Solar shading as a cost-effective means to stop rising air-conditioning needs in Europe

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Abstract
Active space cooling in buildings is projected to rapidly grow until 2050 in Europe. The IEA estimates air-conditioning (AC) in Europe to rise from 115 million units in 2020 to 275 million units by 2050. A comprehensive analysis has been conducted on the extent an uptake of external dynamic solar shading devices on windows could mitigate the predicted additional energy use and associated GHG emissions of AC units in Europe. Results show that dynamic solar shading can effectively stop the predicted trend of rising needs for AC. This means significant reductions of electricity use for AC, net-cost-savings and GHG emissions. In order to get dynamic solar shading a fair chance amongst options for most cost-effective building configurations, the European Energy Performance of Buildings Directive (EPBD) could pave the way by explicitly introducing the energy efficiency first principle as the mandatory guiding principle for setting up minimum energy performance requirements. For new buildings and retrofits a mandatory due diligence for overheating should be introduced, stipulating to first apply solar shading and only then consider active AC if still needed. Furthermore, the EPBD should enable to adequately map the bivalent character of dynamic solar shading – being an element of the building envelope and of building automation and control systems (BACS) at the same time - to the EPBD articles.

Introduction
Due to increasing comfort requirements and ongoing climate change, active space cooling in buildings is projected to rapidly grow during the next decades in Europe. More space cooling typically requires more air conditioning units and longer operation of existing ones. The International Energy Agency (IEA) estimates in its business-as-usual scenario a rise from 115 million air-conditioning units in 2020 to 275 million units in Europe by 2050.[1] As more AC units need more electricity, this will cause additional greenhouse gas (GHG) emissions for every additional unit of electricity for space cooling purposes, as a fully decarbonised energy system is expected to be in place by 2050 only.

The main drivers for this expectedly rising need for cooling are both increasing overheating in buildings due to climate change and rising expectations on summer comfort by building users.[2] [3]

On 29 July 2021, the European Climate Law entered into force.[4] It sets a legally binding target of net-zero GHG emissions by 2050. Reducing GHG emissions for space heating and decarbonising the energy supply to an extent reflecting that obligation already is a tremendous challenge. Any additional burden will increase the risk to miss that target. It is essential to use the full potential of technologies to mitigate or reverse rising electricity needs from space cooling. Otherwise, the transformation to a fully renewable energy system will be even more

1. IEA, 2018.
2. Pezzutto et al., 2017.
3. Jakubcionis et al., 2018.
4. EC, 2021.

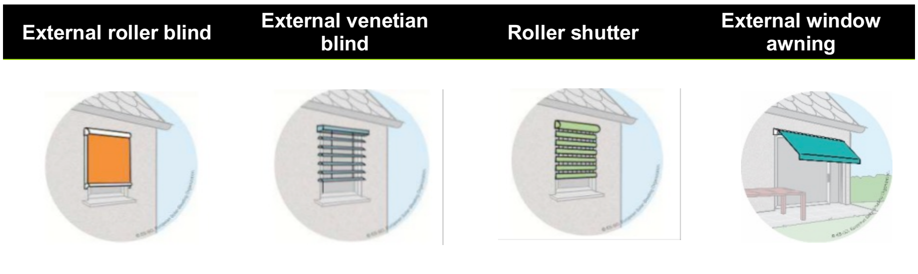


Figure 1. Overview of most relevant solar shading devices (images courtesy European Solar Shading Organisation (ES-SO)).

challenging, meaning probability of both getting on track to climate neutrality by 2050, and to meet the Paris Agreement declines.

Scenarios as presented by IEA do not assume significant improvements in reducing passive solar gains to buildings. Yet, dynamic solar shading devices on windows may be a key technology to avoid future overheating of buildings and to mitigate the additional energy use and associated GHG emissions for space cooling.

The purpose of this analysis is to provide evidence on the role dynamic solar shading can play in reducing energy use and GHG emissions from active space cooling, i.e., air-conditioning and to create political awareness on its potential role for the building sector to achieve an adequate contribution to the European Green Deal. The following main questions are addressed for EU27 between 2020 and 2050:

1. How would the need for air-conditioning likely develop without any improvement in solar shading?
2. To what extent can dynamic solar shading mitigate this development?
3. What is the best possible estimated impact in terms of energy savings, GHG emissions, and cost, dynamic solar shading could have?

Less than 50 % of the EU's buildings are equipped with solar shading devices, of which a large share is non-dynamic or not automated.[5] Therefore the potential to mitigate both overheating and uptake of AC units by a smart uptake of dynamic solar shading devices appears to be significant. To make the topic more tangible, Figure 1 provides an overview on the most relevant solar shading devices.[6]

Methodology

OVERVIEW

To grasp the topic comprehensively, the overall methodological approach comprises three steps:

- Analysis of most relevant determinants for overheating in buildings
- Dynamic, thermal simulation of overheating risk in selected reference buildings, including variants regarding types of shading and their smartness
- Aggregation to the EU27 building stock, in three different shading scenarios, varying relative to their assumptions on uptake of dynamic solar shading.

MOST RELEVANT DETERMINANTS OF OVERHEATING

In order to define reference buildings and scenarios that would capture the most relevant determinants of overheating in buildings, a systematic analysis of these determinants has been made. Figure 2 provides an overview.

