Cooling demand and impact on the energy system

Cooling Down Webinar: Towards a net-zero future

The vital role of geothermal and solar thermal in providing sustainable cooling solutions

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Cool LIFE

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Definition of cooling

Cooling

Space cooling Process cooling

Space cooling is defined as the removal of heat from the air to cool indoor air and ensure healthy conditions and thermal comfort to the occupants of an enclosed space (e.g. buildings). Space cooling lowers the temperature of the air. Typical set-points of indoor air temperature for space cooling vary, occurring between 20 and 30 °C.

Process cooling is defined as the removal of heat from processes (e.g. plastic mould cooling), from products, or from a confined space containing these processes or products in view of maintaining the required set temperature.

Source: Pezzutto, S. et al. Cooling technologies overview and market shares. Part 1 of the study "Renewable cooling under the revised Renewable Energy Directive ENER/C1/2018-493" https://op.europa.eu/en/publication-detail/-/publication/cc824dac-eabe-11ec-a534-01aa75ed71a1/language-en

Definition of demand

The space cooling demand (**useful energy demand**) is the net heat removed from space to be cooled. In contrast, the space cooling consumption (**final energy consumption**) for space cooling is the energy input of the space cooling generators. As such, the two quantities differ by disparate conversion factors. The energy efficiency ratio (EER) for electrically driven space cooling equipment is > 1. Because of that, the final energy consumption for space cooling is lower than the useful energy demand for space cooling.

Source: Pezzutto, S. et al. Cooling technologies overview and market shares. Part 1 of the study "Renewable cooling under the revised Renewable Energy Directive ENER/C1/2018-493" https://op.europa.eu/en/publication-detail/-/publication/cc824dac-eabe-11ec-a534-01aa75ed71a1/language-en

Assessment of space cooling demand

Methodology 1

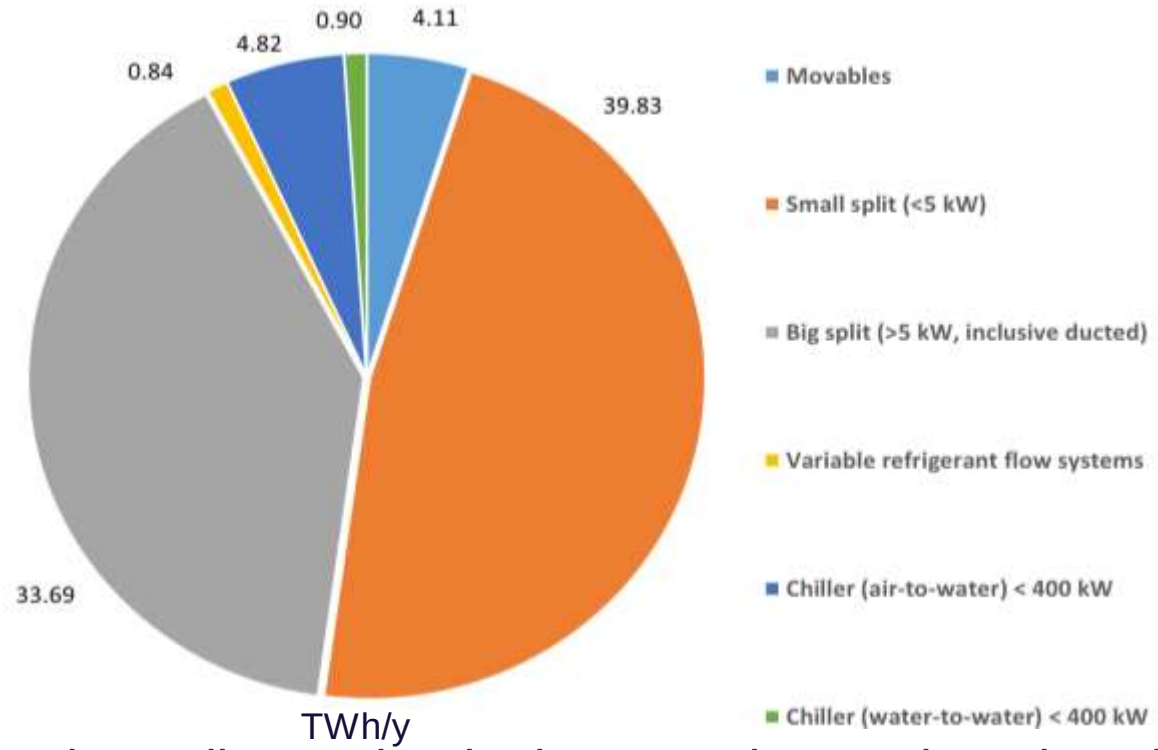
$$\text{Energy consumption}_{\text{Space cooling}} = \text{Nr.}_{\text{AC units}} * T_{\text{equivalent full-load hours}} * W_{\text{electricity}}$$

