Definitions for Climate Neutrality and their Relevance for the Assessment of Solar Energy based Heating Systems

Harald Drück[1,2], Dominik Bestenlehner[1,2]

[1] University of Stuttgart
Institute for Building Energetics, Thermotechnology and Energy Storage (IGTE), Stuttgart (Germany)

[2] Solar- und Wärmetechnik Stuttgart / Solar and Heat Technology Stuttgart (SWT)
Research- and Testing Centre for Solar Thermal Systems (TZS), Stuttgart (Germany)

Abstract

This contribution presents three approaches for the definition of climate neutrality. These three approaches are based on different ways for balancing $CO_{2\ eq}$ emissions. Only with the third approach, called real climate neutrality, it will be possible to achieve climate neutrality on global level. The effort for achieving climate neutrality is varying significantly depending on the chosen approach. The calculation of climate neutrality is exemplarily performed according to the three approaches for a single-family house in Germany with different concepts for heat and power supply. The concept combining photovoltaic and solar thermal has by far the lowest $CO_{2\ eq}$ emissions and only moderate additional costs.

Keywords: Solar thermal, photovoltaic, CO_2 emissions, climate neutrality, heat pump

1. Introduction

The term "climate neutral" is today firmly established in our linguistic usage. However, what does climate neutral really mean?

In this contribution three approaches for achieving climate neutrality are described in detail and are additionally compared and assessed on the basis of ecological and economic aspects using as example different concepts for the heat and power supply of a single-family house in Germany.

In addition, it is shown that the use of solar thermal energy in combination with long-term energy storage is a key technology for achieving real climate neutrality.

2. Definitions of climate neutrality

A generally accepted definition of the term does not yet exist. In many publications and laws such as /1/, /2/ and /3/ "climate neutrality" is understood as net greenhouse gas neutrality, but without this being precisely defined. This leads to the fact that climate neutrality - depending on the individual motivation - is defined very differently. However, what all serious approaches have in common is, that they consider the emissions of climate-damaging gases such as carbon dioxide (CO_2), methane (CH_4) or nitrous oxide (N_2O). Since all gases have a different global warming potential (GWP), their individual GWP is related to the one of CO_2. The mass of greenhouse gases emitted during the production of a product, the provision of a service or the generation of a kilowatt-hour of electricity are therefore expressed in CO_2 equivalents, e.g. 400 g $CO_{2\ eq}$ per kilowatt-hour of electricity.

For a complete life cycle assessment of energy systems, the $CO_{2\ eq}$ emissions associated with their production, operation and maintenance, as well as disposal have to be taken into account.

The three most relevant approaches for defining "climate neutrality" are described and compared in the following. For reasons of simplicity and comprehensibility, only the $CO_{2\ eq}$ emissions resulting from the operation are considered here.

doi:10.18086/eurosun.2022.18.05 Available at http://proceedings.ises.org

2.1. Virtual climate neutrality

In this approach, the $CO_{2\ eq}$ emissions caused are compensated by certificates or other compensatory measures such as tree planting (see Fig. 1). There is no avoidance of additional $CO_{2\ eq}$ emissions and no $CO_{2\ eq}$ emissions are permanently extracted from the atmosphere. Objectively speaking, therefore, this approach does not contribute to climate protection.

