BIM4ENERGY
ERASMUS+

Erasmus+ Project ID: 2023-1-ES01-KA220-HED-000156652

BIM digital competencies to evaluate and improve the energy efficiency of European buildings.
A digital way towards positive energy districts

Energy efficiency of existing buildings in Norway

Thursday, February 8 – Building Energy Efficiency Day
Lucas van Laack, Head of Sustainability Buildings Norway

Speaker: Lucas van Laack

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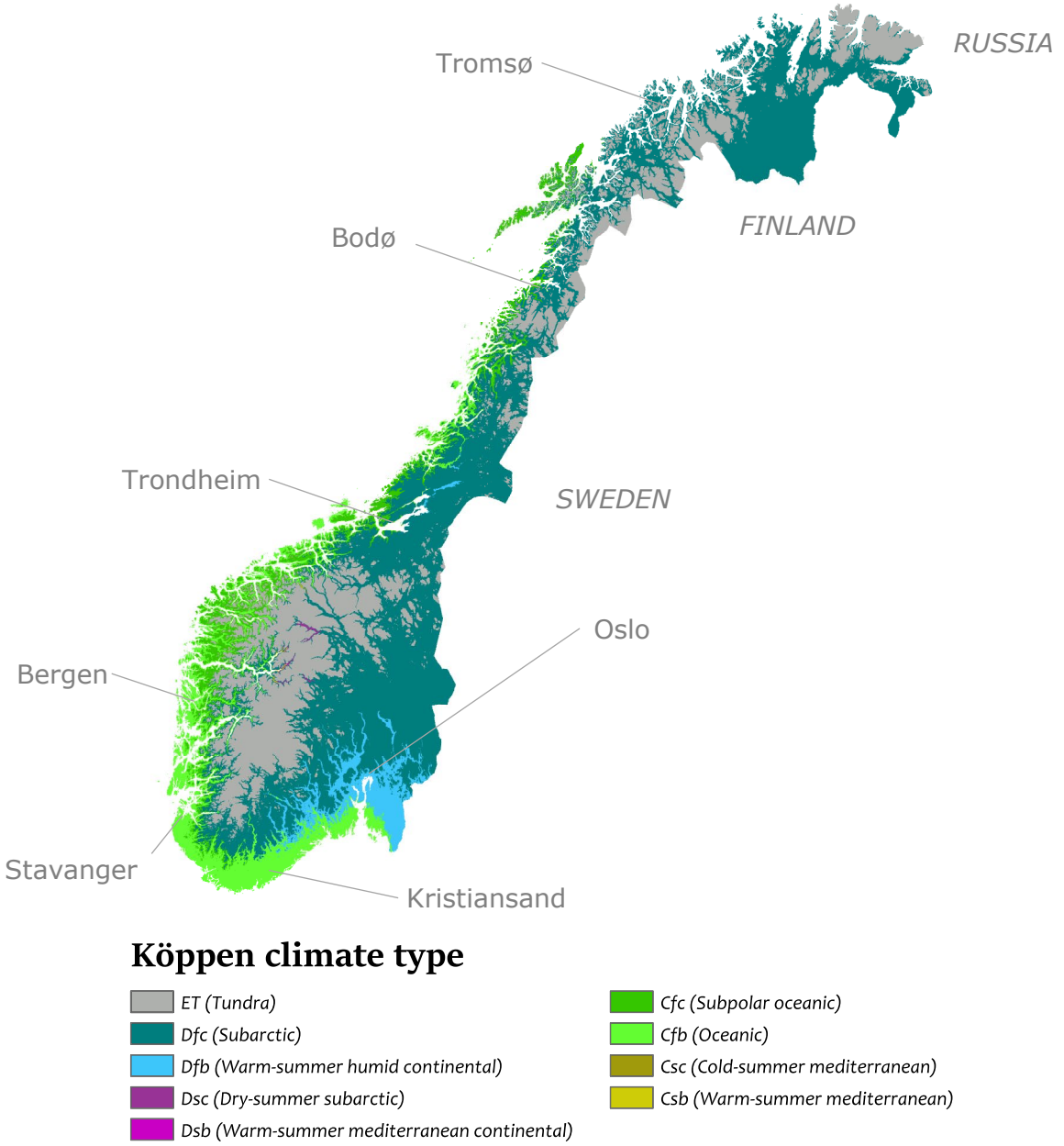
Agenda

1. Introducing Rambøll
2. Energy and Carbon EU/Norway
3. The Norwegian Building Stock
4. Building Regs and Energy
5. Retrofitting Existing Buildings – Case 1
6. Retrofitting Existing Buildings – Case 2
7. Tools for energy design
8. Subsidies in Norway



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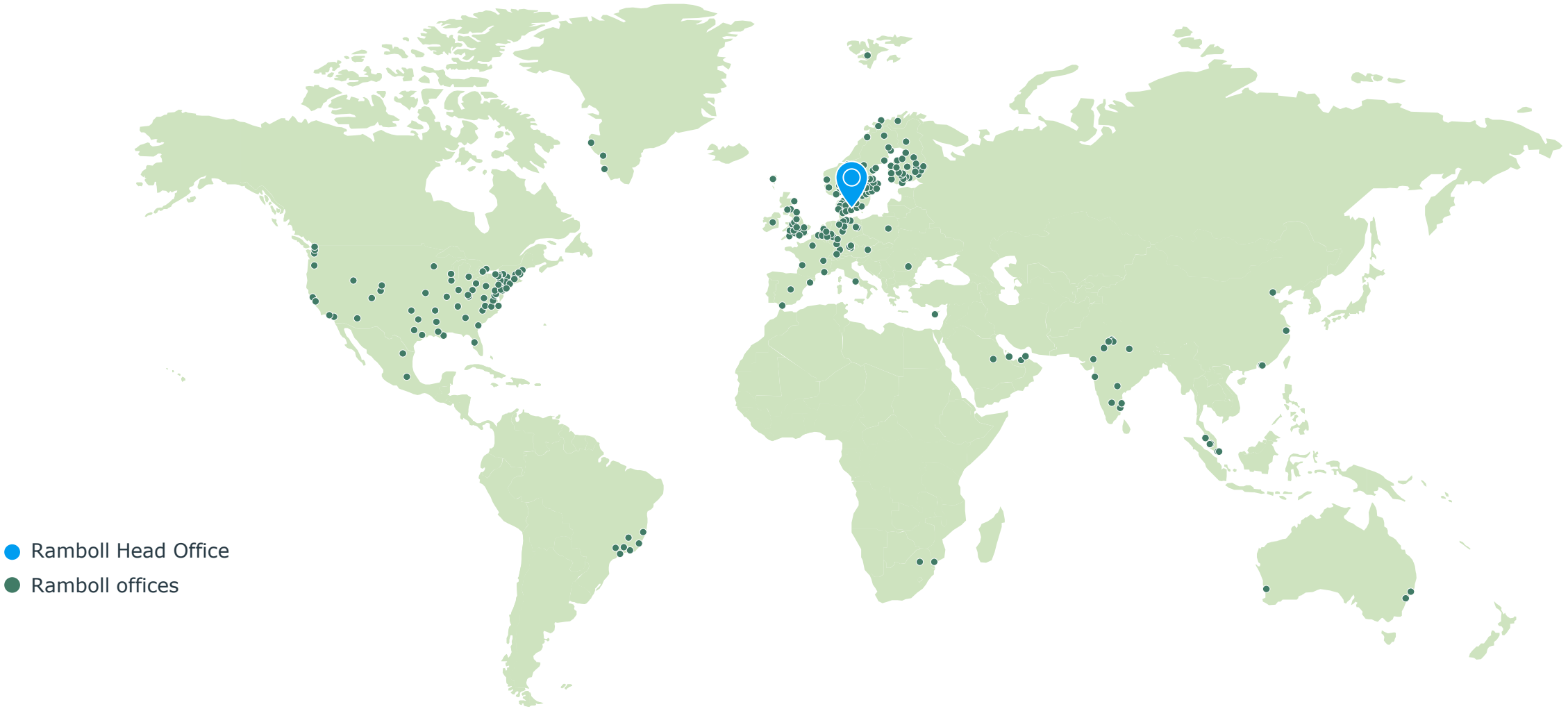
1- Introducing Rambøll

A strong heritage

- Founded in 1945 in Copenhagen, Denmark
- Founders: Professors Johan G. Hannemann and Børge J. Rambøll
- Talented engineering combined with social visionary aspects
- Strong principles and philosophy – communicated in "Our Legacy"

Børge J. Rambøll and Johan G. Hannemann

Geographical footprint



Rambøll - Our Markets

	Revenue share 2022	FTEE Employees 2022
Buildings	26%	4,519
Transport	20%	3,706
Environment & Health	24%	2,809
Energy	14%	1,878
Water	7%	968
Management Consulting	4%	787
Architecture & landscape	5%	803

Buildings

- Aviation
- Arts & culture
- Commercial
- Social housing
- Healthcare
- Higher/Further Education
- Hotels & leisure
- Industrial & Science
- Government & Public
- Residential
- Retail
- Schools
- Sports

Transport

- Bridges, Tunnels & Major Crossings
- Smart Mobility
- Rail Systems
- Aviation
- Roads and Highways
- Ports, Marine and Waterways

Environment & Health

- Air Quality
- Compliance Assurance Ecological Services
- Expert Services
- Impact Assessment
- Occupational & Building Health
- Product Safety & Stewardship
- Risk Assessment & Community Health
- Sciences for Regulatory Support
- Site Solutions
- Sustainability
- Due Diligence
- Waste & Resource Management

Energy

- Wind & solar
- Green hydrogen and Power-to-X
- Carbon capture utilisation & storage
- Energy infrastructure
- District energy
- Bioenergy
- Waste-to-energy
- Energy-intensive industries

Water

- Water supply & treatment
- Water resources management
- Wastewater treatment & resource recovery
- Water & wastewater networks
- Urban climate resiliency
- Storm-surge protection & liveable coastlines

Management Consulting

- Social & Economic Impacts
- Stakeholder Intelligence
- Strategic Sustainability Consulting
- People & Change
- Digital & Technology
- Legal & Contract Management

Architecture & landscape

- Architecture
- Landscape architecture
- Urbanism
- Interiors, Graphics & Lighting Design