Installed capacity per AC type / SEER

Transforming in space cooling demand = * SEER

Source: Pezzutto, S. et al. Status Quo of the Air-Conditioning Market in Europe: Assessment of the Building Stock. 2017 https://www.mdpi.com/1996-1073/10/9/1253

Assessment of space cooling demand

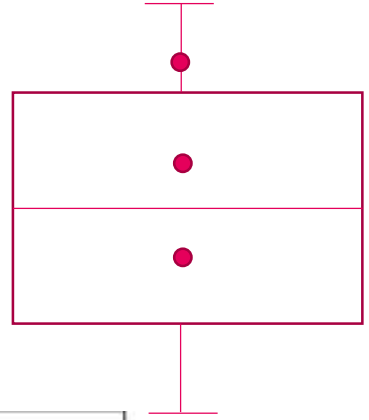


Source: Pezzutto, S. et al. Cooling technologies overview and market shares. Part 1 of the study "Renewable cooling under the revised Renewable Energy Directive ENER/C1/2018-493" https://op.europa.eu/en/publication-detail/-/publication/cc824dac-eabe-11ec-a534-01aa75ed71a1/language-en

Assessment of space cooling demand

Methodology 2

Data assembly by box-plot methodology



Countries	Space cooling demand, residential sector [kWh/m² a]				Calculations				Calculations						Calculations								
					Average	StDev	Dev%	Country	N°	N° data utilized	Average new	Space cooling demand, weighted average, heated floor area, residential sector, EU-15 [kWh/m² a]	Inhabitants [Mil.]	Residential floor area [Mm²]	Cooled floor area, residential sector [Mm²]	Inhabitants per country, EU-15 [%]	Residential floor area per country, EU-15 [%]	Cooled floor area per country, EU-15 [%]	Space cooling demand per country on total [%]	Space cooling demand, residential sector [kWh/inhabitant a]	Space cooling demand average, residential sector, EU-15 [kWh/inhabitant a]	Total cooling demand, per country, residential sector [TWh/a]
Austria	39	38	25		34	8	23%	Austria	3	2	39	41	8	304	8	2%	2%	1%	1%	36	52	0.3
Belgium	28				28	0	0%	Belgium	1	1	28	41	10	418	9	3%	3%	2%	1%	24	52	0.9
Denmark	22				22	0	0%	Denmark	1	1	22	41	6	302	4	1%	2%	1%	0%	15	52	0.1
Finland	27				27	0	0%	Finland	1	1	27	41	5	194	6	1%	1%	1%	1%	28	52	0.2
France	35	36			36	1	2%	France	2	2	36	41	65	2619	103	16%	17%	18%	15%	56	52	4
Germany	35	35	20	36	32	8	24%	Germany	4	3	35	41	82	1396	60	21%	21%	10%	9%	26	52	2
Greece	59	42			51	12	23%	Greece	2	2	51	41	11	361	38	3%	2%	7%	8%	181	52	2
Ireland	12				12	0	1%	Ireland	1	1	12	41	4	148	4	1%	1%	1%	0%	11	52	0.05
Italy	49	45	25	48	42	11	27%	Italy	4	3	47	41	61	2537	120	15%	16%	21%	24%	93	52	6
Luxembourg	30				30	0	0%	Luxembourg	1	1	30	41	1	28	0	0%	0%	0%	0%	13	52	0.01
Netherlands	24	22			23	1	6%	Netherlands	2	2	23	41	17	676	16	4%	4%	3%	2%	22	52	0.4
Portugal	38	14	39		30	14	47%	Portugal	3	2	39	41	11	441	24	3%	3%	4%	4%	86	52	1
Spain	54	50	27	55	47	13	28%	Spain	4	3	53	41	47	1814	126	12%	11%	22%	28%	142	52	7
Sweden	27	22			25	4	14%	Sweden	2	2	25	41	9	403	10	2%	3%	2%	1%	26	52	0.2
United Kingdom	27				27	0	0%	United Kingdom	1	1	27	41	62	2215	56	16%	14%	10%	6%	24	52	2

Source: Pezzutto, S. Analysis of the space heating and cooling market in Europe. PhD Thesis. 2014

