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Note

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Expected developments of thermal networks in Switzerland to reduce CO2 emissions

1. Motivation

For the DeCarbCH Lunch-Talk on 30 November 2021, I estimated the role of thermal networks to decarbonize Switzerland. In this note I show the underlying data from currently available reports (Sres et al. 2014; Chambers et al. 2019; BAFU 2021; BFE 2021a; IRENA 2017; VFS 2021; TEP 2020; BFE 2020). Regarding the future development, (Chambers et al. 2019; Sres et al. 2014) indicate the potential of thermal networks based on technical feasibility and (TEP 2020; BFE 2020) show realistic pathways based on current trends, which are more conservative than the technical feasible potential.

2. Reduction of heat demand

Heat demand is distinguished between the residential, commercial and industrial sector and within those sectors between the usages of space heating, domestic hot water and process heat. In some studies, the industrial sector (mainly process heat) is neglected. The total heat demand (including industry) in 2020 is between 96.7 TWh (BFE 2021a) and 99.9 TWh (TEP 2020; BFE 2020) and is expected to decrease to 81.5 TWh (TEP 2020) and 74 TWh (BFE 2020) by 2050 (Fig. 1a, two lines on top). This corresponds to a decrease of 18 % and 26 %, respectively. Without industry, thus only including the residential and the commercial sector, the heat demand in 2020 is between 71.7 TWh and 84 TWh. By 2050, the heat demand decreases to between 45 TWh and 60 TWh (Fig. 1a, five lines at the bottom). This corresponds to a decrease by 36 % (Chambers et al. 2019), 22 % (TEP 2020), 27 % (BFE 2020) and 40 % (Sres et al. 2014).

Summary

The total heat demand of all sectors is expected to decrease by 18 % to 26 %. If industry is excluded, the heat demand decreases by 22 % to 40 %.

3. Increase of heat delivered by thermal networks

Heat demand delivered by thermal networks is also distinguished between the sectors residential, commercial and industry and within those between the usages space heating, domestic hot water and process heat.

(Sres et al. 2014) (Fig. 1b, red line) excludes industry. For 2010 they cite that 4 % of the heat demand in the considered sectors is covered by thermal networks. With a heat demand of 85 TWh in 2010, 4 % correspond to 3.4 TWh. They estimate that by 2050 thermal networks provide 17 TWh of heat demand. An increase from 3.4 TWh to 17 TWh is a factor of 5. Using linear interpolation to obtain a value for 2020 instead 2010, thermal networks provide 6.8 TWh in 2020. In increase from 6.8 TWh to 17 TWh is a factor of **2.5**.

(Chambers et al. 2019) (Fig. 1b, light blue and green lines) also exclude industry. For 2016 the heat demand covered by thermal networks is 5.4 TWh. By 2050, they estimate a heat demand of 33 TWh and 23 TWh, depending on the scenario SwissRes and SEST, respectively. For 2020, the interpolated heat demand is 8.6 TWh (SwissRes) and 7.5 TWh (SEST). An increase from 8.6 TWh to 33 TWh (SwissRes) is a factor of **3.8** and from 7.5 TWh to 23 TWh (SEST) is a factor of **3**.

(TEP 2020) (Fig. 1b, dark blue lines) provide estimates of heat demand covered by thermal networks for all sectors. For each sector, two variants and two scenarios are considered. Here, we only show the case that most favors thermal networks (their Variante 2, Vorschriftsszenario) and we first consider the sum of residential and commercial (without industry) to compare with (Chambers et al. 2019; Sres et al. 2014). Without industry, the heat demand covered by thermal networks in 2020 and 2050 is 5.7 TWh and 16.6 TWh, respectively, corresponding to an increase of factor **2.9**. With industry included, it is 7.8 TWh and 20.8 TWh, respectively, corresponding to an increase of factor **2.7**.

(BFE 2020) (Fig. 1b, black lines) report the heat demand covered by thermal networks for all sectors and consider various scenarios (WWB, ZERO Basis, ZERO A, ZERO B, ZERO C), where the "ZERO" scenarios all lead to zero emissions in 2050 while focusing on different technologies. The ZERO C scenario favors thermal networks. If only the residential and commercial sectors are considered, the heat demand in thermal network increases in the ZERO Basis scenario from 4.4 TWh in 2020 to 9.2 TWh in 2050 by a factor of **2.1.** If industry is included the increase is from 6.3 TWh to 11.4 TWh by a factor of **1.8**. For the scenario ZERO C, the heat demand covered by thermal networks increases from 6.4 TWh to 14.2 TWh by a factor of **2.2**.