Combining different parameters of those determinants leads to a huge number of variants. These variants again need to be applied to different building types, where they yield different impacts. Therefore, the challenge at this point was to bring down the number of combinations of variants and building types to a manageable level.

First, the question of a suitable climate trajectory (2020–2050), climate zones and reference locations for each of those zones was addressed.

- Climate data: the Meteonorm dataset for IPCC scenario B1[7] / A1B[8] was selected (temperature rise of 1.8 °C at the end of the 21st century) for the sake of caution relative to the influence of global warming on future AC needs
- Five climate zones were selected to match the ones used for the EPBD Impact Assessment 2021 (see Figure 3). Reference locations for each of those zones were selected by applying European Environmental Agency (EEA) data on population weighted cooling degree days (CDD).[9] Within those five zones, the two zones 'Western' and 'Southern' by far have the highest population. To simplify the exercise therefore the originally five climate zones were clustered into two zones, called 'Western' and 'Southern', where 'Western' now includes original Western, Northern and North-Eastern zones, while 'Southern' includes original Southern and South-Eastern.
- Brussels was chosen as reference location for Western, Toulouse for Southern.

5. Estimate based on van Elburg et al., 2015b.

6. For simulations, shading devices were assumed that still allow sufficient outside view and daylight, like external venetian blinds.

7. IPCC, 2012.

8. Nakicenovic et al., 2000.

9. EEA, 2021.

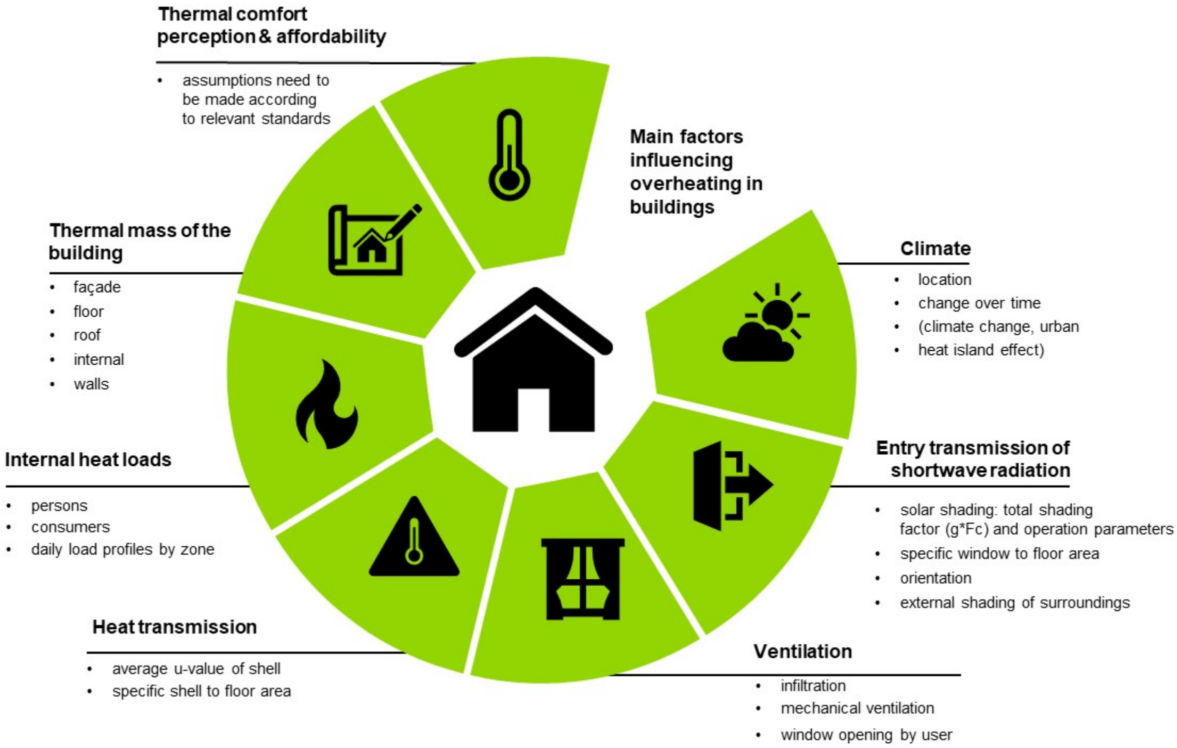


Figure 2. Determinants for overheating in buildings (own illustration).

- Taking the selected locations, and weighting by population results in 114 CDD for EU27 in 2020, while the EEA weighted average is 110, i.e. this is a very good match. For 2050, applying the B1 Meteonorm data for the selected locations results in 156 CDD, an increase by approx. 37 %.

In a second step, a sensitivity analysis applying thermal, dynamic simulation using the software package TRNSYS was performed. For this purpose, the geometry of a small single-family home (SFH) typical for the Western zone was selected, with two thermal zones on the ground floor (Z1: kitchen, living & dining room; Z2: bathroom, secondary rooms) and another two on the upper floor (Z3: children; Z4: 2 bedrooms). Differences between base case and variants were defined as depicted in Table 1.

As the impact of different effectiveness of solar shading is of interest, already the baseline features different variants for the solar shading coefficient Fc, which is assumed to be either 1 (no shading), 0.5 or 0.2.