Henning Larsen

2- Energy and Carbon EU/Norway

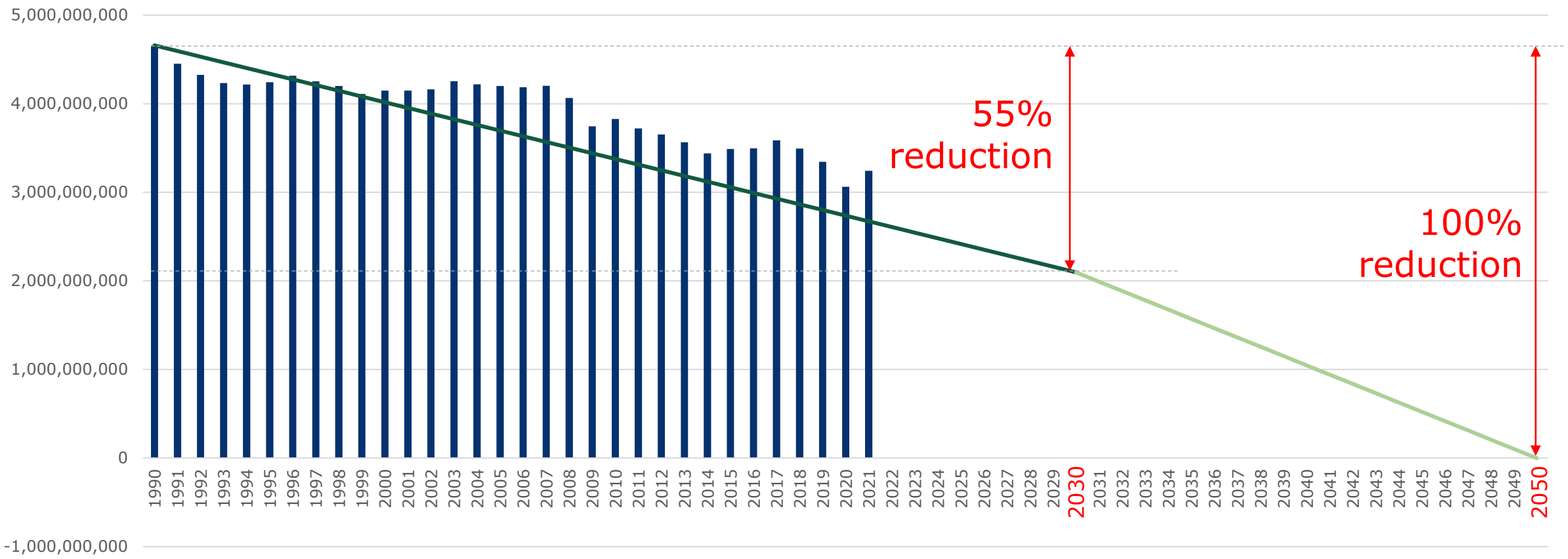
EU goals

#Paris agreement

```
If year == 2030:
        greenhousegas_emissions = 0.45 * greenhousegas_emissions[«1990»]
elif year == 2050:
         greenhousegas_emissions = 0
else:
        pass
```

Source:https://www.eumonitor.eu/9353000/1/j9vvik7m1c3gyxp/vkqp9dzgriys?ctx=vg9hjjllgxmz#:~:text=In%202021%2C%20the%20EU%20made,become%20climate%2Dneutral%20by%202050.

EU progress towards its 2030/2050 climate change goals



Source: https://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer

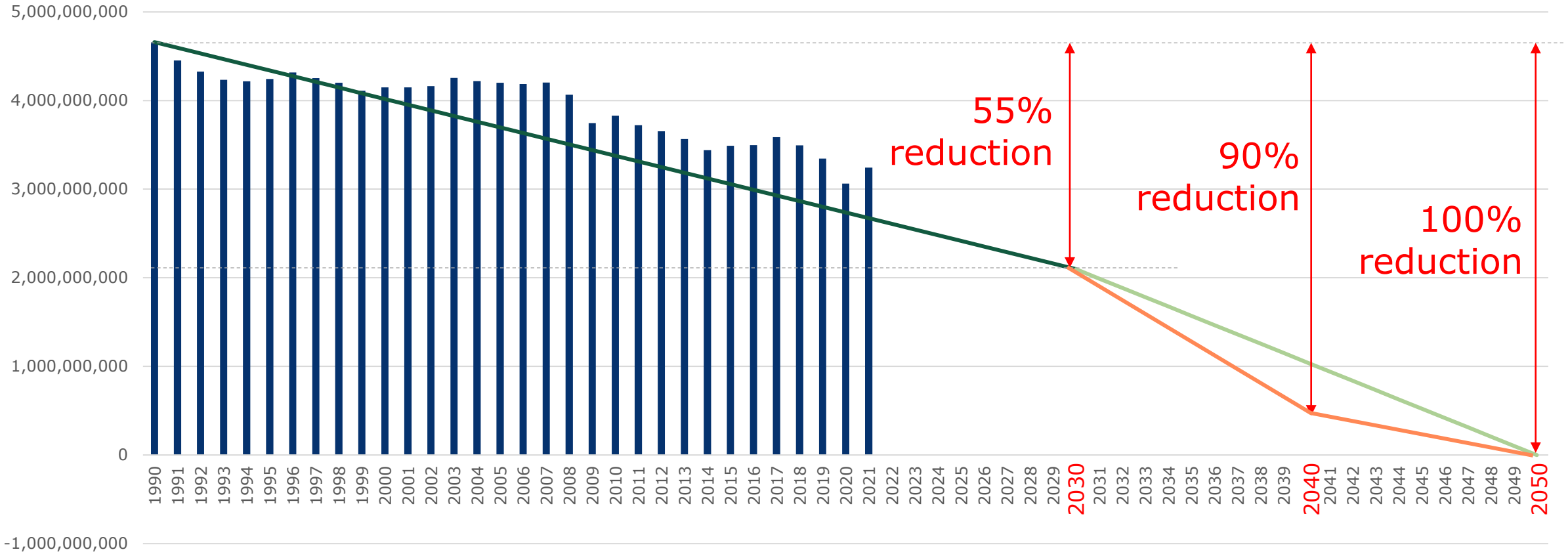
EU progress towards its 2030/2050 climate change goals

EU lays out plan to cut greenhouse emissions by 90% by 2040

Proposal is part of European Commission's aim to become world's first climate-neutral continent

Source: https://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer

EU progress towards its 2030/2040/2050 climate change goals



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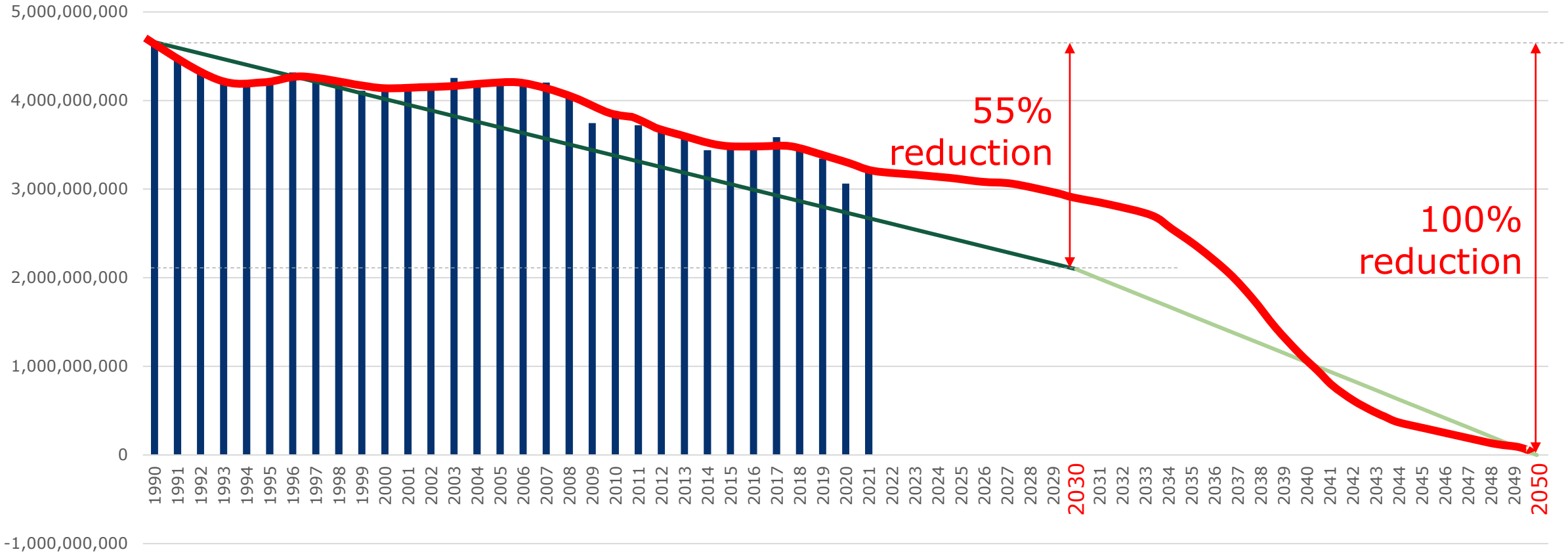
EU progress towards its 2030/2050 climate change goals