(VFS 2021; BFE 2021a) (Fig. 1b, red and blue circles) do not provide predictions for the future, but values of heat demand covered by thermal networks in 2020. (BFE 2021a) estimates the heat demand to be 5.8 TWh and (VFS 2021) estimates it to be 8.4 TWh. According to Verband Fernwärme Schweiz, the difference is caused by the fact that (BFE 2021a) only considers the largest DH networks and many smaller thermal networks based on wood are missing and the statistics.

(Marcucci et al. 2021b) (Fig. 1b, magenta circle) estimate that 20 TWh of heating demand will be covered by thermal networks.

(Panos et al. 2021) (Fig. 1b, magenta line) report the most conservative estimate of district heating development from 5.4 TWh (even lower than (BFE 2021a)) in 2020 to 6.9 TWh in 2050, an increase by a factor of **1.3**

Summary:

The heat demand covered by thermal networks for all sectors in 2020 varies between 5.8 TWh (BFE 2021a) and 8.4 TWh (VFS 2021). For 2050 the heat demand covered by thermal networks varies between 11.4 TWh (2050+ ZERO Basis with industry) and 33 TWh (Ch2019 SwissRes) and thus by a factor of 3. In the different reports, thermal networks are expected to increase by factor 2 to 4. The 2020 values of (BFE 2020) (ZERO Basis and ZERO C with industry, black dashed and dotted lines) seem to be based on (BFE 2021a) and might thus underestimate the heat demand covered by thermal networks, according to (VFS 2021).