Assessment of space cooling demand

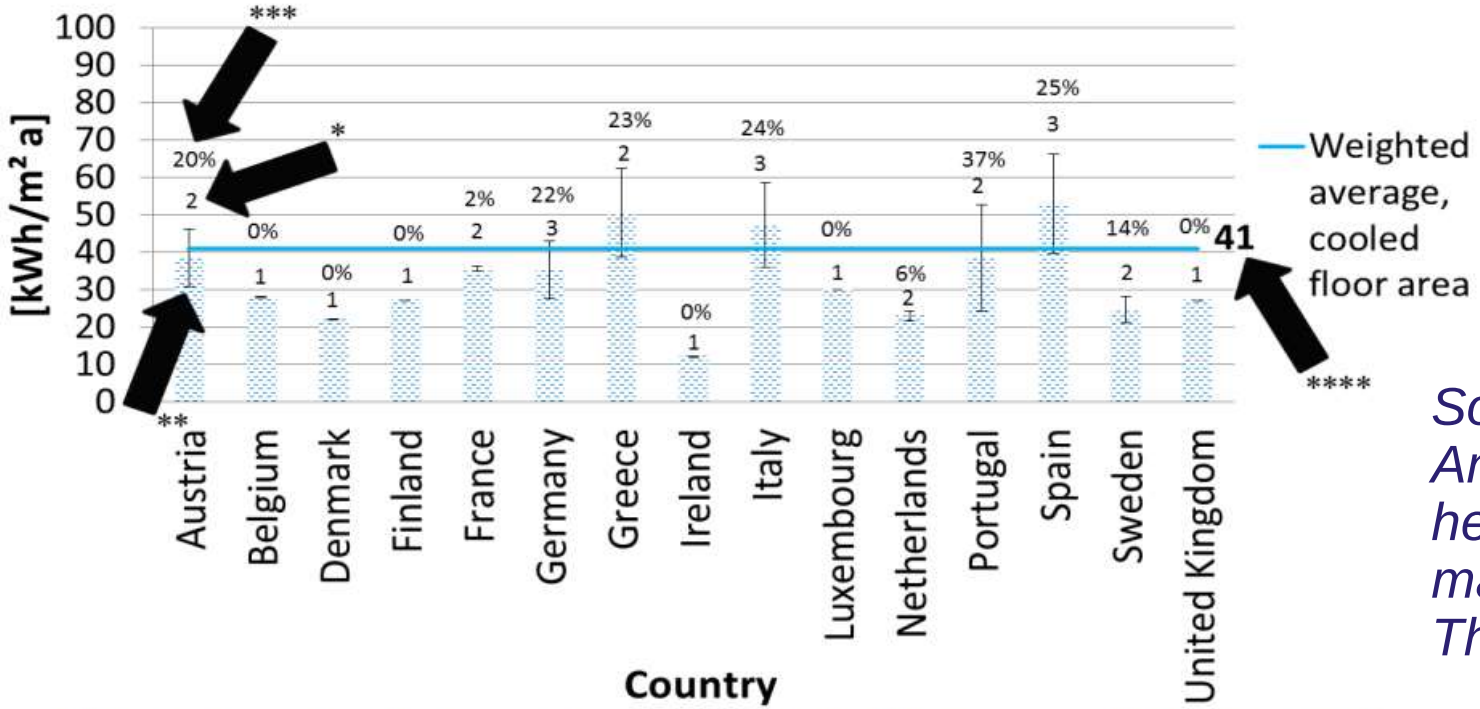


Figure 4: Space cooling demand per country, cooled floor area, residential sector with graphic indication [kWh/m² a] (source: Appendix A, Table 18 and 25)

* Amount of data utilized to form the column

** Error bar with standard deviation of the collected data to form the column

*** Uncertainty percentage of the collected data to form the column

**** Weighted average per cooled floor area of the EU-15 countries

Source: Pezzutto, S. Analysis of the space heating and cooling market in Europe. PhD Thesis. 2014