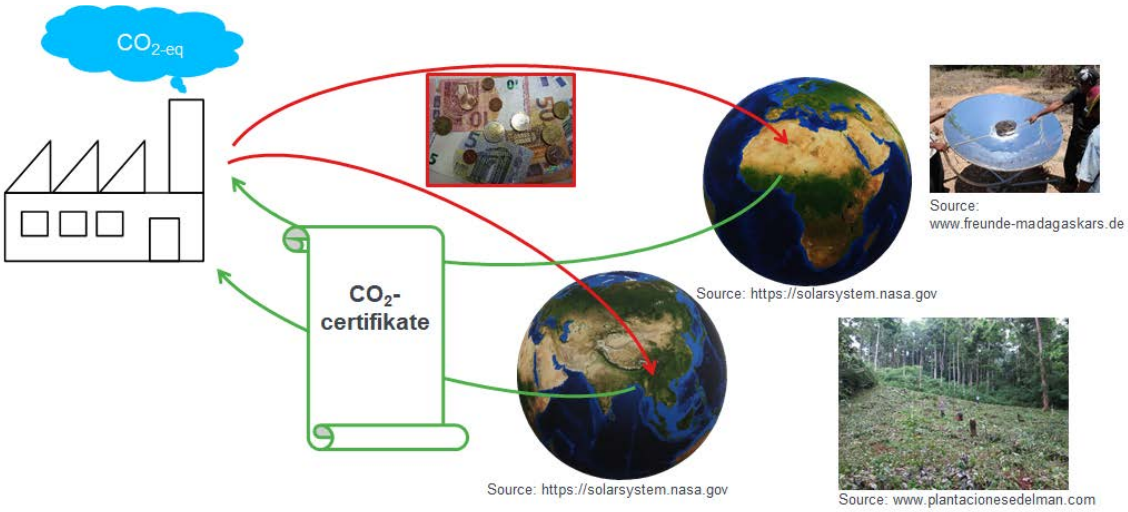

Fig. 1: Virtual climate neutrality

2.2. Balance sheet climate neutrality

Here, compensation for the $CO_{2\ eq}$ emissions caused also is carried out by a compensation that must take place within a certain period of time, usually one year.

If, for example, a building with a PV system draws electricity from the grid in the winter period and feeds electricity into the grid in the summer period, it is possible, depending on the amount of electricity and the size of the specific $CO_{2\ eq}$ emissions of the grid electricity and the PV electricity, that the building compensates for as many $CO_{2\ eq}$ emissions by feeding PV electricity into the grid as are associated with drawing electricity from the grid. Looking at a balance over the year, the $CO_{2\ eq}$ emissions related to the building are also zero or can even become negative. This means that a certain contribution to climate protection is made (see Fig. 2).

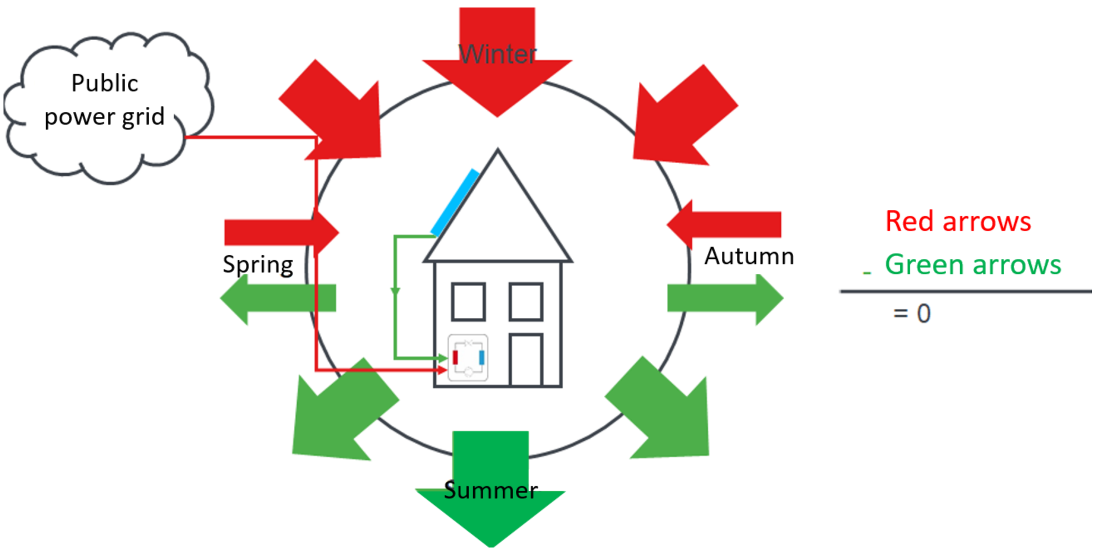

Fig. 2: Balance sheet climate neutrality

2.3. Real climate neutrality

In the case of real or genuine climate neutrality, the energy demand is continuously covered by the energy sources available locally, i.e. within the system boundary under consideration. For practical consideration, a balance period of 15 min has been established here, in which the energy balance must be balanced (see Fig. 3). If fluctuating energy sources, such as solar radiation energy, are used for energy generation, such a system can only be implemented in combination with energy storage devices.