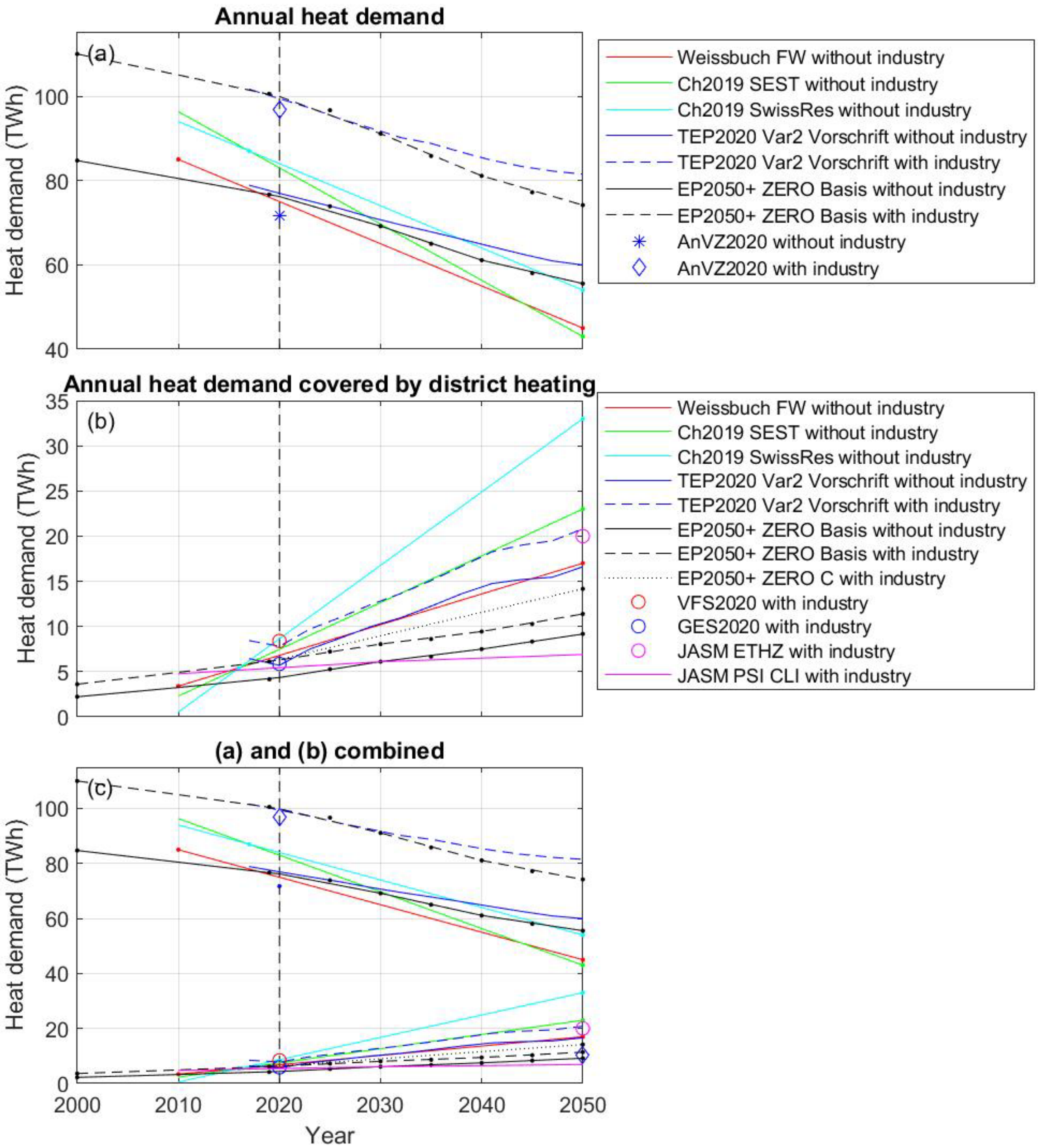


Fig. 1: Development of heat demand and thermal networks in Switzerland. a, Decrease of the annual heat demand for various reports, either with or without industry (see legend). The vertical dashed

line marks the reference year 2020. **b,** Increase of annual heat demand covered by thermal networks for various reports, with or without industry. **c,** Combined illustration of (a) and (b).

Sources for Fig. 1a
Weissbuch FW without industry: (Sres et al. 2014), page 18, 19
Ch2019: (Chambers et al. 2019), Table 6
TEP2020 Var2 Vorschrift without industry: (TEP 2020), Fig. 10b, 12b,
TEP2020 Var2 Vorschrift with industry: (TEP 2020), Fig. 10b, 12b, 14b
EP2050+ ZERO Basis without industry: (BFE 2020), Fig. 8
EP2050+ ZERO Basis with industry: (BFE 2020), Fig. 8
AnVZ2020 without industry: (BFE 2021b) Tab. 16
AnVZ2020 with industry: (BFE 2021b) Tab. 16

Sources for Fig. 1b
Weissbuch FW without industry: (Sres et al. 2014), page 18, 19
Ch2019: (Chambers et al. 2019), Table 6
TEP2020 Var2 Vorschrift without industry: (TEP 2020), Fig. 10b, 12b,
TEP2020 Var2 Vorschrift with industry: (TEP 2020), Fig. 10b, 12b, 14b
EP2050+ ZERO Basis without industry: (BFE 2020), Fig. 11
EP2050+ ZERO Basis with industry: (BFE 2020), Fig. 11
EP2050+ ZERO C with industry: (BFE 2020), Fig. 15
VFS2020 with industry: (VFS 2021), p. 13, bottom figure
GES2020 with industry: (BFE 2021a), Tab. 4
JASM ETHZ: (Marcucci et al. 2021b), Fig. 3.12
JASM PSI CLI : (Panos et al. 2021), Fig. 6.1

4. Fraction of the total heat demand provided by thermal networks

The fraction of heat demand covered by thermal networks (Fig. 1c) will drastically increase in the future, because (i) the total heat demand decreases and (ii) new thermal networks will be built. Again, the studies are distinguished depending on whether the industrial sector is included or not. Without the industrial sector, (Sres et al. 2014) expect in increase from 6.8/75 = 9 % to 17/45 = 38 %. (Chambers et al. 2019) estimate an increase from 8.6/84 = 10 % to 33/54 = 61 % in the SwissRes scenario and from 7.5/83 = 9 % to 23/43 = 53 % in the SEST scenario. (TEP 2020) estimates in increase from 5.7/77 = 7 % to 16.6/60 = 28 %. (BFE 2020) estimates 4.4/76.2 = 6 % to 9.2/55.6 = 17 %. Summarizing this section without industry, the fraction of heat demand covered by thermal networks is between 6 % and 10 % in 2020 and between 17 % to 61 % in 2050.
With industry included, the fraction of heat demand covered by thermal networks in 2020 is, according to (BFE 2021a) is 5.9/96.7 = 6 %. According to estimates of (VFS 2021), it is 8.4/96.7 = 9 %. (TEP 2020) report increases between 2020 and 2050 from 7.8/99.4 = 8 % to 20.8/81.5 = 26 %, (BFE 2020) from 6.3/99.9 = 6 % to 11.4/74.2 = 15 % in the ZERO Basis scenario and from 6.4/99.9 = 6 % to 14.2/74.2 = 19 % in the ZERO C scenario (here assuming that the heat demand in the ZERO C decreases in the same way as in ZERO Basis scenario). Summarizing this part with industry included, the fraction of heat demand covered by thermal networks varies between 6 % and 9 % in 2020 and between 15 % and 26 % in 2050.

