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Considering dynamics of electricity demand and production for the environmental benchmark of Swiss residential buildings

SBE 2019 – Special Session on Management of Complexity in Sustainable Construction
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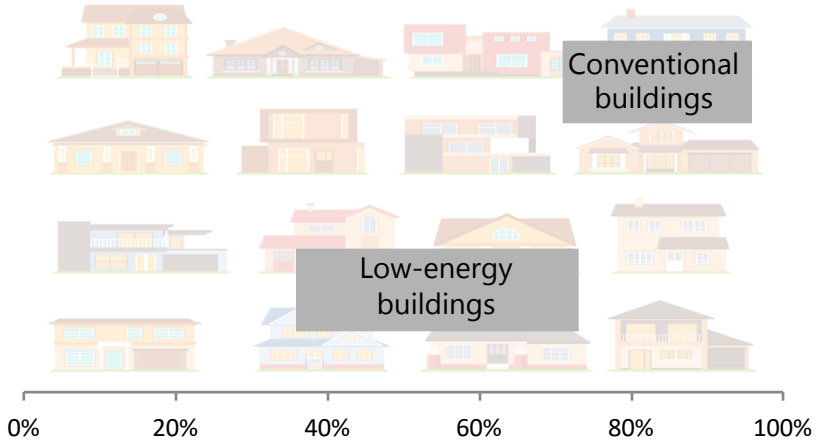
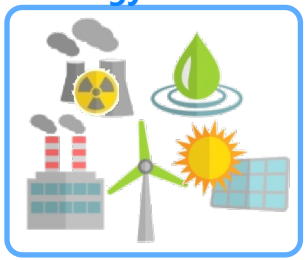
Dynamics of Energy in Buildings

Proportion of operational energy over the life cycle energy

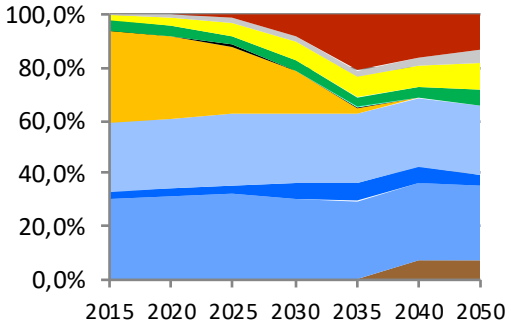


Based on values from:
T. Ramesh, R. Prakash, and K. K. Shukla, "Life cycle energy analysis of buildings: An overview," *Energy and Buildings*, vol. 42, pp. 1592-1600, 2010/10/01/ 2010.

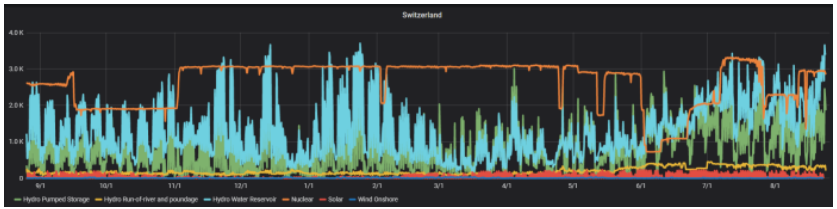
Energy sources



Long-term evolution



Short-term variation



images: Freepik.com
@macrovector (energy/buildings)

Previous dynamic studies for buildings

~16 **Dynamic LCA (DLCA)** studies on buildings

# of studies	Focus of DLCA	Environmental indicator	Observed difference with standard LCA
8	Long-term evolution	Global warming potential	From -70% to +60%
8	Short-term variation	Many (e.g. ReCiPe)	From -60% to +40%

DLCA frameworks and methods

1. W. O. **Collinge**, A. E. Landis, A. K. Jones, L. A. Schaefer, and M. M. Bilec, "Dynamic life cycle assessment: framework and application to an institutional building," *International Journal of Life Cycle Assessment,* vol. 18, pp. 538-552, **2013**
2. S. **Su**, X. Li, Y. Zhu, and B. Lin, "Dynamic LCA framework for environmental impact assessment of buildings," *Energy and Buildings,* vol. 149, pp. 310-320, 2017/08/15/ **2017**.
3. K. **Negishi**, L. Tiruta-Barna, N. Schiopu, A. Lebert, and J. Chevalier, "An operational methodology for applying dynamic Life Cycle Assessment to buildings," *Building and Environment,* vol. 144, pp. 611-621, 2018/10/15/ **2018**.