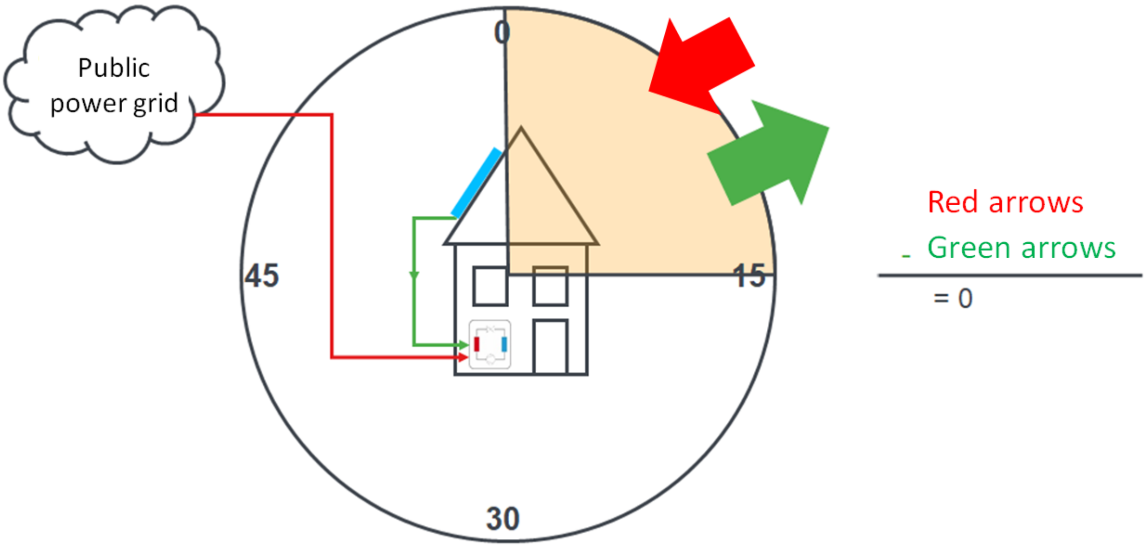

Fig. 3: Real climate neutrality

2.4. Discussion of the approaches

The first approach, referred to as "**virtual**", is characterized by the fact that it is currently very cost-effective. This is because a large number of climate-friendly measures are being carried out anyway, such as the reforestation of forests with a view to future timber harvesting or the generation of electricity from hydropower using existing hydropower plants. However, the virtual approach does neither make a substantial contribution to climate protection, nor can it be implemented globally on an unlimited scale, as there would then be a lack of corresponding compensation projects.

The **balance sheet** approach does not lead to actual climate neutrality either, as it also produces de facto substantial $CO_{2\,eq}$ emissions that contribute to global warming.

The approach referred to as "**real**" theoretically allows for achieving a true climate neutrality.

However, if solar radiation is used as the primary energy source, the realization of this approach is challenging, especially in our climate, from an economic and environmental point of view, since very large storage capacities are needed to fully cover the energy demand in winter. With regard to the heat supply of buildings, the seasonal storage of thermal energy can be reasonably implemented. However, seasonal storage of electrical energy is not practical with the technologies available today.

But complete real climate neutrality is not necessary either, since nature can compensate for a certain amount of anthropogenic, i.e. man-made, $CO_{2\,eq}$ emissions. This amount is about 2 tons of $CO_{2\,eq}$ per year and person. In Germany, however, we are still far away from this target, with 8 - 9 tons of $CO_{2\,eq}$ per person per year at present. As we do not only cause $CO_{2\,eq}$ emissions with our energy supply, but also through our nutrition and consumption, the $CO_{2\,eq}$ budget ultimately available for the energy supply of our residential buildings is less than one ton per year and person.