Few parameters were kept constant throughout all sensitivity analyses and simulations:

- internal load: in residential buildings 4.2 W/m², in office buildings 14 W/m² during office hours (7:00–18:00) and 2 W/m² beyond office hours
- 'medium' thermal mass + furniture
- reduction of irradiation: 10 % by urban dust, 40 % for sun height <16.5 ° and 80 % when <5.5 °, additional reductions by window frame width 0.12 m and embrasure of 0.15 m.

For this sensitivity analysis, 21 variants as shown in Figure 4 have been calculated, all without AC. The occurrence of over-

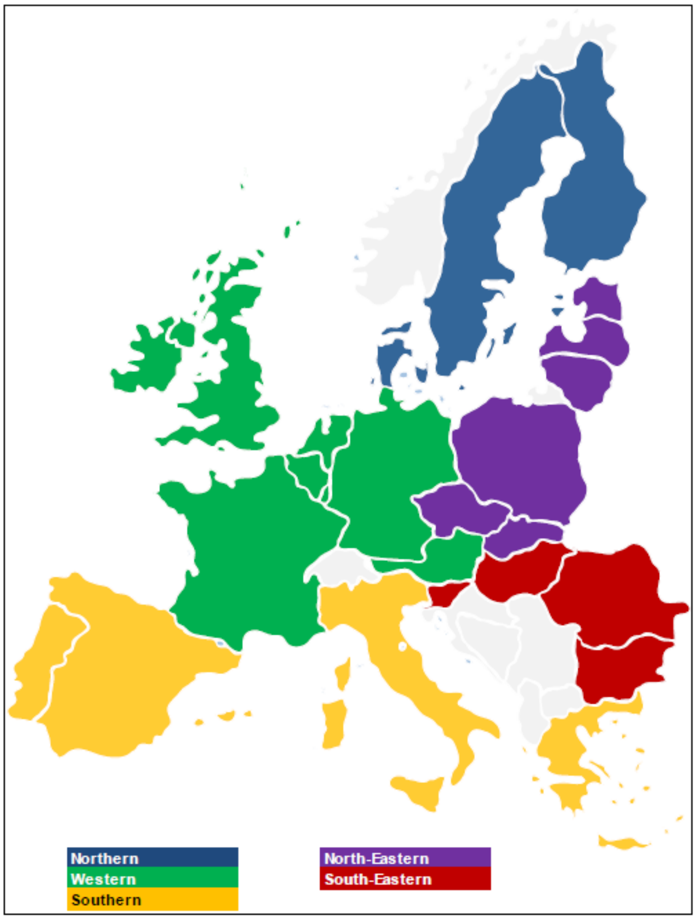


Figure 3. European climate zones used for the study (own illustration).

Table 1. Parameter variation for sensitivity analysis on most relevant parameters for overheating.

	Baseline	Variants
Location	'West' (Brussels)	'S' (Toulouse)
Climate projection	Meteonorm 2020 IPCC Scenario A1B*	Meteonorm 2050, IPCC Scenario A1B*
Orientation (Zone 1+3)	SW	SE
Ventilation* (air changes per hour)	0.5 + either 2.5 during daytime, or 1.5 during night time (11 pm – 6 am)	constant: 0.5
Average U-value	0.6 W/m²K (envelope, incl. windows)	0.35 and 0.9 W/m²K (envelope, incl. windows)