Swiss context of building LCA

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LCA benchmark

KBOB 2016

- Database: ecoinvent v2.2+
- Electricity: **annual average**
- Impact categories:
  1. Ecopoints (UBP 2013)

  Primary energy:
  2. Non-renewable
  3. Renewable
  4. GWP IPCC 2013

KBOB, "Data of the ecobalances in construction 2009/1:2016," ed. Switzerland: Coordination Conference of Construction Services and Buildings of Public Owners (KBOB), **2016**.

Electricity

2020

Recent studies

× variation between neighbours
× analysis of temporal precision

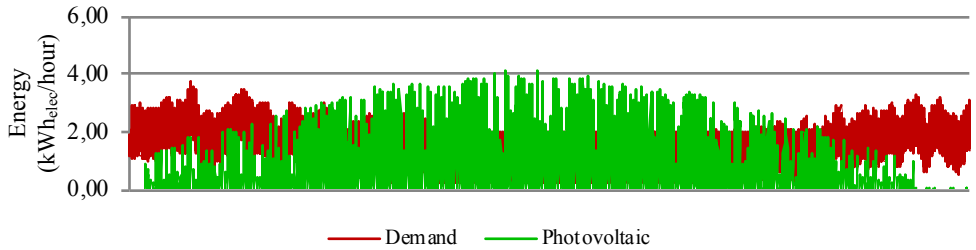
D. **Vuarnoz** and T. Jusselme, *Energy*, vol. 161, pp. 573-582, 2018/10/15/ **2018**.
D. **Vuarnoz**, S. Cozza, T. Jusselme, G. Magnin, T. Schafer, P. Couty, *et al.*, *Sustainable Cities and Society*, vol. 43, pp. 305-316, 2018/11/01/ **2018**.