It is therefore obvious that for the energy supply of building, only concepts that focus very strongly towards real climate neutrality are viable in the long term. Such concepts can, for example, be based to a large extend on the usage of solar radiation for the energy supply of buildings. Since the development of systems and technologies for buildings predominately supplied with solar energy is of global interest, the IGTE of the University of Stuttgart (Germany) together with AEE INTEC from Gleisdorf (Austria) in the "Solar Heating and Cooling Programme"

(SHC) of the International Energy Agency (IEA) established the working group or Task 66 on the topic "Solar Energy Buildings - Integrated Solar Energy Supply Concepts for Climate Neutral Buildings and Neighborhoods for the City of the Future". Task 66 is led by Dr. Harald Drück from IGTE of the University of Stuttgart as Task Manager and has a duration from July 1st, 2021 to June 30th, 2024.
Further information: https://task66.iea-shc.org/

3. Comparison and assessment of the three approaches for climate neutrality

Using the example of a single-family house with different concepts for heat and power supply, this chapter compares and assesses the three approaches for defining climate neutrality under ecological and economic aspects.

3.1. The single-family house

It is assumed that the single-family house has a floor space of 145 m² and is located in the city of Würzburg, Germany The household electricity demand is 3,500 kWh/a and the heat demand is 11,000 kWh/a. This results from a heat demand of 9,000 kWh/a for space heating and 2,000 kWh/a for domestic hot water.

3.2. Total energy supply concepts

The following system concepts are considered for the total energy supply, i.e. the complete coverage of the heat and household electricity demand of the single-family house.

System "HP + Grid”
Provision of the entire heat demand for domestic hot water and space heating with an air-to-water heat pump with an annual performance factor of 4.0. The electricity required by the heat pump as well as the household electricity is completely drawn from the grid.

System "HP + PV”
Provision of the entire heat demand for domestic hot water and space heating with an air-to-water heat pump with an annual performance factor of 4.0.
In addition, the building has a PV system with an output of 9 kW_P. The electricity generated by the PV system is used primarily to the meet household electricity needs. If there is still a PV-electric power surplus, the heat pump is supplied with PV-electricity. Any other surpluses that may exist are fed into the power grid. This chosen prioritization for the use of the PV electricity is based on the fact that household electricity purchased from the grid at 0.35 €/kWh is more expensive than electricity to operate the heat pump at 0.25 €/kWh. The building has no electrical energy storage.
The difference between the total electricity demand for heat pump and household and the electricity supplied by the PV system is taken from the grid.

System "ST + Grid”
From a solar thermal system with 55 m² collector area and 4 m³ storage volume, 65 % of the heat demand for domestic hot water and space heating is covered. The remaining 35 % are provided by biomass combustion. The solar fraction of 65 % was chosen in particular because the planned amendment of the German Building Energy Act will stipulate that a minimum fraction of 65 % of the building's heat demand has to be covered by renewable energies /4/.
The electricity demand to cover the household electricity and the auxiliary electricity to operate the solar thermal system of 44 kWh/a is completely taken from the grid.

System "ST + PV”
The same combination of thermal solar system and biomass system is assumed as in the ST+grid variant.
In addition, the building is equipped with a PV system with a capacity of 3 kW_P to partially cover the household and auxiliary electricity demand. The building does not have an electrical energy storage system. The remaining electricity demand for household and auxiliary power is taken from the grid.

Additional assumptions

In addition to the systems as well as energy and financial parameters mentioned above, the following was assumed:

- Both the large PV system with 9 kW_P and the small one with 3 kW_P cover 30 % of the household and auxiliary power demand of the corresponding building simultaneously or at least in the time interval of 15 min used as a basis for the investigations carried out here.
- The share of self-used PV electricity for the operation of the heat pump is 30 %.
- The specific $CO_{2\ eq}$ emissions for electricity are 0.399 kg/kWh /5/.
- The same specific $CO_{2\ eq}$ emissions are applied for electricity taken from the grid and fed into the grid.
- No seasonal variance in specific $CO_{2\ eq}$ emissions.
- Specific $CO_{2\ eq}$ emissions for biomass are 0.029 kg/kWh /5/.
- Investment cost solar thermal system 31,500 € and useful lifetime 25 years.
- Investment costs for outdoor air heat pump 20,000 €, useful lifetime 15 years and annual performance factor 4.0.
- Investment costs for PV system 1,590 €/kW_P and useful lifetime 25 years.
- Feed-in tariff for partial self-consumption of PV electricity: 0.08 €/kWh
- Feed-in tariff in case of complete feed-in of the PV electricity: 0.12 €/kWh according to the plans in the "Easter Package" of the German government /6/
- Investment costs biomass heat source 7,000 € and useful lifetime 20 years
- specific costs biomass (fuel and maintenance): 0,09 €/kWh
- All costs and prices indicated are inclusive of value added tax of currently 19%.

3.3. Results - Power balances

Table 1 below shows the annual amounts of electricity used to meet the demand for household electricity (HH) and for the heat pump (HP) as well as auxiliary electricity, where needed.

Tab. 1: Annual electricity demand of the four overall energy supply concepts considered

	HP+Grid	HP+PV	ST+Grid	ST+PV
HH and auxiliary power	3,500 kWh/a	3,500 kWh/a	3,544 kWh/a	3,544 kWh/a
HP power	2,750 kWh/a	2,750 kWh/a	0 kWh/a	0 kWh/a
Total amount power	6,250 kWh/a	6,250 kWh/a	3,544 kWh/a	3,544 kWh/a
Electricity PV system	---	9,000 kWh/a	---	3,000 kWh/a
Power from grid at annual balance	6,250 kWh/a	0 kWh/a	3,544 kWh/a	544 kWh/a
Power fed into grid at annual balance	---	2,750 kWh/a	---	0 kWh/a
Power from grid at 15 min. balance	6,250 kWh/a	4,375 kWh/a	3,544 kWh/a	2,481 kWh/a
Power fed into grid at 15 min. balance	---	7,125 kWh/a	---	1,937 kWh/a

The household electricity amounts to 3,500 kWh/a for all variants considered, apart from the variants with solar thermal. Here, an additional electricity demand of 44 kWh/a was assumed as auxiliary energy for the operation of the solar circuit pump and the control system. For the variants with a heat pump to cover the heat demand, the assumed annual performance factor of 4.0 results in an electricity demand for the heat pump of 2,750 kWh/a. This means that the total electricity demand is 2,750 kWh/a. Thus, the total electricity demand for the variants with heat pump amounts to 6,250 kWh/a and for the variants with solar thermal to 3,544 kWh/a.

For the photovoltaic systems, a specific yield of 1,000 kWh/kWp is applied, resulting in a yield of 9,000 kWh/a for the variant with a PV system with 9 kWp and a yield of 3,000 kWh/a for the variant with the 3 kWp system.

Both variants without a PV system have to cover their entire electricity demand from the public grid, while with a balancing over one year the variants with a PV system do not need to draw any electricity from the grid (variant WP+PV), or significantly reduce the grid purchase to 544 kWh/a (variant ST+PV). However, if the balance is performed over a period of 15 min, the WP+PV variant draws 4,375 kWh/a and the ST+PV variant 2,481 kWh/a of electricity from the public grid. The reason why the electricity quantities taken from the grid are significantly larger for a balancing period of 15 min than for a balancing period of one year is the fact, that only at relatively few points in time there exists a simultaneous supply of electricity from the PV system and at least an equal demand for electricity for the heat pump or the household.

In principle the same relationships apply when PV electricity is fed into the public grid. When balancing over 15 min, variant WP+PV feeds in 7,125 kWh and variant ST+PV still 1,937 kWh/a.

3.4. Results - $CO_{2\ eq}$ balances

Using the three different approaches for defining climate neutrality described in Chapter 2 and the electricity quantities given in Table 1, the $CO_{2\ eq}$ emissions listed in Table 2 were calculated. For this purpose, it was assumed that each kilowatt-hour of electricity withdrawn from the grid causes $CO_{2\ eq}$ emissions of 399 g. Similarly, for each kilowatt-hour of electricity fed into the grid, avoided $CO_{2\ eq}$ emissions of 399 g were assumed.