** according to German standard DIN V 4108.*

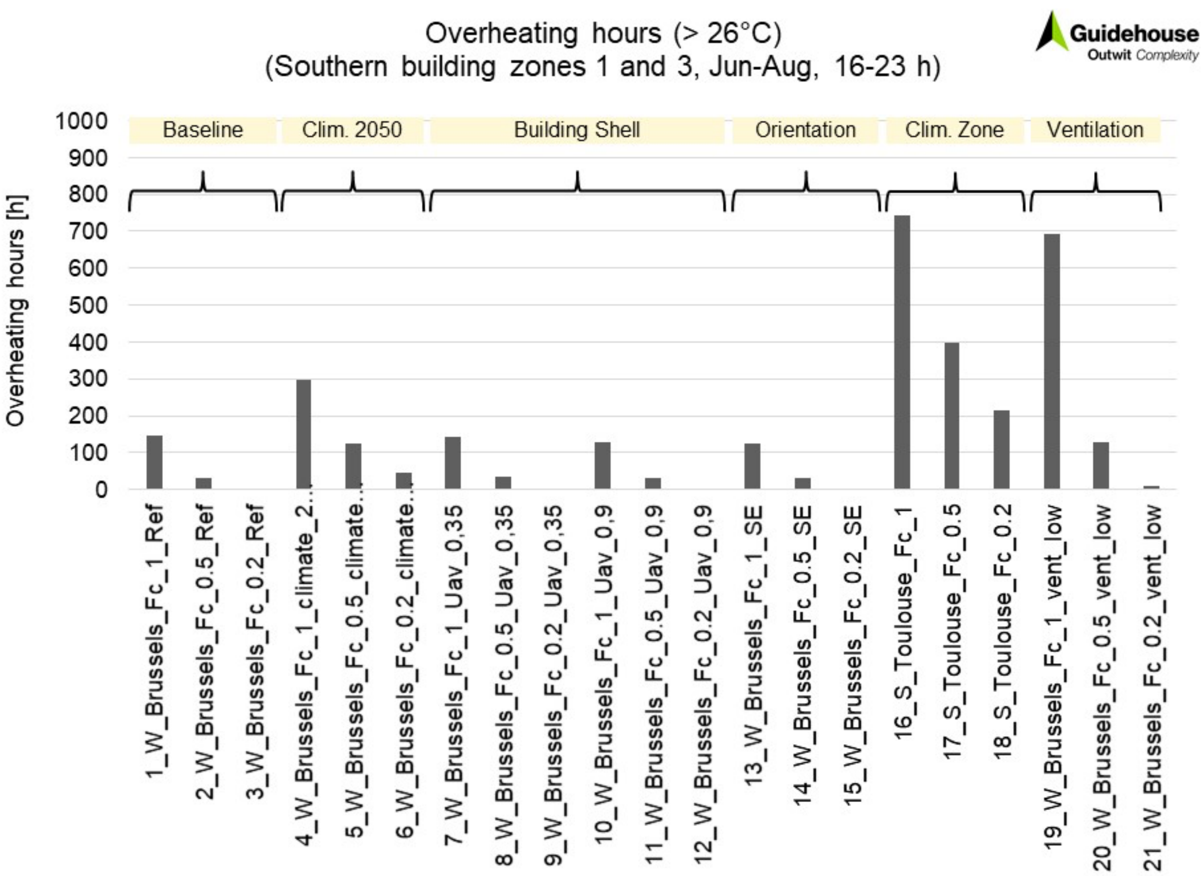


Figure 4. Sensitivity analysis: overheating hours June-August, applying criterion a) (>26°C) (own illustration).

heating has been mapped using two different criteria, either >26 °C indoor air temperature, or > Θ_i max[10] (according to EN 15251: 2012–12, Category III) in the relevant building zones (Z1+Z3) during the main attendance time of persons (16:00–23:00) and during summer month (June-August). Figure 4 shows the results for the >26 °C criterion in those 21 variants.

From left to right, altogether 7 triples of bars can be seen showing overheating hours for the simulated SFH. Within each of these triples the solar shading coefficient F_c varies (1, 0.5 or 0.2, from left to right). In the following six triples always only one parameter is changed compared to the base case: first the building is exposed to 2050 climate, then the insulation of the envelope improves (0.35), then deteriorates (0.9), then orientation is set to South-East, then the building is moved to Toulouse, and finally there is no additional ventilation beyond 0.5 air changes per hour.

As can be seen, varying the insulation quality of the building envelope as well as orientation have comparatively low impact in buildings being typical for the stock. This seems to contradict the often-heard assumption of very well-insulated buildings being very prone to overheating – yet, note that the simulations consider a typical building stock geometry, having average window to wall ratios, evenly distributed around the building, whereas newly constructed buildings may feature significantly higher window to wall ratios and an emphasis on Southern, Western and Eastern windows. Still, putting that typical building stock-geometry SFH into 2050 climate, or to

10. $\Theta_{i,max} = 0.33\ \Theta_{rm + 18.8}$; Θ_{rm} is the floating daily mean temperature.

Table 2. Main parameters of reference buildings for dynamic thermal simulation.

Type of building	Floor area	Orientation	Window/wall area	Net room height	Internal loads 1)	Ventilation
SFH	113 m²	4 zones with 4 façades to opposite orientations	18% (W zone) OR 15% (S zone)	2.6 m	4.2 W/m²	0.5 1/h (plus summer ventilation) 2)
MFH apartment	80 m²	2 zones with 2 façades to opposite orientations	23% (W zone) OR 15% (S zone)	2.6 m	4.2 W/m²	0.5 1/h (without summer ventilation) 3)
Office	20 m² 4)	1 zone with 1 façade	35%	3.0 m	14 W/m² 5)	2.0 1/h 5)

1) referring to EN ISO 13791.

2) plus 2.5 1/h during daytime OR plus 1.5 1/h during night-time (11 pm to 6 am).

3) no summer ventilation due to noise and pollution.

4) 1 room with 4x5 m (depth x façade length).

5) during operating times: 7 am to 6 pm.

the Southern zone or significantly reducing its ventilation all increase overheating hours significantly.

Improving shading (i.e., moving from Fc_1 to Fc_0.5 to Fc_0.2 variants, see each columns' captions) yields significant reductions of overheating hours in all six 'triples' of cases shown in Figure 4.

Based on these insights, the final set of reference buildings was selected and parameters for variation defined. Reference buildings are defined as reference geometries plus standard internal loads and ventilation rates. Geometries were derived from European building stock data: a single-family home (SFH), a multi-family home (MFH) and an office building (see Table 2).[11 12]

Results

FINAL VARIANTS

Varying a) the climate zone, b) AC yes/no, c) additional summer ventilation yes/no, d) 2020 vs. 2050, e) thermal quality of the building envelope 0.35 vs. 0.6 vs. 0.9 W/m²K and f) type of sun protection (different g_{tot}), I) overheating and II) resulting AC need for altogether 77 variants (24 SFH, 28 MFH and 25 offices) were calculated using TRNSYS dynamic thermal simulation. Based on the sensitivity analysis, bundles of sun protection and their control strategy were defined, now applying the more universal total solar gain coefficient g_{tot} instead of F_c:[13]

- 'no shading': no shading devices installed (g_{tot}=0.6)
- 'moderate shading': moderately effective shading, achieving 50 % reduction of solar gains during overheating season, e.g. effective manually controlled shading or moderately effective irradiation controlled shading[14] (g_{tot}=0.1, when closed)
- *optimised shading*: best-practice irradiation-controlled dynamic shading, e.g. effective external shading which is closed when irradiation on a window surface exceeds 150 W/m² (g_{tot}=0.05 when closed)