Goal: Identify key model parameters for the DLCA of Swiss buildings

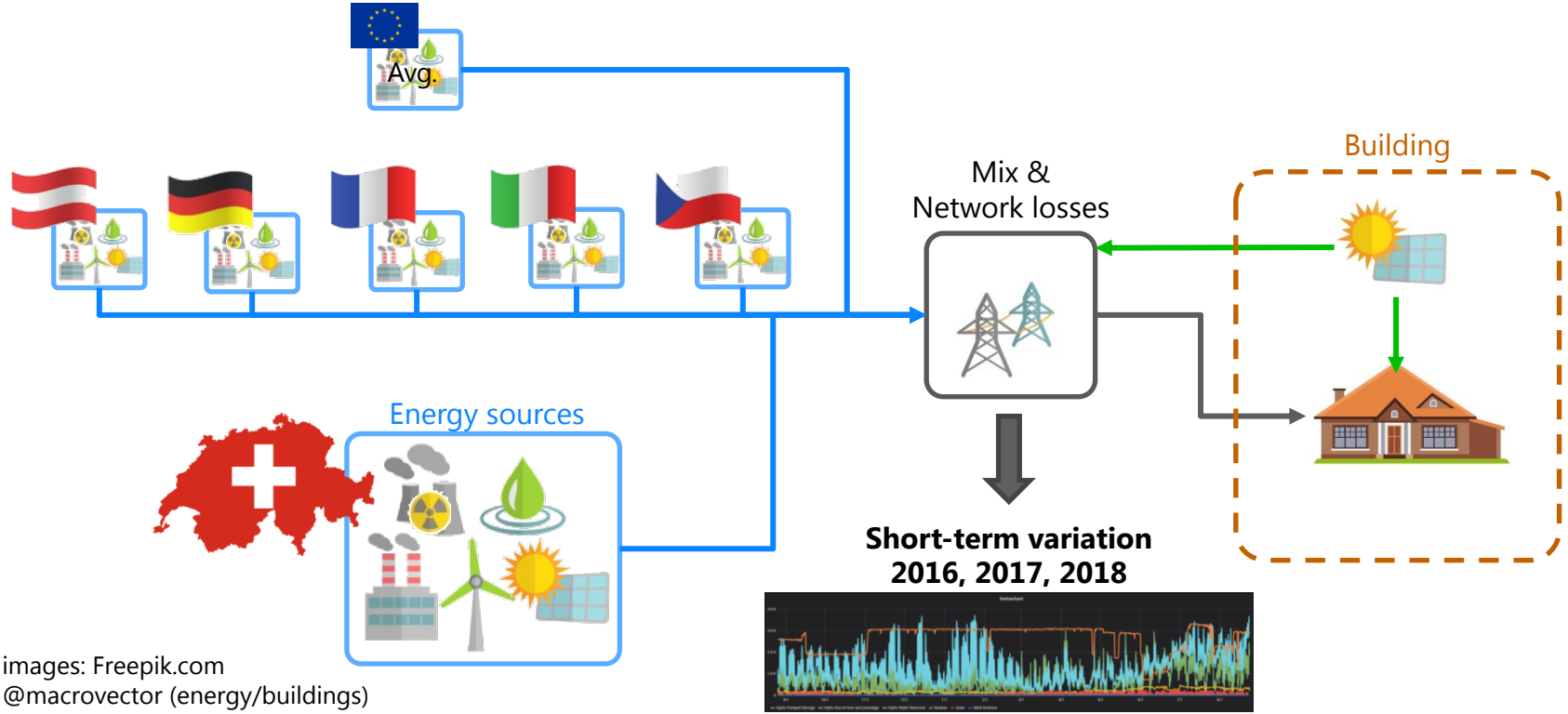
Case study

- Single-family house
- Energy reference area (ERA): 199 m^2
- Considered demand (hourly): 44 kWh/year·m^2 ERA
  - Appliances
  - Lighting equipment
  - Domestic hot water
  - Heat pump

  } Based on SIA 2024
- Decentralised production (hourly): 19 kWh/year·m^2 ERA
  - PV installation (mono-crystalline)
  - Peak power: 4.5 kW
  - Orientation: East
  - Inclination: 45°
  - Grid connected
  - Priority to self consumption



Scope and dynamic model



images: Freepik.com
@macrovector (energy/buildings)
@luis_molinero (flags)

Sources of data and mapping

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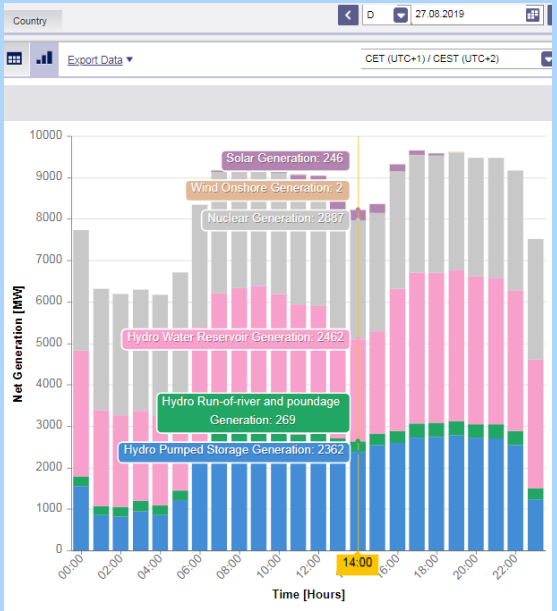
entsoe