For the virtual approach, it was assumed that, on the one hand, non-certified green electricity was purchased at an additional price of €0.01/kWh and, on the other hand, in the case of the variants with a PV system, the electricity generated was fed completely into the grid. The decisive factor for the assumption is the relatively high feed-in tariff of 0.12 €/kWh planned with the "Easter Package" /6/, which, however, only applies in the case of complete feed-in of the generated PV electricity, i.e. partial self-consumption is not permitted in this case.

Tab. 2: $CO_{2\ eq}$ emissions for the three approaches to defining climate neutrality

	HP + Grid	**HP + PV**	**ST + Grid**	**ST + PV**
Virtual	0 kg/a	-3,590 kg/a	110 kg/a	-1,086 kg/a
Balance sheet	2,493 kg/a	-1,097 kg/a	1,524 kg/a	327 kg/a
Real	2,493 kg/a	1,745 kg/a	1,524 kg/a	1,100 kg/a

In the figures shown in Table 2, positive values represent $CO_{2\ eq}$ emissions generated and thus de facto released into the atmosphere. Negative values are calculated for avoided $CO_{2\ eq}$ emissions, whereby it should be noted that the corresponding negative $CO_{2\ eq}$ emissions have of course not been or will not be extracted from the atmosphere.

It can be seen from Table 2 that the **virtual approach** arithmetically achieves the lowest $CO_{2\ eq}$ emissions or the highest credits. This is due to the fact that, on the one hand, the purchased electricity is green electricity and thus theoretically without $CO_{2\ eq}$ emissions, and, on the other hand, the generated PV electricity is completely fed into the grid and credited with 399 g $CO_{2\ eq}$/kWh.

In the **balance sheet approach**, the balance sheet is drawn up over a period of one year. Here, each kilowatt-hour of electricity purchased and fed into the grid is credited with the specific $CO_{2\ eq}$ emissions of 399 g/kWh. If the PV system generates more electricity over the year than is needed in the household and to operate the heat pump, this can even result in negative $CO_{2\ eq}$ emissions, as is the case here with -1,097 kg/a.

In the **real approach**, the electricity taken from the grid and fed in by the PV system is balanced over a time interval of 15 min. For the variants without a PV system, there are therefore no differences between the real and the balance sheet approach, since the calculation methodology for the purchase of grid electricity does not differ.

In the real approach, it is assumed that surplus PV electricity cannot be fed into the grid, or can only be fed into the grid to a negligible extent, since all other PV systems installed in the vicinity also feed into the grid at the same time. In this case, the electricity in the public grid is already completely "green" and no credits for avoided $CO_{2\ eq}$ emission can be credited. This assumption is especially justified if the corresponding technological approach, in this case PV+WP, is implemented on a large scale for the heat supply of a large number of buildings and a global climate neutrality is aimed at.

With the real approach for climate neutrality, there are significant differences in the variants with PV system compared to the virtual and balance sheet approach.

In particular, for the PV+WP concept, the transition from the balance sheet approach to the real definition of climate neutrality leads to an increase in $CO_{2\ eq}$ emissions of 2,842 kg/a, i.e., from -1,097 kg/a to 1,745 kg/a.

This effect is also observed for the PV+ST concept. However, it is much lower with an increase of the $CO_{2\ eq}$ emissions by 773 kg/a, i.e. from 327 kg/a to 1,100 kg/a.

With the real approach, the comparison between the two variants without PV system shows the great advantage of the solar thermal system with regard to $CO_{2\ eq}$ emissions, since these can be reduced by almost 40 % to 1,524 kg $CO_{2\ eq}$ emissions per year. However, the same also applies to the comparison of the variants with PV system. Here, the $CO_{2\ eq}$ emissions are significantly lower due to the coverage of the own electricity demand with the yields from the PV systems, whereby here, too, the variant with solar thermal has again 38 % lower $CO_{2\ eq}$ emissions than the variant without solar thermal.