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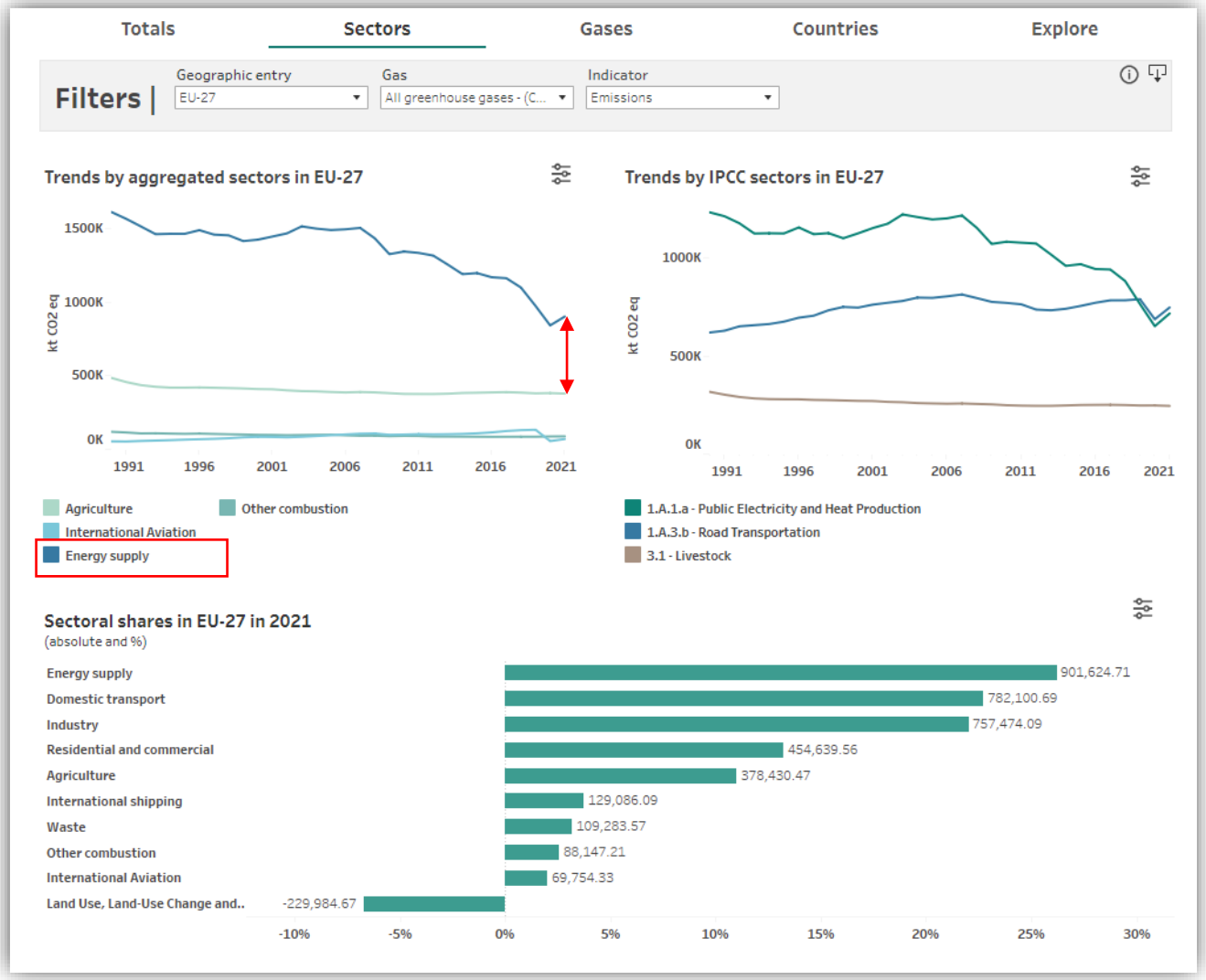

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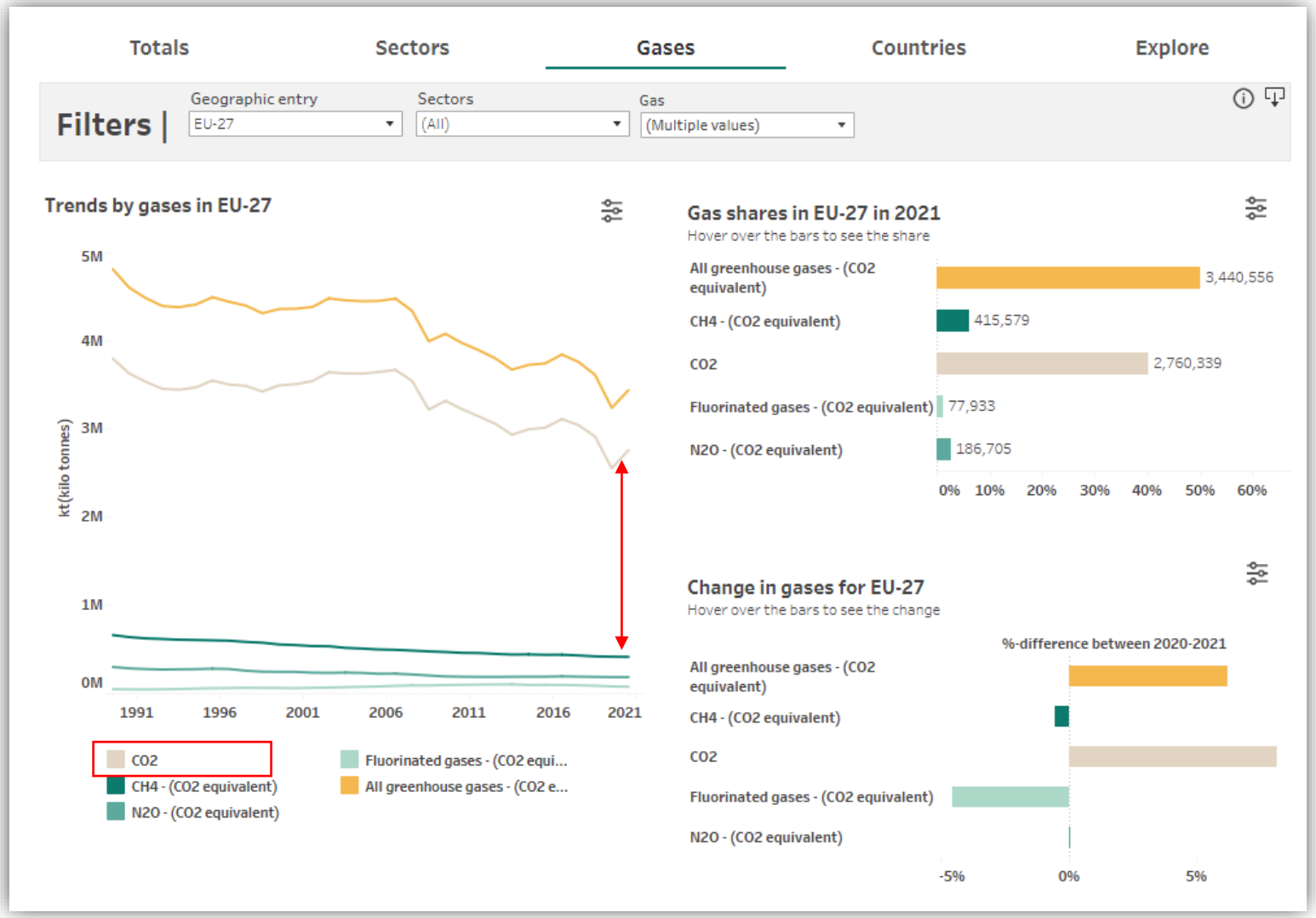
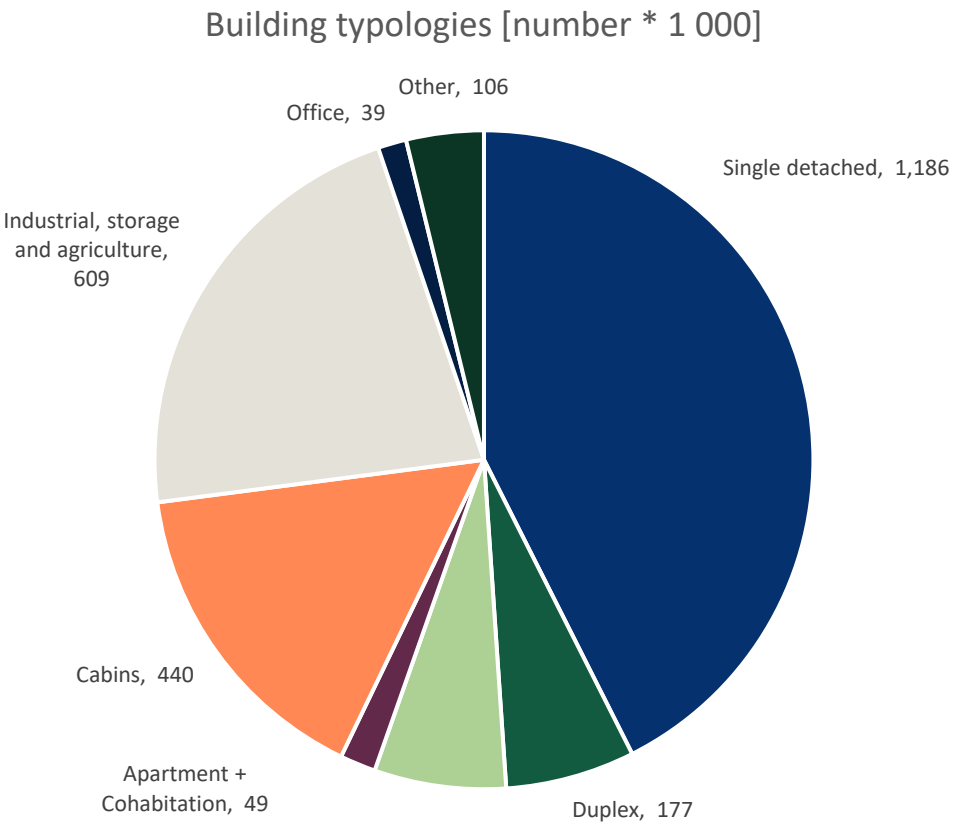