Between 2016 and 2018



https://transparency.entsoe.eu/dashboard/show

Mapping the connections

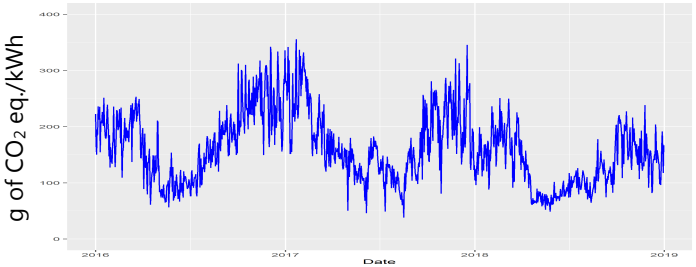
eco'nvent

V3.4
System model:
Cut-Off

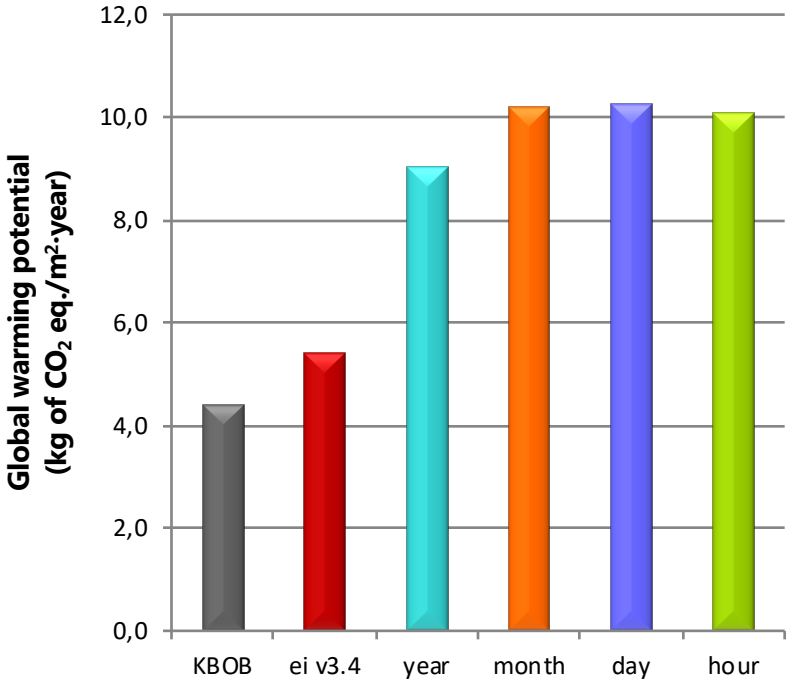
For the *Swiss* electricity mix:

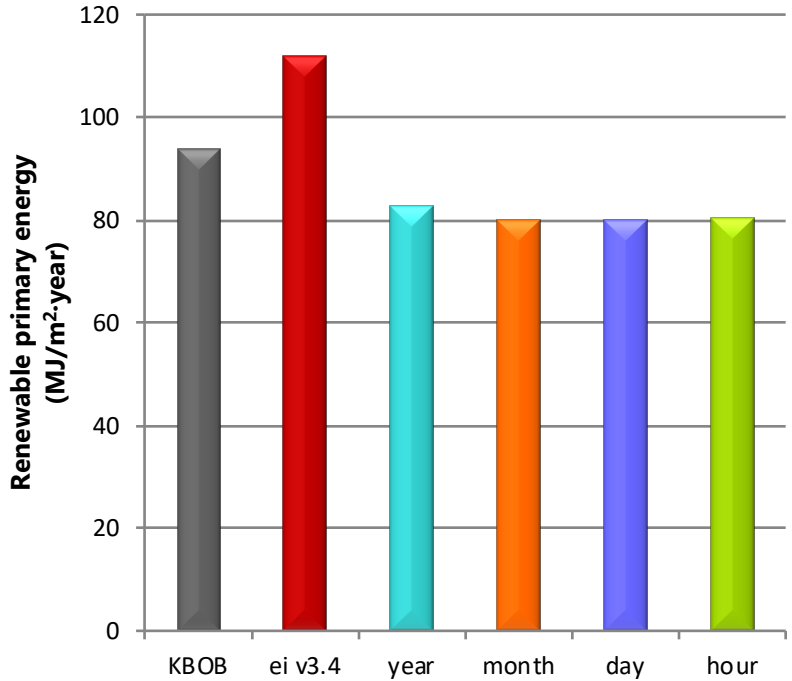
1 Natural gas plant
1 Hydro, pumped storage process
1 Run-of-river dam
1 Reservoir dam (alpine region)
2 Technologies of nuclear plant
3 Sizes of Wind turbine
16 Types of PV installations