With a view to the scenario building, for all 77 variants either the number of days where overheating occurs (i.e., for both cooling criteria mentioned above) and alternatively cooling demand (in case AC is assumed to be existent) has been calculated. These numbers are shown in three lines in the table below the graph. Cooling demand has been calculated in a way that days where overheating occurs are *just* reduced to zero. Figure 5 shows results for the office building variants, divided by 'Western' and 'Southern' zone. A heading like '2020_U0.6 no AC' means: 2020 climate, average U-value of building envelope 0.6 W/m²K, no active air-conditioning. All 'AC' variants show the cooling demand that brings down the number of overheating days just to zero.

Major insights from the results presented in Figure 5 are the following:

- Cooling demand in the Southern zone is drastically higher than in Western zone – almost by a factor of 4. Cooling demand means the cooling need, i.e., the heat that needs to be removed from the conditioned area to meet the comfortable temperature level of 24.5 °C.[15] Electricity demand for AC then depends on the AC's seasonal energy efficiency ratio (SEER) and was determined both for 2020 and 2050, considering improvements of SEER till 2050[16].

11. IWU, 2015.

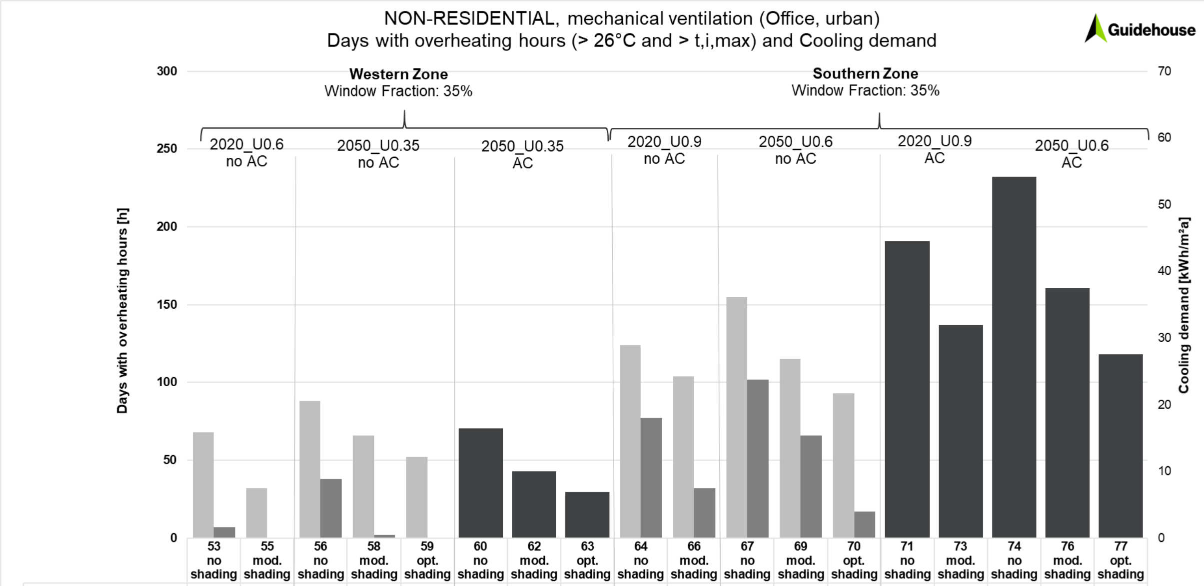
12. Esser et al., 2019.

13. For comparison purposes also solar glazing with g_{tot}=0.3 was part of the analysis; due to increased energy consumption in winter this variant was not analysed further.

14. This option can mean quite different things which had been analysed separately before: a) fixed (non-movable) shading: g_{tot}=0.3 or manual control for residential/office buildings, g_{tot}=0.1 (when closed).

15. The European standard EN 15251:2012-12 recommends a range of 23.5–25.5 °C for energy calculations; here the midpoint, 24.5 °C, was chosen.

16. Years in between were interpolated. SEERs used: RES 2020/50, 3.1/4.9; Non-RES 2020/50: 2.5/3.9.



	53 no shading	55 mod. shading	56 no shading	58 mod. shading	59 opt. shading	60 no shading	62 mod. shading	63 opt. shading	64 no shading	66 mod. shading	67 no shading	69 mod. shading	70 opt. shading	71 no shading	73 mod. shading	74 no shading	76 mod. shading	77 opt. shading
Days > 26°C	68	32	88	66	52	0	0	0	124	104	155	115	93	4	0	8	0	0
Days > t,i,max (EN 15251)	7	0	38	2	0	0	0	0	77	32	102	66	17	0	0	0	0	0
Cooling demand	0	0	0	0	0	16	10	7	0	0	0	0	0	45	32	54	37	28

Figure 5. Days with overheating and alternative cooling demand; non-residential (office) building (own illustration).

- In 2020 there is no need for cooling in the Western zone, which is why it is not shown in Figure 5. Yet, there is a need for cooling in 2050.
- Optimised shading reduces cooling demand by approximately 50 % compared to no shading, and 30 % compared to moderate shading.