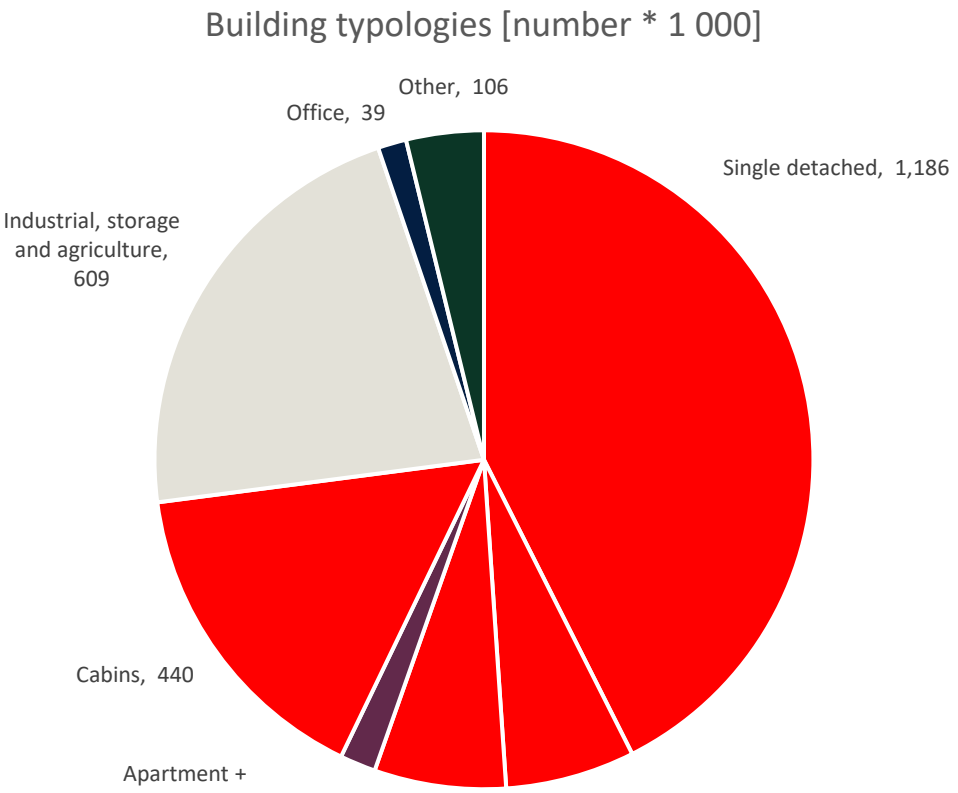
Source: https://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer

3- The Norwegian Building Stock

The Norwegian building stock – all typologies



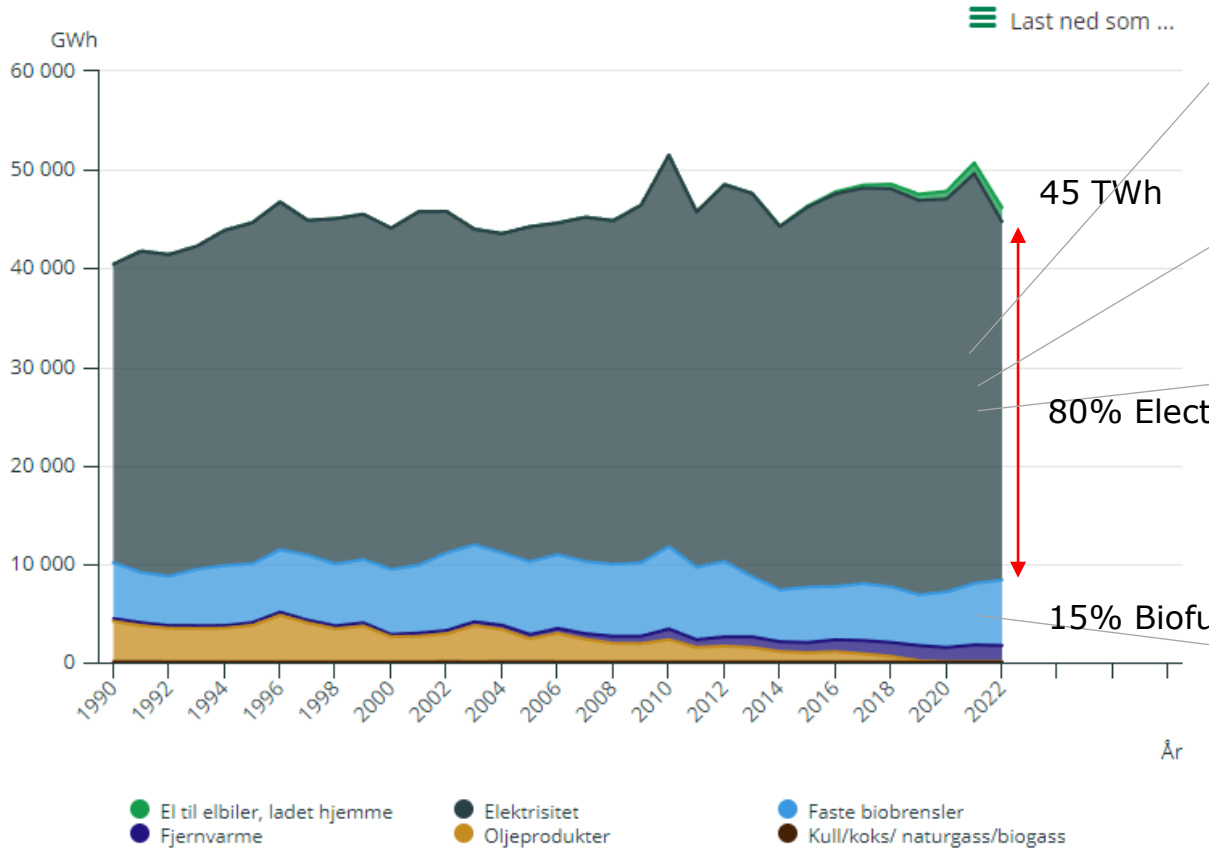
The Norwegian building stock – all typologies