Environmental impacts of electricity mix for every hour in Switzerland

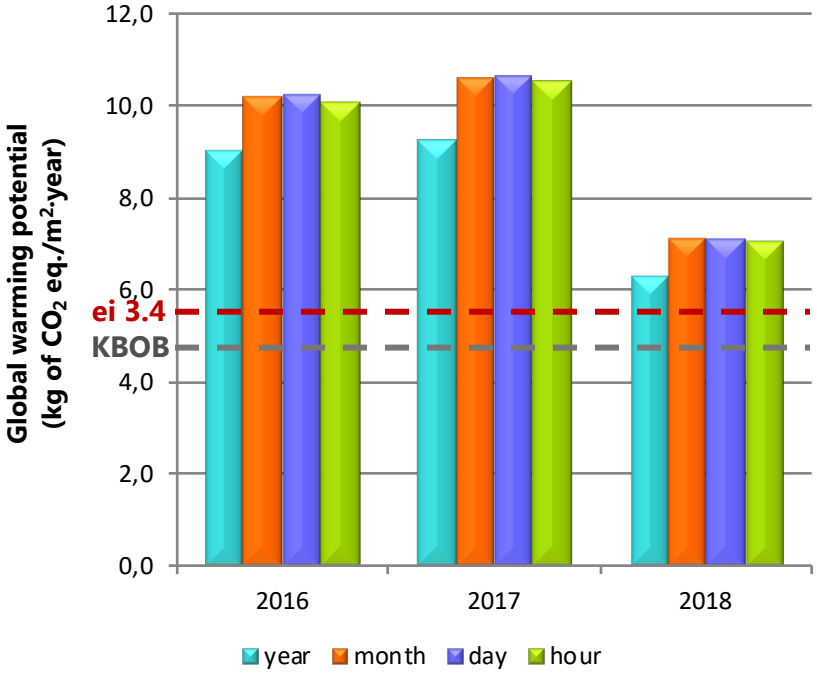


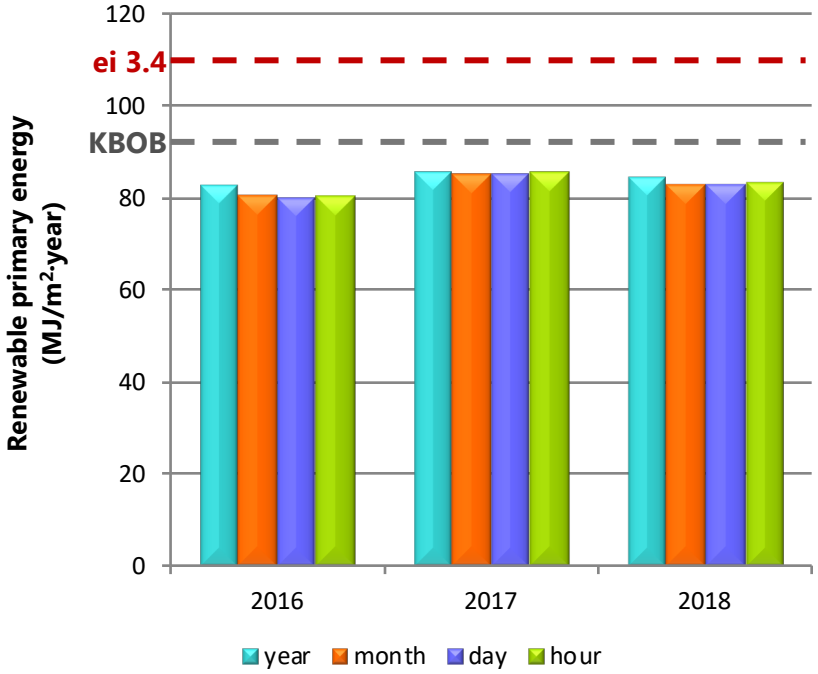
Results for 2016





Results for all years





Conclusions

- Confirmation of expected variations between databases
- System dynamics also bring changes in results for Swiss buildings
  - Increase for GWP, Non-renewable energy use and ecological scarcity
  - Decrease for renewable energy use
  - Importation of neighbouring countries should be considered
  - Data sources for electricity flows should be validated
- Monthly precision is sufficient to consider most of the difference
- Significant variations are observed only for global warming potential

Thank your for your attention

While the results do not engage the provider of research funds, we would like to thank the Swiss federal office of energy (SFOE) for supporting this project under contract SI/501814-01.

For further questions, please contact: dib@empa.ch