SHADING SCENARIOS

In a second step, based on the comprehensive set of results from dynamic thermal simulations, the European building stock is modelled using results of the Guidehouse BEAM model.[17] Using those building stock data is the pre-condition to achieve results aggregated to EU level to answer the questions formulated at the beginning of this paper. Scenario results are meant to comprise the effects of dynamic solar shading on electricity use and GHG emissions for space cooling, as well as capital expenses (CAPEX) and operational expenses (OPEX)[18] for additional shading devices and avoided cooling systems. Results are calculated for two scenarios compared to a Business-as-usual (BAU) scenario.[19] Thus, there are three scenarios.

- Business-as-usual (BAU): No change in the distribution of shading devices between 2020 and 2050.
- Maximum shading: The share of optimised, automated dynamic shading devices increases to a theoretical maximum of 95 %. This scenario assesses a theoretical maximum impact.
- Preferred scenario: An *economically optimised* uptake of automated, dynamic solar shading devices is assumed. This is approximated by assuming that only buildings which according to simulation results would need AC by 2050 in the BAU scenario will be equipped with automated, dynamic solar shading. Thus, this scenario creates a theoretical *best result possible estimate* on what can be achieved by solar shading.

In the following more details are provided on how the scenarios have been set up.

Business-as-usual (BAU)

In BAU the 2020 status for the share of shading devices has been assumed to be in line with a market study on windows.[20] Those shares are then assumed to remain constant until 2050. Floor-area distribution in the EU (SFH, MFH, non-residential buildings) has been taken for weighting and extrapolation purposes. Calculated, aggregated final energy use for AC (TWh/a in 2020) was compared with literature[21] [22] [23] and calibrated with IDEES[24] data. The final energy projection until 2050 is based on increasing cooling degree days (CDD) as prescribed by the IPCC B1 scenario and an increasing saturation of AC penetration is assumed. Furthermore, improvements in cooling unit efficiencies are assumed, see above. Results for office buildings are taken as proxy for non-residential buildings as a whole.

17. Built-Environment Analysis Model, BEAM, which also has been used in support of the Energy Performance of Buildings Directive (EPBD) Impact Assessments of the European Commission in 2021, 2016, and 2010.

18. OPEX includes energy cost and maintenance; the latter assumed to be 4 %/a of investment, both for different types of AC and all relevant potential types of (external) shading.

19. In general, a GDP forecast is also relevant for the AC penetration, but in Europe there are no additional GDP constraints assumed.

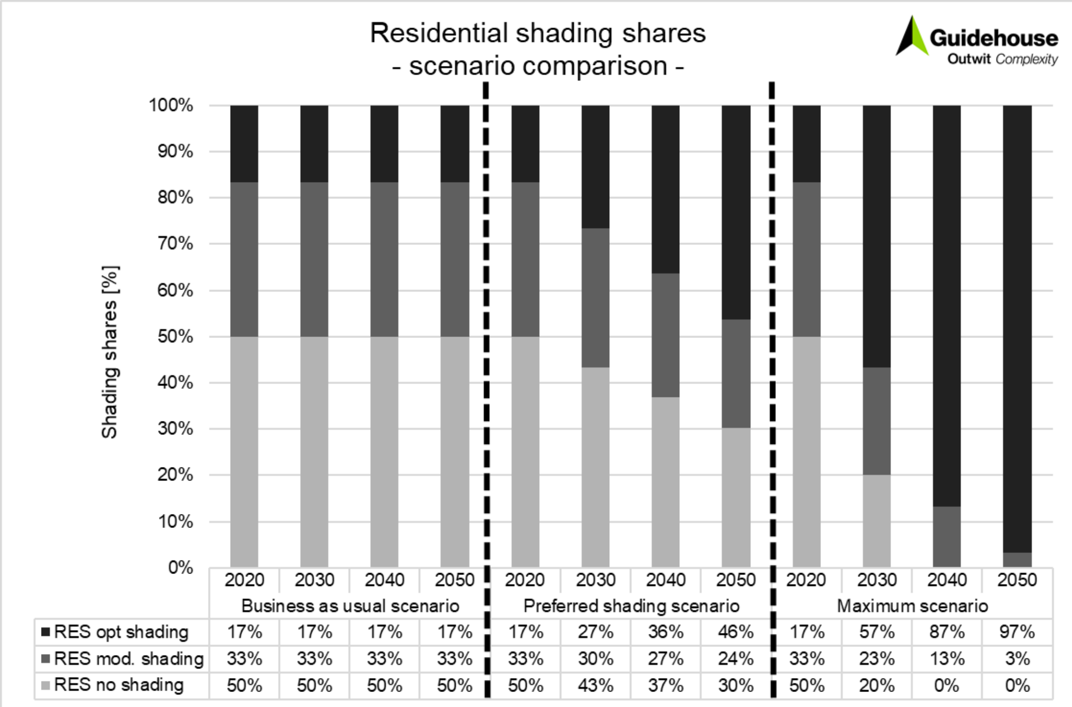
20. van Elburg et al., 2015a.

21. Fleiter et al., 2017.

22. Pezzutto et al., 2017.

23. Jakubcionis et al., 2018.

24. Mantzos et al., 2017.



	Business as usual scenario				Preferred shading scenario				Maximum scenario			
	2020	2030	2040	2050	2020	2030	2040	2050	2020	2030	2040	2050
RES opt shading	17%	17%	17%	17%	17%	27%	36%	46%	17%	57%	87%	97%
RES mod. shading	33%	33%	33%	33%	33%	30%	27%	24%	33%	23%	13%	3%
RES no shading	50%	50%	50%	50%	50%	43%	37%	30%	50%	20%	0%	0%

Figure 6. Residential shading shares, scenario comparison (own illustration).

