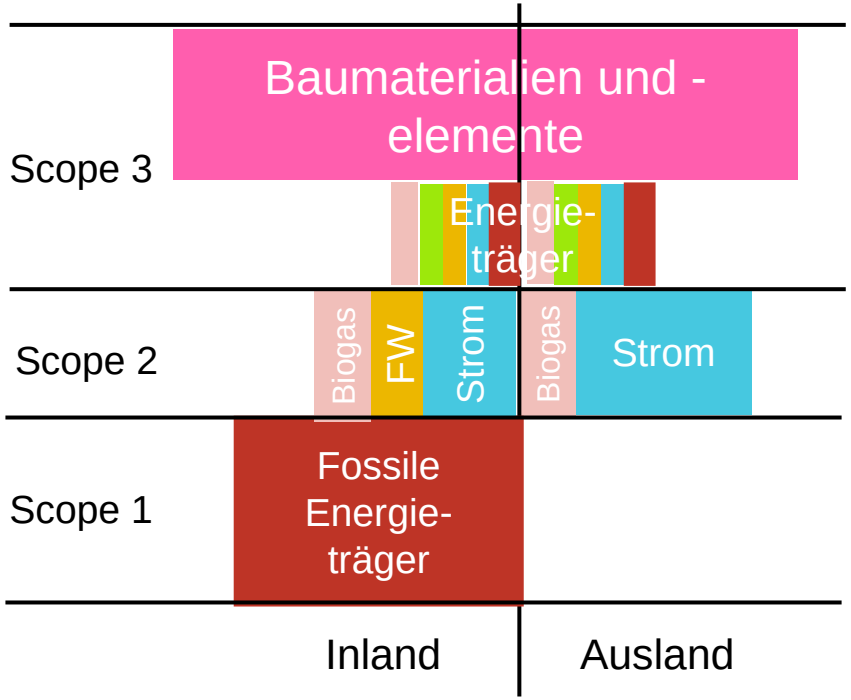
F0.1 Emissionsbudget

Welches CO_2-Budget bis 2050 leitet sich aus dem Absenkpfad für den Gebäudesektor (direkte Emissionen) gemäss KIG ab?

Emissionspfad Gebäudesektor und Gebäudebereich



Territoriale Allokation



Graue Energie und graue Emissionen im Vergleich

GHG-Protocoll und SIA-Effizienzpfad nicht direkt vergleichbar

- Methodische Unterschiede:
- Scope 3 Emissionen gemäss GHG Protocol erstrecken sich über zwei SIA 2040 Phasen: Betrieb + Erstellung
- SIA 2040 inkludiert Mieterausbau und -verbrauch, grenzt jedoch Grundausbau und Mieterausbau bzw. Eigentümer- und Mieterverbrauch **nicht** voneinander ab

SIA 2040: kg/m² pro Jahr über Lebensdauer		**GHG Protocoll kg/m² im Betrachtungsjahr**
Betrieb	Direkte Emissionen	Scope 1
	Indirekte Emissionen	Scope 2
	Graue Emissionen Energiebereitstellung	Scope 3
Erstellung		Scope 3
Betrieb+Erstellung		**Scope 1 bis 3**