Assessment of space cooling demand

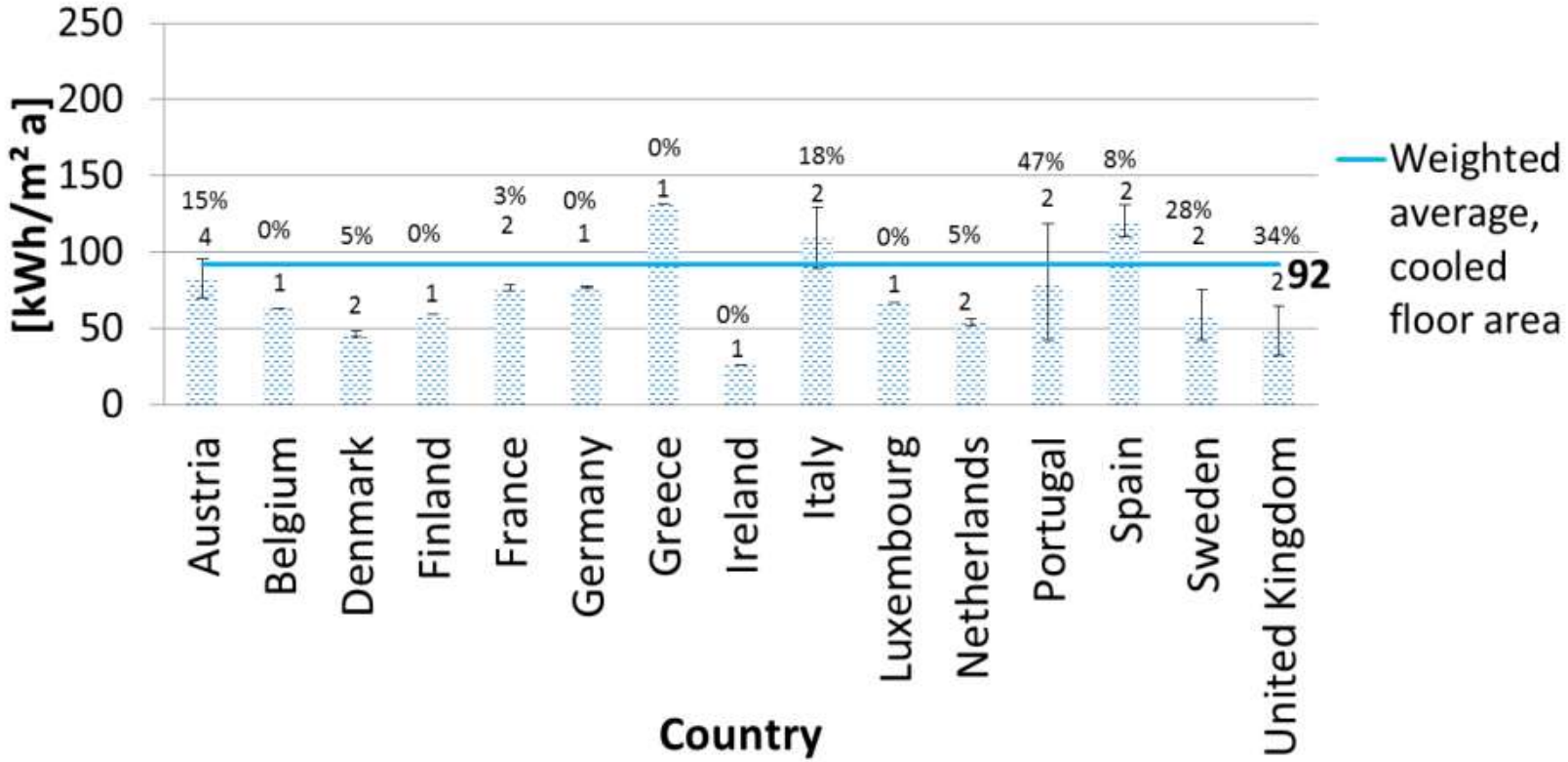


Figure 22: Space cooling demand per country, cooled floor area, service sector [kWh/m² a] (source: Appendix A, Table 30 and 31)

Source: Pezzutto, S. Analysis of the space heating and cooling market in Europe. PhD Thesis. 2014

Impact on the energy system

- *Electricity network (~99% of installed space cooling systems in the EU are electrically powered vapour compression systems)*

Grid overload
RES (local RES)
Natural cooling, passive cooling, free cooling

Source: Pezzutto, S. et al. Cooling technologies overview and market shares. Part 1 of the study "Renewable cooling under the revised Renewable Energy Directive ENER/C1/2018-493" https://op.europa.eu/en/publication-detail/-/publication/cc824dac-eabe-11ec-a534-01aa75ed71a1/language-en

Impact on the energy system

Natural cooling is characterized by the use of natural and renewable energy source (e.g. air, water, sky, ground temperature, etc.) which is at a lower temperature compared with the air inside the building. Source: Delgado MC G. Using the sky as heat sink: Climatic applicability of night-sky based natural cooling techniques in Europe. 2020 https://www.sciencedirect.com/science/article/pii/S019689042030959 6?casa_token=onXpFeOJIfAAAAAA:cIxI4M2HaKW4T3DXoSBCb4HfbLtFMIVAOrg7yBdIFHR699F-MgQM6mpMwY_tG9NmLHHzjZFT4g

Passive cooling is intended as an approach that makes use of the building design and materials in order to keep a comfortable temperature inside the buildings without the use of mechanical or electrical devices. Source: AG. Passive cooling. 2021 https://www.yourhome.gov.au/passive-design/passive-cooling

Free cooling is a cooling technique that stores cold when temperatures are low and absorbs heat when room temperatures are high. Thus, it uses the low temperature of a heat source to efficiently decrease energy consumption for cooling. Source: Wu S. Heat energy storage and cooling in buildings. 2010 https://www.sciencedirect.com/science/article/pii/B9781845695262500049

Thank you for your attention

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