As for AC-penetration rates for within the different scenarios, for 2020, 2030, 2040 and 2050 a refined approach has been developed compared to the one used in previous studies:

- A refined algorithm with adapted equations (overheating hours instead of CDD as input value) was developed: it is assumed that AC equipment is purchased as soon as 100 hours>26 °C per year is exceeded.
- An equation for AC saturation from McNeil and Letschert[25] was translated with a regression analysis (based on the TRNSYS hourly results) to an AC penetration based on overheating hours.

Maximum shading

In this scenario, 4 % per year of floor area in the EU building stock moves from "no shading" or "moderate shading" to "optimised shading" equally over all building types and zones, regardless of the calculated need for space cooling. Consequently, this scenario reaches a minimum of overheating and thus need for space cooling and the lowest increase of AC-penetration over time due to avoided AC installation of AC in the future for existing and new buildings.

'Preferred' shading scenario

Compared to the maximum scenario in this scenario the move from "no shading" or "moderate shading" to "optimised shading" is targeted to the buildings and zones with highest AC need. Therefore, percentages of annual shift from "no shading" or "moderate shading" to "optimised shading" vary between 0.1 % and 3.0 %. Like with maximum shading, less overheating is achieved and AC increase is lowered compared to BAU, but not to the same extent, yet with significantly less investment in shading devices than for maximum shading.

Figure 6 illustrates the evolution of shading device shares in the building stock per scenario, for residential buildings. A similar exercise was performed for non-residential buildings.

In general, by calculating the difference between BAU and the alternative scenarios, two effects of solar shading uptake are considered:

- Reducing cooling loads for existing space cooling systems.
- Avoiding new AC units, as they will not be needed to enable comfortable indoor climate, leading to their slower uptake in new and existing buildings until 2050.

In the following, results are provided for BAU and the optimised 'preferred' scenario. The maximum scenario turned out to provide slightly better results in terms of reduced cooling loads and avoided new AC, yet at drastically higher costs than the optimised scenario and thus by far not yielding economically viable results.

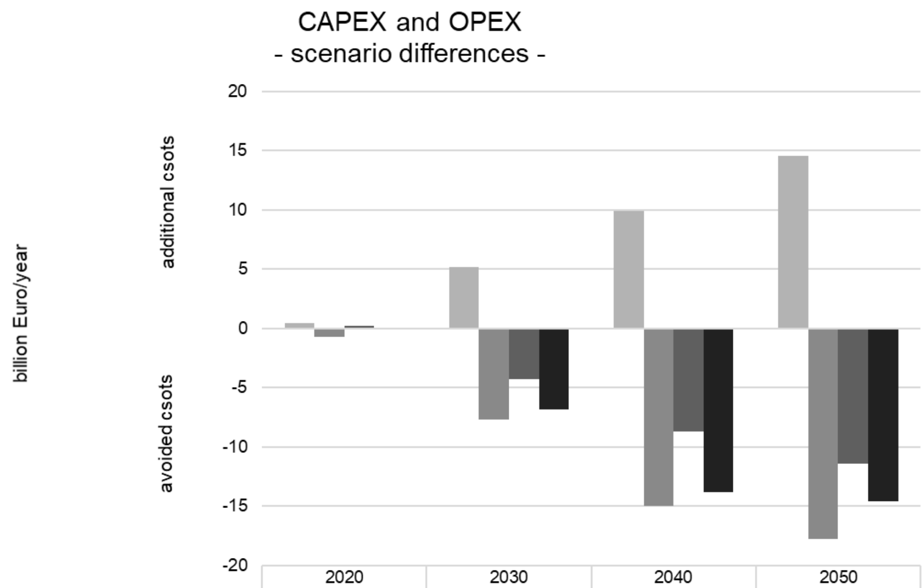
EVOLUTION OF COOLING FINAL ENERGY AND GHG EMISSIONS IN EU BUILDING STOCK

Literature provides a range between 20 TWh/a and 250 TWh/a electricity use for space cooling, the majority of studies providing values around 130 TWh/a.[26]

In this study we assumed approximately 80 TWh/a in 2020. With BAU shading, approximately 90 TWh/a would be needed

25. McNeil et al., 2008.

26. compare overview provided by Pezzutto et al., 2017.



	2020	2030	2040	2050
(Preferred-BAU) scenario CAPEX, shading	0,5	5,2	9,9	14,6
(Preferred-BAU) scenario CAPEX, AC	-0,7	-7,7	-15,0	-17,8
(Preferred-BAU) scenario OPEX	0,2	-4,3	-8,7	-11,4
(Preferred-BAU) scenario CAPEX+OPEX	0,0	-6,8	-13,9	-14,6

Figure 7. CAPEX and OPEX, BAU vs. Preferred Shading scenario.

by 2050, already considering continuous improvement of AC units' efficiency. With the optimised, preferred shading scenario, theoretically a reduction towards 35 TWh/a by 2050 could be achieved, i.e., up to minus approx. 60 % vs. BAU, assuming the same improvement of AC units' efficiency as in the BAU scenario.