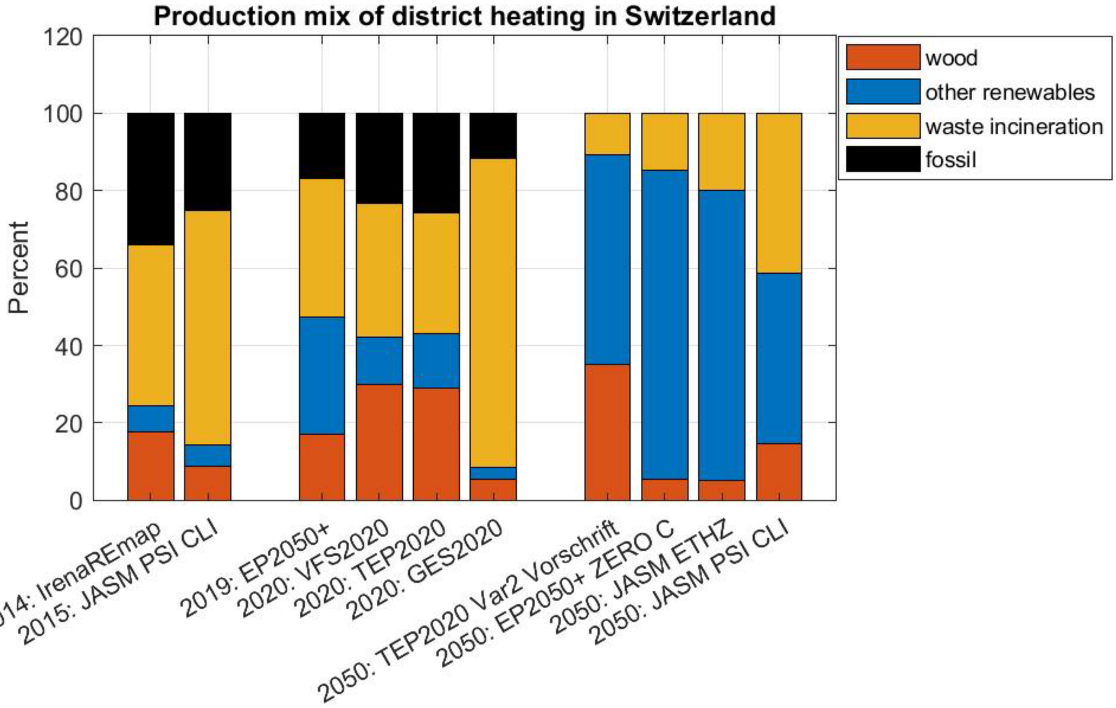
Summary:
(Chambers et al. 2019) estimates fractions of more than 50 % in the future share of thermal networks for covering the heat demand (excluding industry), (Sres et al. 2014) mentions 38 % (also excluding industry). These two studies, as mentioned above, indicate potentials based on technical feasibility.

(BFE 2020; TEP 2020) are more conservative and estimate future shares of 20 % to 30 % of thermal networks, both, with and without industry.

5. Fraction of renewables in thermal networks

Determining the fraction of renewables in thermal networks is not straight forward. In Fig. 2 an attempt was made to compare various reports with respect to the production mix of heat provided by thermal networks. “Fossil” (black) is mainly natural gas with a small fraction of oil and is clearly not renewable. “Wood” (orange) is renewable. “Other renewables” (blue) contain a number of small renewable heat sources (geothermal, solar thermal, heat pumps, lakes, rivers, H2, biomethane), but also nuclear. Waste incineration (yellow) covers a large fraction of the production mix and is considered CO2 neutral in Switzerland (BFE 2018). However, if materials based on fossils are burned, CO2 is emitted to the air, which should be captured and stored in the future to reach net-zero (Marcucci et al. 2021a). The fraction of renewables in thermal network thus depends on to which extent waste incineration is considered renewable. In the report (IRENA 2017) (left bar in Figure 2), for example, a renewable fraction of 40 % in thermal networks is quoted for the year 2014. To obtain 40 % renewables, waste incineration of biodegradable waste is included, but the remaining fraction not (personal communication Martin Soini, Infras). Different reports on the production mix for similar years (2019, 2020, third to sixth bar in Fig. 2) differ in their estimates. (BFE 2021a) (sixth bar), which states an 80 % share of waste incineration and only 5 % biomass, is an outlier. The reason is that (BFE 2021a) only considers the largest thermal networks in Switzerland that are often based on waste incineration. The many small wood-based networks are not included. This is also the reason why (BFE 2021a) underestimates the heat delivered by thermal networks (Fig. 1b) by about 30 %. In future scenarios (seventh to tenth bar in Fig. 2), the fossil part (black) is vanishing and waste incineration only contributes by a small fraction (except in (Panos et al. 2021), right bar). The largest part will be delivered by “other renewables” and “biomass”, whereas “other renewables” is mainly heat pumps, biogas and geothermal.