3.5. Results - additional costs

This section lists the additional costs incurred for a "climate-neutral" overall energy supply for the single-family house under consideration. The "HP+grid" system was selected as the basis for this. In order to achieve virtual climate neutrality with this system, only the purchase of green electricity at an additional price of 0.01 €/kWh is required. The additional costs in this case are 6,250 kWh/a x 0.01 €/kWh = 62.50 €/a.

For the other overall energy supply concepts considered, the additional costs result primarily from the additional investment costs for the PV system or the higher costs for the large thermal solar system and the biomass system compared to a heat pump. Financial credits arise from feeding surplus PV electricity into the grid or, in the case of the virtual approach, from full feed-in of the generated PV electricity. Table 3 shows the additional costs incurred to achieve the respective $CO_{2\ eq}$ emissions.

Tab. 3: Additional costs for the four overall energy supply concepts depending on the approaches used to define climate neutrality

	HP+Grid	**HP+PV**	**ST+Grid**	**ST+PV**
Virtual	62.50 €/a	-302 €/a	659 €/a	537 €/a
Balance sheet	62.50 €/a	69 €/a	659 €/a	601 €/a
Real	62.50 €/a	294 €/a	659 €/a	601 €/a

When considering the overall energy supply concepts without PV system, it becomes clear that it is irrelevant for the calculation of additional costs which approach or definition of climate neutrality is used. It is therefore obvious to prefer the approach that arithmetically leads to the lowest $CO_{2\ eq}$ emissions, i.e. the virtual approach. However, the fact that this approach also contains a certain absurdity from an economic point of view is shown by the consideration of supply concepts with PV systems. Here, the virtual approach assumes full feed-in of the generated PV electricity in order to benefit from both, the high feed-in tariff of 0.12 €/kWh and to achieve low values for the $CO_{2\ eq}$ emissions. However, in return, all the electricity for the household and the heat pump must of course be purchased from the grid at a price of 0.25 €/kWh and 0.35 €/kWh, respectively.

Further, Table 3 shows that supply concepts with solar thermal are significantly more robust with respect to the choice of approach for defining climate neutrality. There are hardly any differences between the approaches in terms of additional costs. In contrast, the additional costs for the PV+WP concept change by a maximum of 596 €/a depending on the approach chosen to define climate neutrality, from -302 €/a for the virtual approach to 294 €/a for the real approach.

However, if only the additional costs of the real approaches are compared, the supply concept WP+grid with 62.50 €/a of additional costs shows that by the partial substitution of the grid electricity by a PV system in the concept WP+PV with only about 230 € additional annual costs (294 €/a- 62.50 €/a), the $CO_{2\ eq}$ emissions can be reduced from 2,493 kg/a to 1,745 kg/a by around 750 kg/a. If then the heat pump is replaced by a large solar thermal system in combination with a biomass heating to supply concept ST+PV, the additional costs amount to 601 €/a. This means that with another approx. 300 €/a of additional costs (601 €/a - 294 €/a) the $CO_{2\ eq}$ emissions can be reduced additionally by approx. 650 kg/a from 1,745 kg/a to 1,100 kg/a or another third.

Particularly noteworthy is the fact that when a supply concept based on solar thermal and biomass is supplemented with a small PV system, both the additional costs can be reduced by approx. 40 €/a and the $CO_{2\ eq}$ emissions can also be reduced by approx. 400 kg/a.

3.6. Discussion of the results

The studies that have been realized show that with a large solar thermal system for the heat supply and a moderately dimensioned PV system for partial coverage of the household electricity demand, by far the lowest $CO_{2\ eq}$. emissions are caused. This means that only with such energy supply concepts real climate neutrality can be achieved to a large extend. The resulting additional costs are moderate and amount to about 300 €/a compared to the PV+WP concept, and lead to an additional avoidance of about 650 kg $CO_{2\ eq}$ emissions per year.