Due to the decarbonisation of electricity, even in the BAU scenario with its increase in electricity, the total CO_{2e}-emissions for space cooling are estimated to decrease by approximately 16 Mt/a (from 24 Mt/a to 8 Mt/a) between today and 2050. In comparison, in the Preferred shading scenario, this decrease is estimated to be approximately 20 Mt/a (from 24 Mt/a to 3 Mt/a). As this advantage builds up between today and 2050, annual savings increase over time and cumulate until 2050 to up to approximately 100 Mt.

COSTS AND BENEFITS

With an optimised uptake of dynamic solar shading, the chance to meet mid-century climate targets increases - at an even lower cost. An optimised uptake of dynamic solar shading saves on capital expenditure (CAPEX) for AC units and on operational expenditures (OPEX) for their electricity use. These savings are significantly higher than additional capital expenditure (CAPEX) on dynamic solar shading. This means that the total cost (CAPEX plus OPEX) of the 'Preferred' shading scenario is significantly lower than in the BAU scenario – see Figure 7 for an illustration of details.

For each milestone year – 2020, 2030, 2040, and 2050 – the figure shows the difference between the Preferred and BAU scenarios: (additional) CAPEX for dynamic solar shading, (avoided) CAPEX for AC, (avoided) OPEX mainly from electricity savings, and the total savings, i.e., the sum of all three previously mentioned items.

Generally speaking, there is a significant economic potential: while additional and avoided CAPEX roughly compensate each other, the economic advantage of the Preferred scenario mainly stems from avoided OPEX. As an example, it is estimated that in 2050, theoretically up to approximately €11 billion in annual OPEX can be saved. Even if only a fraction of this theoretical potential will be realised, this is still very significant.

Avoided infrastructure costs for electricity generation have not yet been included and would potentially further improve the economic benefit of a wider uptake of dynamic solar shading.

Conclusions and Recommendations

The analysis shows that uptake of solar shading, specifically dynamic solar shading can strategically be designed in a very cost-effective way to mitigate or even stop increasing overheating and significantly increasing electricity use and GHG emissions from space cooling across Europe.

By the end of September 2021, the European Commission published its Energy Efficiency First Recommendation and Energy Efficiency First Guidelines.[27] Applying the Commission's words for 'action in energy efficiency', so far solar shading, being an effective energy efficiency action as pointed out, has not been considered on the same level as AC.

The EPBD offers several opportunities to enable such equal consideration of (dynamic) solar shading with active cooling provided by AC.

In general, we recommend that the following major items should be taken up by the EPBD:

27. EC European Commission 9/28/2021.

- The EPBD should explicitly introduce the energy efficiency first principle as the mandatory guiding principle for setting up minimum energy performance requirements (e.g. 'by improving first the performance of the building envelope before other measures are applied,' as suggested in the Commission's Energy Efficiency First guidelines.
- For the case of solar shading this would mean that for new buildings and retrofits a mandatory due diligence for overheating should be introduced, stipulating to first apply shading so far as this is technically, functionally, and economically feasible and only then consider active AC if still needed.
- The EPBD should ensure that the bivalent character of dynamic solar shading can be adequately mapped to the EPBD Articles. So far it falls into a gap between building envelope and technical building systems. Such gap does not exist in EN 15232 on building automation and control or in the SRI. The solar shading itself should be considered as part of the building envelope, while smart controls, transforming solar shading into a dynamic component that actively manages solar gains and potentially interacts with automation and control of other technical building systems (e.g., heating, ventilation and AC (HVAC)), should be considered as BACS. This would also reflect the existing link to technical building systems.

As the EPBD is a complex set of inter-related requirements, there are several Articles that could potentially take up the items mentioned above. The following provides a number of concrete examples for updates that would serve those major items.

- Art. 3a (building automation and control systems) should be amended, stipulating that 'building automation and control systems […] support […] technical building systems or elements of the building envelope […]'
- Art. 4 (setting of minimum energy performance requirements) should be amended by the Energy Efficiency First principle, e.g. 'Minimum energy performance requirements need to be set with a view to the Energy Efficiency First principle; i.e. first energy needs for space heating, space cooling, domestic hot water, ventilation, and lighting need to be reduced in so far as this is technically, functionally, and economically feasible and then need to be supplied by technical building systems, which need to be optimised according to Art. 8.'
- Art. 5 (Calculation of cost-optimal levels of minimum energy performance requirements) could be updated indirectly, as Art. 22 requires an update to Annex I (points 3 and 4) to technical progress, with a focus on existing delegated acts.
  - As there is a delegated act on cost-optimality, where so far in its application by Member States dynamic solar shading has played a minor role, points 3 or 4 or the delegated act could be updated.
  - Annex I, point 3 g) could be updated: 'passive solar systems and solar protection including their controls and integration into BACS.'
- Art. 11 (energy performance certificates) currently requires the energy performance certificate (EPC) to include 'recommendations for the cost-optimal or cost-effective improvement of the energy performance of a building or building unit,' both for the cases of major renovation or measures for individual building elements. As the ongoing revision of the EPBD suggests harmonisation of EPC across Europe, a template including recommendations for standard measures would be useful. These standard measures could include installation or upgrade of solar shading based on previous due diligence of overheating. Alternatively, such recommendations could also be part of the envisaged template for building renovation passports (BRP).

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