Energy use in residential buildings

Figur 2. Energibruk i husholdninger, 1990-2022. GWh

Vis som figur | Vis som tabell

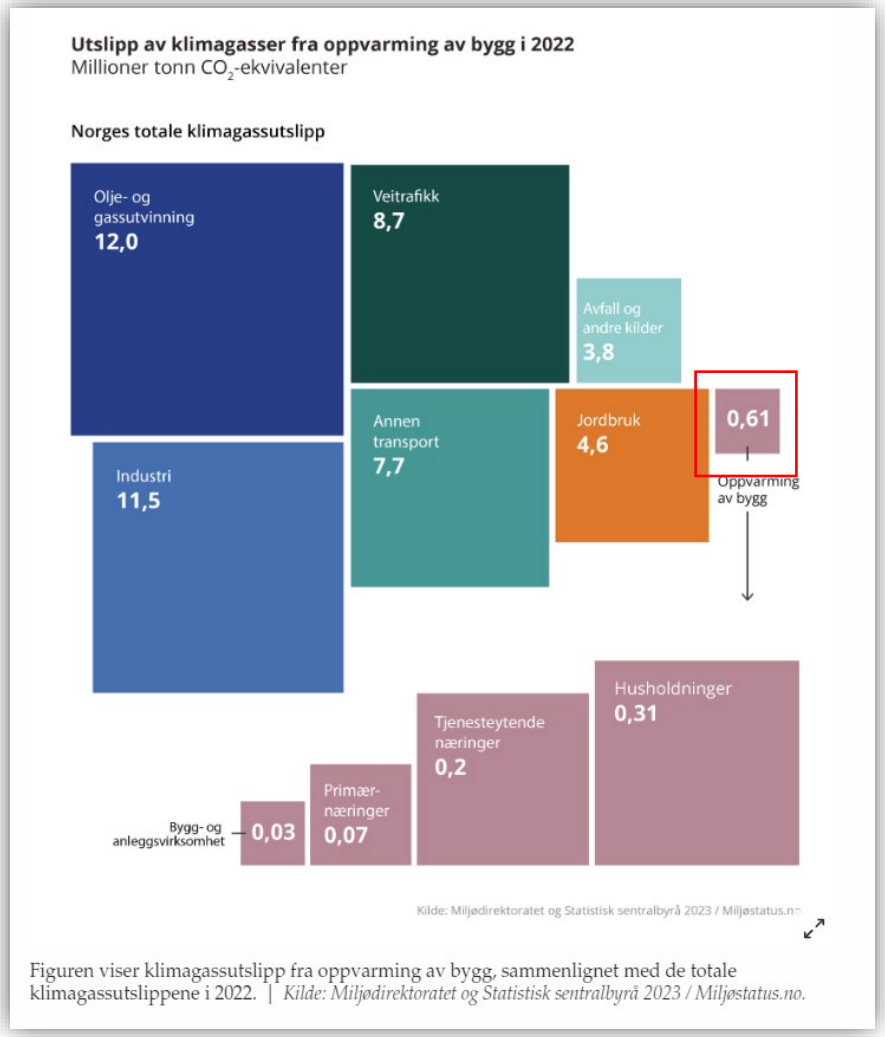


45 TWh

80% Electricity

15% Biofuels

Carbon emissions from heating buildings in Norway

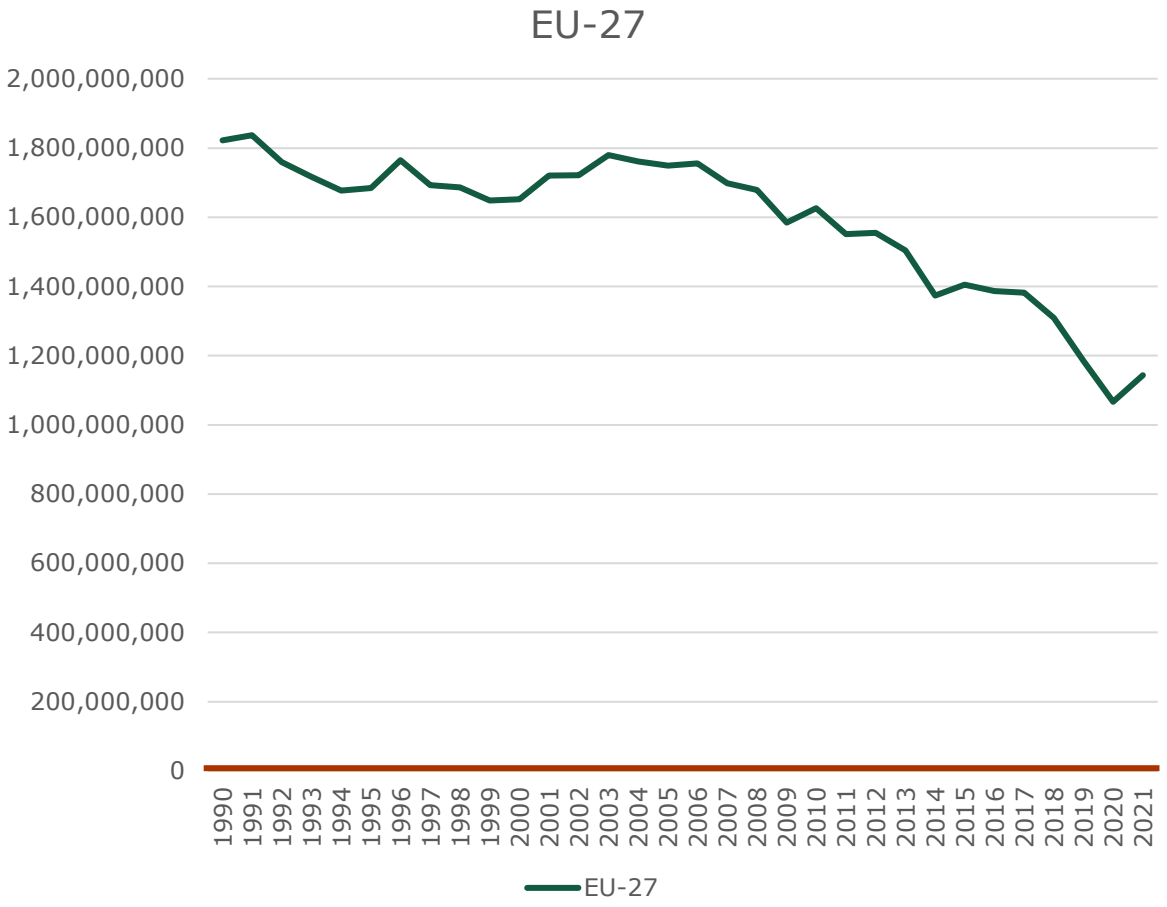


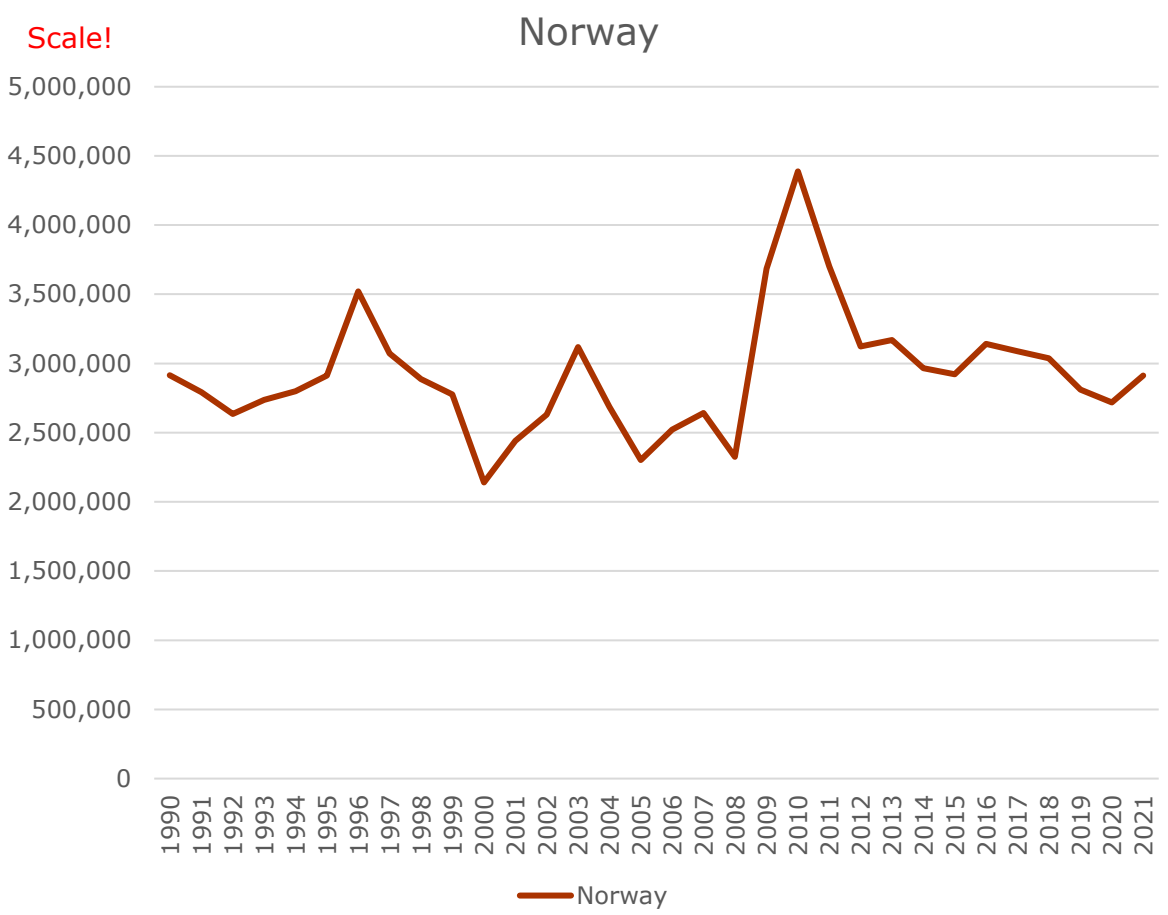
Figuren viser klimagassutslipp fra oppvarming av bygg, sammenlignet med de totale klimagassutslippene i 2022. | *Kilde: Miljødirektoratet og Statistisk sentralbyrå 2023 / Miljøstatus.no.*

Source: https://miljostatus.miljodirektoratet.no/tema/klima/norske-utslipp-av-klimagasser/klimagassutslipp-fra-oppvarming-av-bygg/

Carbon emissions from buildings

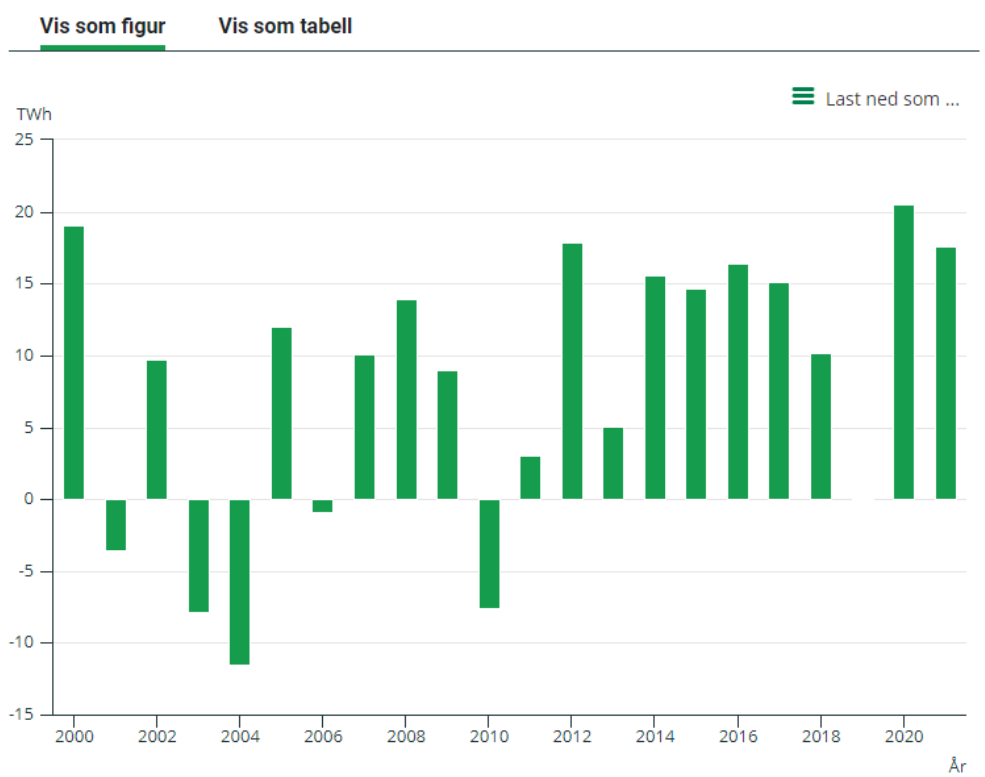
1.A.1.a - Public Electricity and Heat Production, 1.A.4.a - Commercial/Institutional, 1.A.4.b - Residential



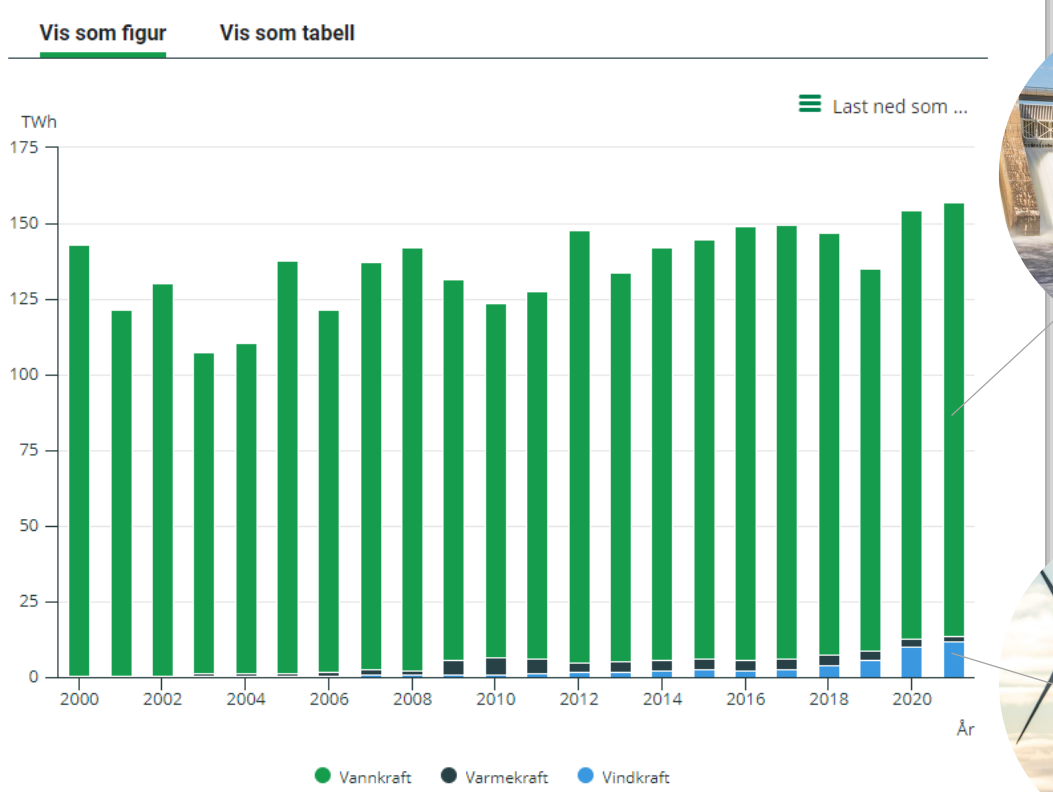


Net energy export of electricity and sources

Figur 1. Nettoeksport av elektrisitet



Figur 2. Produksjon av elektrisitet



Source: https://miljostatus.miljodirektoratet.no/tema/klima/norske-utslipp-av-klimagasser/klimagassutslipp-fra-oppvarming-av-bygg/