Summary:
Only considering the studies (TEP 2020; VFS 2021; BFE 2020), the largest fraction of the production mix of thermal networks is provided by waste incineration (31 % - 36 %). To which extent waste incineration is considered renewable thus largely influences the share of renewables in thermal networks. The fossil part (17 % - 26 %) is clearly not renewable. The sum of wood and “other renewables” is renewable (43 % - to 47 %). The current fraction of renewables in thermal networks is thus between 43 % and 83 %.



Sources of Fig. 2:
2014: IrenaREmap: (IRENA 2017), Fig. ES3 and personal communication Martin Soini, Infras
2019: EP2050+: (BFE 2020), Fig. 33
2020: VFS2020: (VFS 2021), p. 13, bottom figure
2020: TEP2020: (TEP 2020), Fig. 23, left bar
2020: GES2020: (BFE 2021a), Tab. 26
2050: TEP2020 Var2 Vorschrift: (TEP 2020), Fig. 23, right bar
2050: EP2050+ ZERO C: (BFE 2020), Fig. 33
2050: JASM ETHZ: (Marcucci et al. 2021b), Fig. 3.12
2015, 2050 : JASM PSI CLI: (Panos et al. 2021), Fig. 6.1

6. Overall summary

As a simple, crude estimate one might remember a “30/3/30” relation. The heat demand decreases by about 30 % from 2020 to 2050, the heat delivered by thermal networks will increase by a factor of 3 and thermal networks will cover 30 % of the future (2050) heat demand. The current fraction of renewables in thermal networks is between 43 % and 83 %, depending on to which extent waste incineration is considered renewable.

7. Literature

BAFU, 2021: Kenngrössen zur Entwicklung der Treibhausgasemissionen in der Schweiz 1990-2019.

BFE, 2018: *Faktenblatt Abwärme für den Umgang mit energie- und klimapolitischen Instrumenten*. 1 pp.

——, 2020: *Energieperspektiven 2050 +: Kurzbericht*. Bundesamt für Energie BFE, 1–112 pp.

——, 2021a: Schweizerische Gesamtenergiestatistik 2020.

——, 2021b: *Analyse des schweizerischen Energieverbrauchs 2000 - 2020 nach Verwendungszwecken*.

Chambers, J., K. Narula, M. Sulzer, and M. K. Patel, 2019: Mapping district heating potential under evolving thermal demand scenarios and technologies: A case study for Switzerland. *Energy*, **176**, 682–692, https://doi.org/10.1016/j.energy.2019.04.044.

IRENA, 2017: *Renewable energy in district heating and cooling: A sector roadmap for REmap*. International Renewable Energy Agency, 112 pp.

Marcucci, A., and Coauthors, 2021a: *Transformation of the Swiss Energy System for a Net-Zero Greenhouse Gas Emission Society – Results from the Joint Activity Scenarios & Modelling*.

——, G. Guidati, and D. Giardini, 2021b: *Probabilistic Assessment of the Swiss Energy Strategy - Scenario Analysis With the SES-ETH Model*.

Panos, E., T. Kober, K. Ramachandran, and S. Hirschberg, 2021: *Long-term energy transformation pathways*.

Sres, A., B. Nussbaumer, and H. Eicher, 2014: *Weissbuch Fernwärme Schweiz - VFS Strategie*. 65 pp.

TEP, 2020: *Erneuerbare- und CO2-freie Wärmeversorgung Schweiz - Eine Studie zur Evaluation von Erfordernissen und Auswirkungen*.

VFS, 2021: *Jahresbericht 2020*.