The results shown here using the example of a single-family house can in principle also be transferred to multi-family houses as well as districts and complete cities. However, for the solar thermal heat supply of several buildings, solar local heating systems in combination with seasonal heat storage should be used instead of decentralized systems, as this technology is more efficient and cost-effective.

In order to effectively limit global warming and thus mitigate climate change, it is crucial to significantly reduce $CO_{2\ eq}$ emissions. Therefore, in the future, only technologies that enable real climate neutrality should be used. In the area of heat supply, these are primarily biomass and seasonal electricity or energy storage, e.g. using green hydrogen, in addition to solar thermal energy.

Biomass is cost-effective, but its potential is relatively limited and its use is associated with odor and particulate emissions. It should therefore preferably be used only on a small scale, e.g. as a supplementary heat source for thermal solar systems with high solar fractions.

Green hydrogen as seasonal energy storage medium or technology respectively, represents a technology that enables real climate neutrality in the area of heat supply in the same way as solar thermal in combination with seasonal heat storage - but with much higher costs and a significantly greater technological effort.

4. Summary

Using the example of the heat and power supply of a single-family house, it was shown for four different overall energy supply concepts that the specific definitions of climate neutrality are essential for the amount of $CO_{2\ eq}$ emissions calculated for an operation period of one year. But in fact, the actual $CO_{2\ eq}$ emissions are of course independent from the approach of defining climate neutrality and are only determined by the overall energy supply concept.

The approach chosen to define climate neutrality has a significant impact on the calculated $CO_{2\ eq}$ emissions, especially for the PV+WP concept. For concepts with large solar thermal systems to cover the heat demand, the influence of the chosen approach on the calculated $CO_{2\ eq}$ emissions is small.

The additional costs for achieving climate neutrality are primarily influenced by the definition of climate neutrality in the PV+WP concept. For the other overall energy supply concepts considered, the influence of the definition of climate neutrality on the additional costs is negligible.

Only on the basis of real climate neutrality (definition see Section 2.3) global climate neutrality is achievable. It is therefore important that this definition is used exclusively in the future.

This should also be in the interest of the solar thermal sector, as only by using the approach for real climate neutrality is it possible to make an objective ecological comparison of different overall energy supply concepts.

5. Acknowledgments

The leadership of the IEA SHC Task 66 "Solar Energy Buildings" by Dr. Harald Drück as well as the substantial work of the IGTE in Task 66 are funded in connection with the research project Sol4City "Development of integrated solar supply concepts for climate-neutral buildings of the 'City of the Future'" by the German Federal Ministry of Economics and Climate Protection (BMWK) via the Project Management Agency Jülich (PTJ) on the basis of a resolution of the German Bundestag under the funding code 03ETW019A.
The authors gratefully acknowledge the support and take the full responsibility for the content of this publication.

6. References

/1/ IPCC glossary: https://www.ipcc.ch/sr15/chapter/glossary

/2/ Bundes-Klimaschutzgesetz 2021:
https://www.bundesregierung.de/breg-de/themen/klimaschutz/klimaschutzgesetz-2021-1913672

/3/ Klimaschutzgesetz Baden-Württemberg 2021:
https://um.baden-wuerttemberg.de/de/klima/klimaschutz-in-baden-wuerttemberg/klimaschutzgesetz/

/4/ Koalitionsvertrag 2021 – Mehr Fortschritt wagen; Koalitionsvertrag zwischen SPD, Bündnis 90 / Die Grünen und FDP
https://www.bundesregierung.de/breg-de/service/gesetzesvorhaben/koalitionsvertrag-2021-1990800
Website accessed on 17.04.2022

/5/ ProBas – Prozessorientierte Basisdaten für Umweltmanagementsystem
https://www.probas.umweltbundesamt.de/php/index.php
Website accessed on 15.04.2022

/6/ Erste Details des EEG-„Osterpakets" bekannt – Viele Verbesserung für Photovoltaik geplant
https://www.pv-magazine.de/2022/02/28/erste-details-des-eeg-osterpakets-bekannt-viele-verbesserung-fuer-photovoltaik-geplant/
Website accessed on 17.04.2022