4- Building Regs and Energy

Current energy requirements for new and retrofitted projects (translated) – TEK17

Building Type	Total net energy demand [kWh/m2]
Single Family, incl cabins >150 m2	100 + 1600/m2 heated floor area
Apartment	95
Nursery	135
Office	115
School	110
University	125
Hospital	225 (265)
Elderly	195 (230)
Hotels	170
Sport	145
Commercial	180
Culture	130
Light industrial	140 (160)

Energy efficiency measures as alternative for residential as long as below net energy demand	Single Family	Apartment
U-value external wal [W/m2K]	<= 0.18	<= 0.18
U-value roof [W/m2K]	<= 0.13	<= 0.13
U-value floor [W/m2K]	<= 0.10	<= 0.10
U-value windows/doors [W/m2K]	<= 0.8	<= 0.8
Ratio window/door area to heated floor area	<= 25%	<= 25%
Annual average temperature efficiency for heat recovery in ventilation system	>= 80%	>= 80%
Specific fanpower in ventilation system (SFP) [kW/m3s]	<= 1.5	<= 1.5
Airtightness at 50 Pa	<= 0.6	<= 0.6
Normalised thermal bridge per m2 [W/m2K]	<= 0.05	<= 0.07

https://www.dibk.no/regelverk/byggteknisk-forskrift-tek17/14/14-2

Special requirements

Kapittel 14 Energi

§ 14–3. Minimumsnivå for energieffektivitet

(1) Følgende minimumsnivå skal alltid være oppfylt:

Veiledning til første ledd

a) Alle bygninger, unntatt boligbygning og fritidsbolig med laftede yttervegger, skal ha:

Tabell: Minimumsnivå

U-verdi yttervegg [W/(m² K)]	*U-verdi tak [W/(m²K)]*	*U-verdi gulv på grunn og mot det fri [W/(m² K)]*	*U-verdi vindu og dør inkludert karm/ramme [W/(m² K)]*	*Lekkasjetall ved 50 Pa trykkforskjell (luftveksling per time)*
≤ 0,22	≤ 0,18	≤ 0,18	≤ 1,2	≤ 1,5

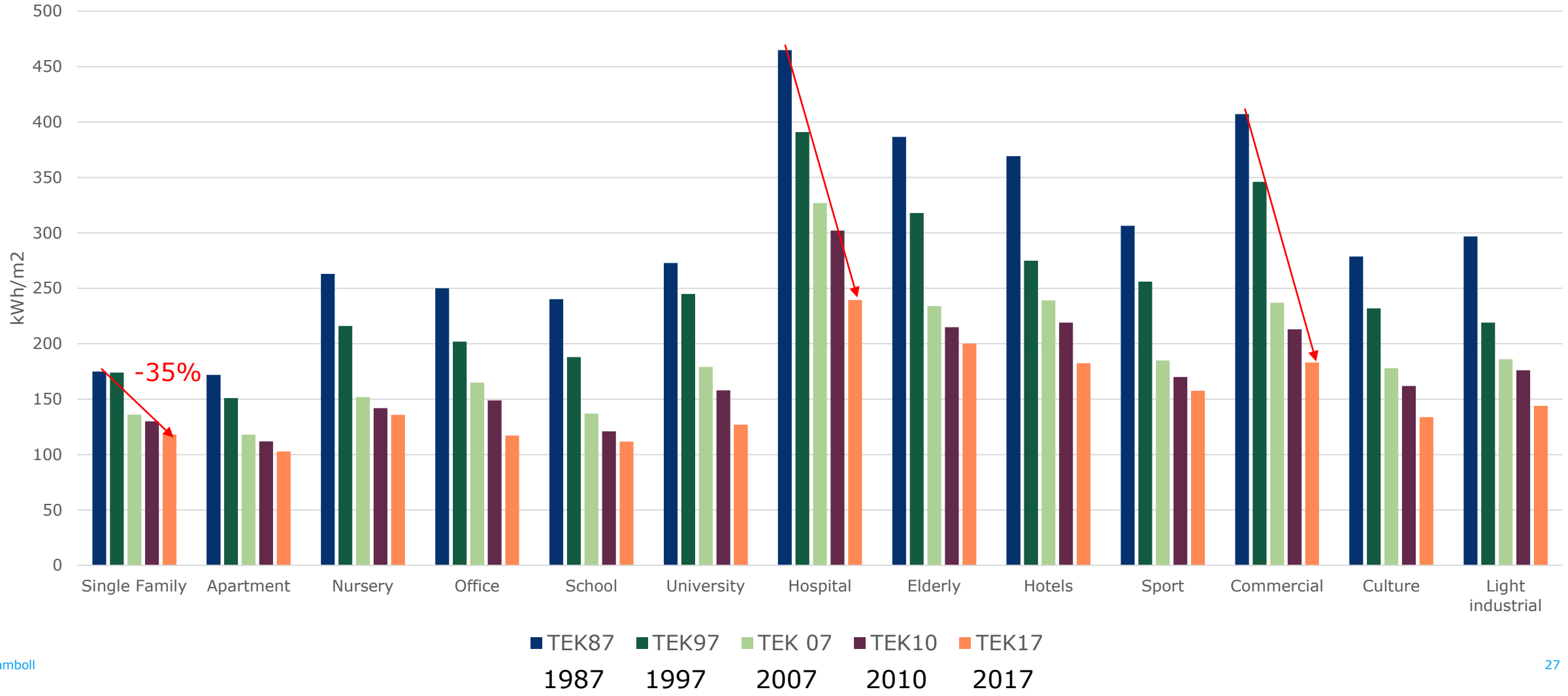
Veiledning til første ledd bokstav a

b) Boligbygning og fritidsbolig med laftede yttervegger skal ha:

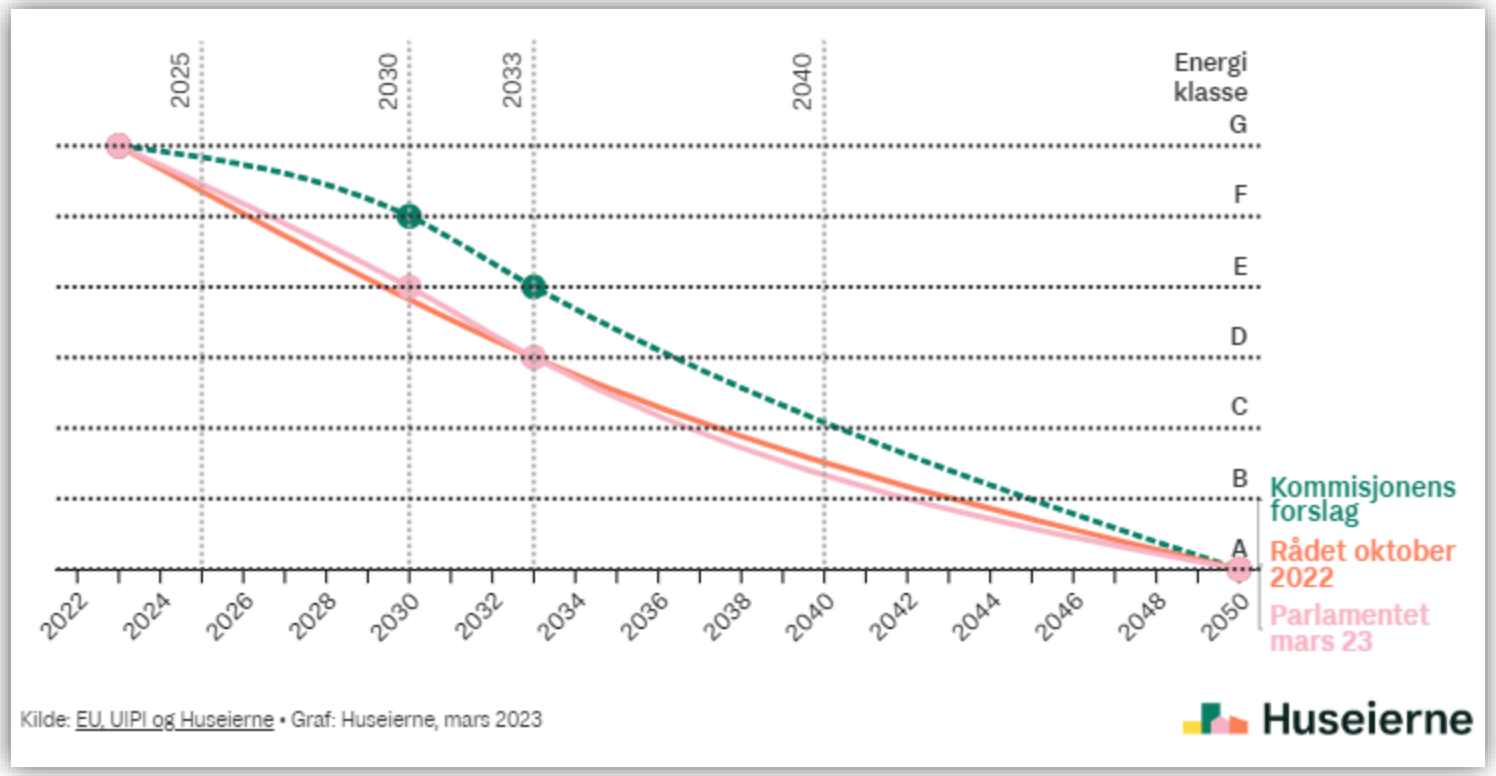
Tabell: Minimumsnivå

Dimensjon yttervegg	*U-verdi tak [W/(m² K)]*	*U-verdi gulv på grunn og mot det fri [W/(m² K)]*	*U-verdi vindu og dør, inkludert karm/ramme [W/(m² K)]*	*Lekkasjetall ved 50 Pa trykkforskjell (luftveksling per time)*
≥ 6" laft	≤ 0,18	≤ 0,18	≤ 1,2	≤ 6

Comparing calculated energy demand for different building regulations



Energy efficiency targets for residential buildings



https://www.huseierne.no/nyheter/nye-krav-om-energieffektivisering-av-boliger---desember-2022/

Energylevels Norway

Energimerkeordningen for bygninger

Ny energikarakterskala fra 10.06.15 10.06.2015

Bygningskategorier	Levert energi pr m² oppvarmet BRA (kWh/m²)						
	A	B	C	D	E	F	G
	Lavere enn eller lik	Lavere enn eller lik	Lavere enn eller lik	Lavere enn eller lik	Lavere enn eller lik	Lavere enn eller lik	Ingen grense
Småhus	95	120	145	175	205	250	>F
Arealkorreksjon	+800/A	+1600/A	+2500/A	+4100/A	+5800/A	+8000/A	
Leiligheter (boligblokk)	85	95	110	135	160	200	>F
Arealkorreksjon	+600/A	+1000/A	+1500/A	+2200/A	+3000/A	+4000/A	
Barnehage	85.00	115.00	145.00	180.00	220.00	275.00	> F
Kontorbygning	90.00	115.00	145.00	180.00	220.00	275.00	> F
Skolebygning	75.00	105.00	135.00	175.00	220.00	280.00	> F
Universitets- og høgskolebygning	90.00	125.00	160.00	200.00	240.00	300.00	> F
Sykehus	175.00	240.00	305.00	360.00	415.00	505.00	> F
Sykehjem	145.00	195.00	240.00	295.00	355.00	440.00	> F
Hotellbygning	140.00	190.00	240.00	290.00	340.00	415.00	> F
Idrettsbygning	125.00	165.00	205.00	275.00	345.00	440.00	> F
Forretningsbygning	115.00	160.00	210.00	255.00	300.00	375.00	> F
Kulturbygning	95.00	135.00	175.00	215.00	255.00	320.00	> F
Lett industribygning, verksted	105.00	145.00	185.00	250.00	315.00	405.00	> F

A = oppvarmet del av BRA [m²]

Øvre grense for karakter C er basert på nivå for TEK 2010.

Skalagrenser for boliger er avhengig av oppvarmet BRA, og beregnes med to desimaler

EMS Versjon 7.24
Gjelder fra 10.06.2015
Endringer Årsvirkningsgrad oppvarming satt til 0,77 for alle skalatrinn
Kjølefaktor satt til 2,2 for alle skalatrinn
Beregningsstandard oppdatert til NS 3031:2014

Forutsetninger	A	B	C	D	E	F	G
Øvre grenser	"Passivhus"	(A+C)/2	"TEK10"	(2C+F)/3	(2F+C)/3	"TEK 69"+7%	> F
Referanse	NS 3700 prNS 3701		Varmegjenvinner 80 %			Varmegjenvinner 70 %	
Årsvirkningsgrad, oppvarming	0.77						
Kjølefaktor	2.2						
Luftmengder i driftstid	NS 3031 tab A6	NS 3031 tabell B1					
Luftmengder utenfor driftstid	NS 3031 tab A7	NS 3031 tabell A6					
SFP og belysning	Iht. prNS 3701 / NS 3700	Iht. NS 3031					
Utstyr og varmtvann	Iht. NS 3031	Iht. NS 3031					
Bevegelig solskjerming	"På" hele året						
Bygningsmodeller	Bygningsmodeller som TEK 2010. Unntak barnehager: Nå PH-modell						
Arealkorreksjon	Nivåtilpasset arealkorreksjon boliger, avhengig av skalatrinn.						
Beregningsstandard EMS	NS 3031:2014						

Energimerkeordningen for bygninger

Ny energikarakterskala fra 10.06.15: Leiligheter (boligblokk) 10.06.2015

Leilighet	Levert energi pr m² oppvarmet BRA (kWh/m²)						
	A	B	C	D	E	F	G
Oppvarmet BRA (m²)	Lavere enn eller lik	Lavere enn eller lik	Lavere enn eller lik	Lavere enn eller lik	Lavere enn eller lik	Lavere enn eller lik	Ingen grense
50	97.00	115.00	140.00	179.00	220.00	280.00	> F
75	93.00	108.33	130.00	164.33	200.00	253.33	> F
100	91.00	105.00	125.00	157.00	190.00	240.00	> F
125	89.80	103.00	122.00	152.60	184.00	232.00	> F
160	88.75	101.25	119.38	148.75	178.75	225.00	> F
200	88.00	100.00	117.50	146.00	175.00	220.00	> F
300	87.00	98.33	115.00	142.33	170.00	213.33	> F
400	86.50	97.50	113.75	140.50	167.50	210.00	> F
500	86.20	97.00	113.00	139.40	166.00	208.00	> F

Øvre grense for karakter C er basert på nivå for TEK 2010.

EMS Versjon 7.24
Gjelder fra 10.06.2015

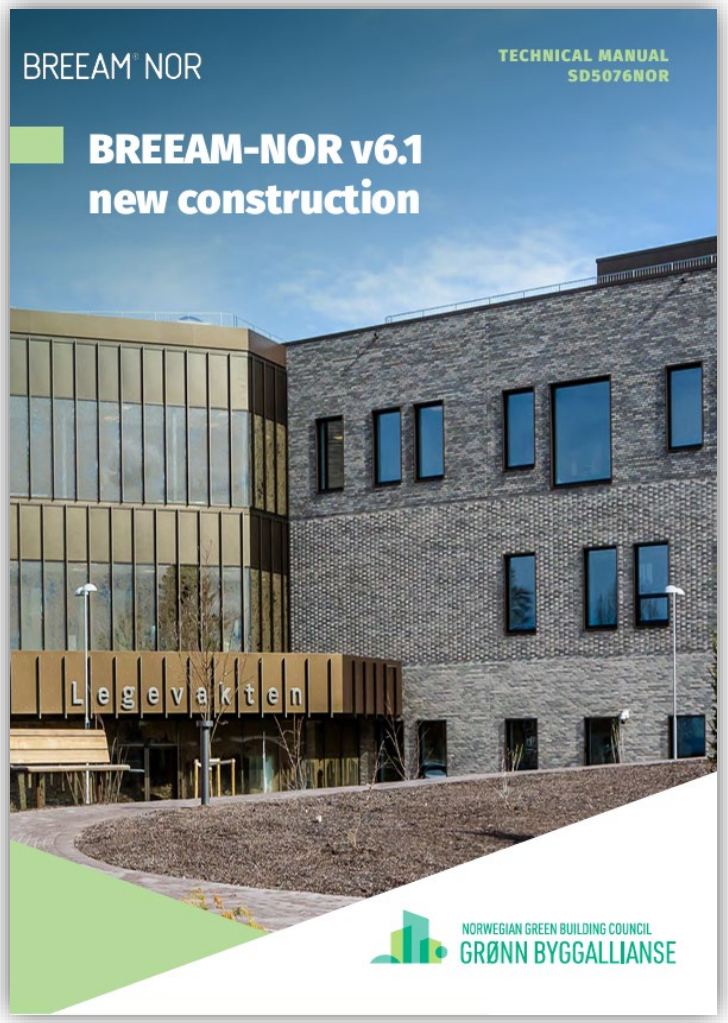
Skalagrenser for boliger er avhengig av oppvarmet BRA, og beregnes med to desimaler

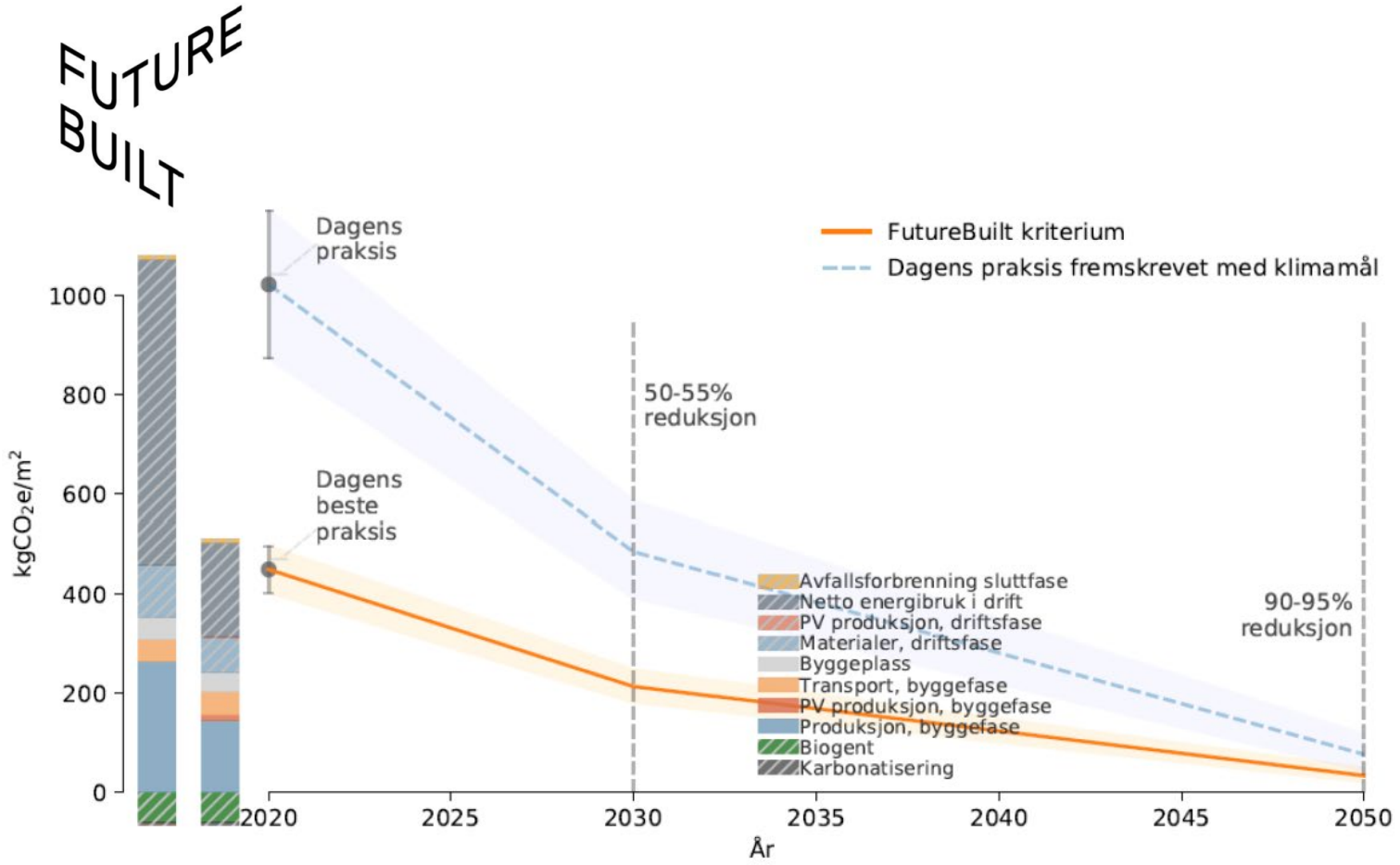
Table 6.3.: Building energy labels in the Nordic countries

Denmark*	Estonia**		Finland	Sweden	Norway**		Classification
Limit value [kWh/m²]	Apartment Limit value [kWh/m²]	Office Limit value [kWh/m²]	Limit value [kWh/m²]	Limit value [Energy performance of a new building]	Apartment Limit value [kWh/m2]	Office Limit value [kWh/m2]	Energy label
27							A++
< 30 + 1000/Areal							A+
< 52,5 + 1650/Areal	< 170	< 100	< 90	EP is ≤ 50%	90	85 + 600/Areal	A
< 70,0 + 2.200/Areal	< 171 - 200	< 101 - 130	< 91 - 155	EP is > 50 - ≤ 75%	115	95 + 1000/Areal	B
< 110 + 3.200/Areal	< 201 - 250	< 131 - 160	< 156 - 192	EP is > 75 - ≤ 100%	145	110 + 1500/Areal	C
< 150 + 4.200/Areal	< 251 - 300	< 161 - 210	< 193 - 272	EP is > 100 - ≤ 135%	180	135 + 2200/Areal	D
< 190 + 5200/Areal	< 301 - 350	< 211 - 260	< 273 - 402	EP is > 135 - ≤ 180%	220	160 + 3000/Areal	E
< 240 + 6.500/Areal	< 351 - 410	< 261 - 320	< 403 - 472	EP is > 180 - ≤ 235%	275	200 + 4000/Areal	F
> 240 + 6.500/Areal	< 411 - 470	< 321 - 400	< 473	EP is > 235%	> F	> F	G
	> 471	> 401					H

*A2020, A2015 and A2010 instead of A++, A+ and A
** Varies for different building typology

BREEAM NOR and Futurebuilt ZERO/nZEB





5- Retrofitting Existing Buildings Case Study 1

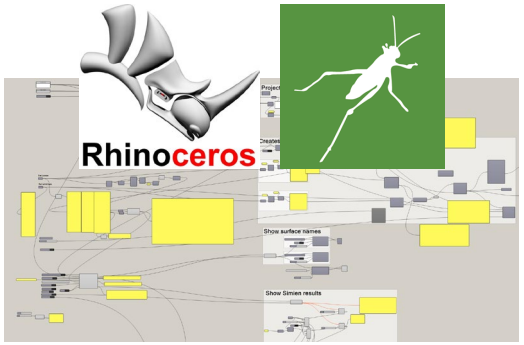
Retrofit vs. Refurbishment vs. Renovation

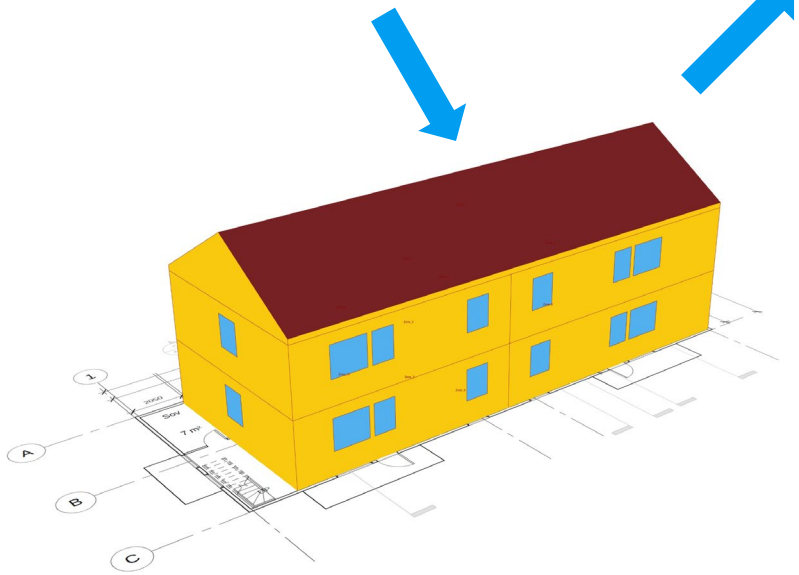
- **Retrofitting** means "providing something with a component or feature not fitted during manufacture or adding something that it did not have when first constructed" (Ref Retrofit 2050: Critical challenges for urban transitions). It is often used in relation to the installation of new building systems, such as heating systems, but it might also refer to the fabric of a building, for example, retrofitting insulation or double glazing.

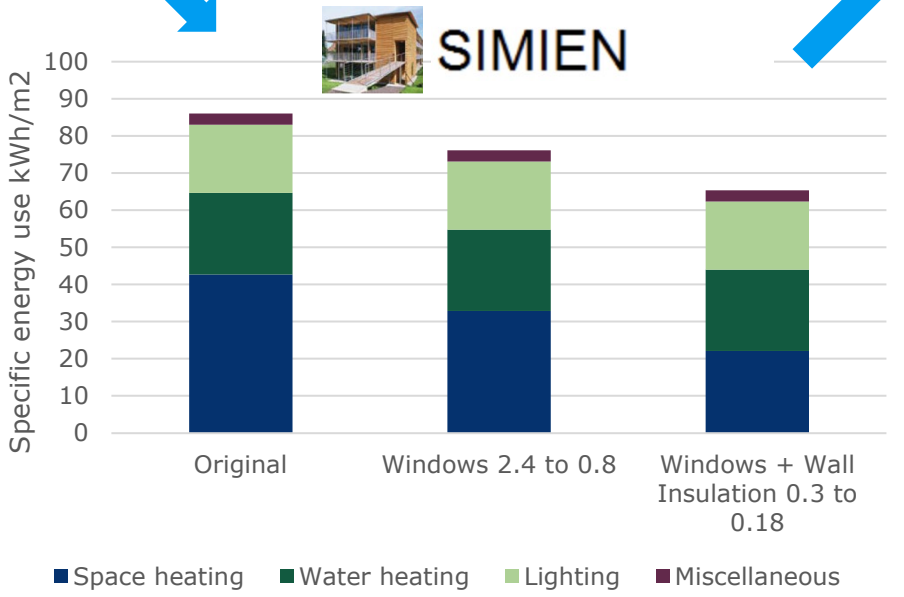
- **Refurbishment** on the other hand implies a process of improvement by cleaning, decorating, and re-equipping. It may include elements of retrofitting.

- **Renovation** refers to the process of returning something to a good state of repair.

Retrofitting existing buildings





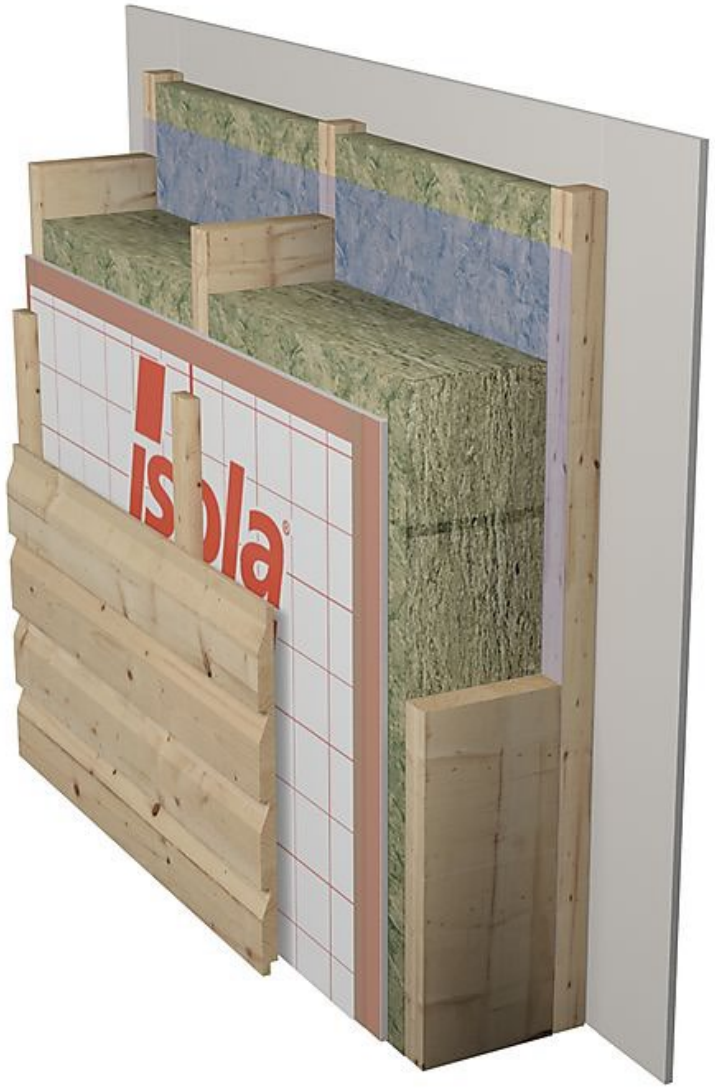


Retrofitting existing buildings





Typical wall construction of new residential buildings in Norway



U-value <= 0.18

40 cm wall thickness

Retrofitting existing buildings - Measures

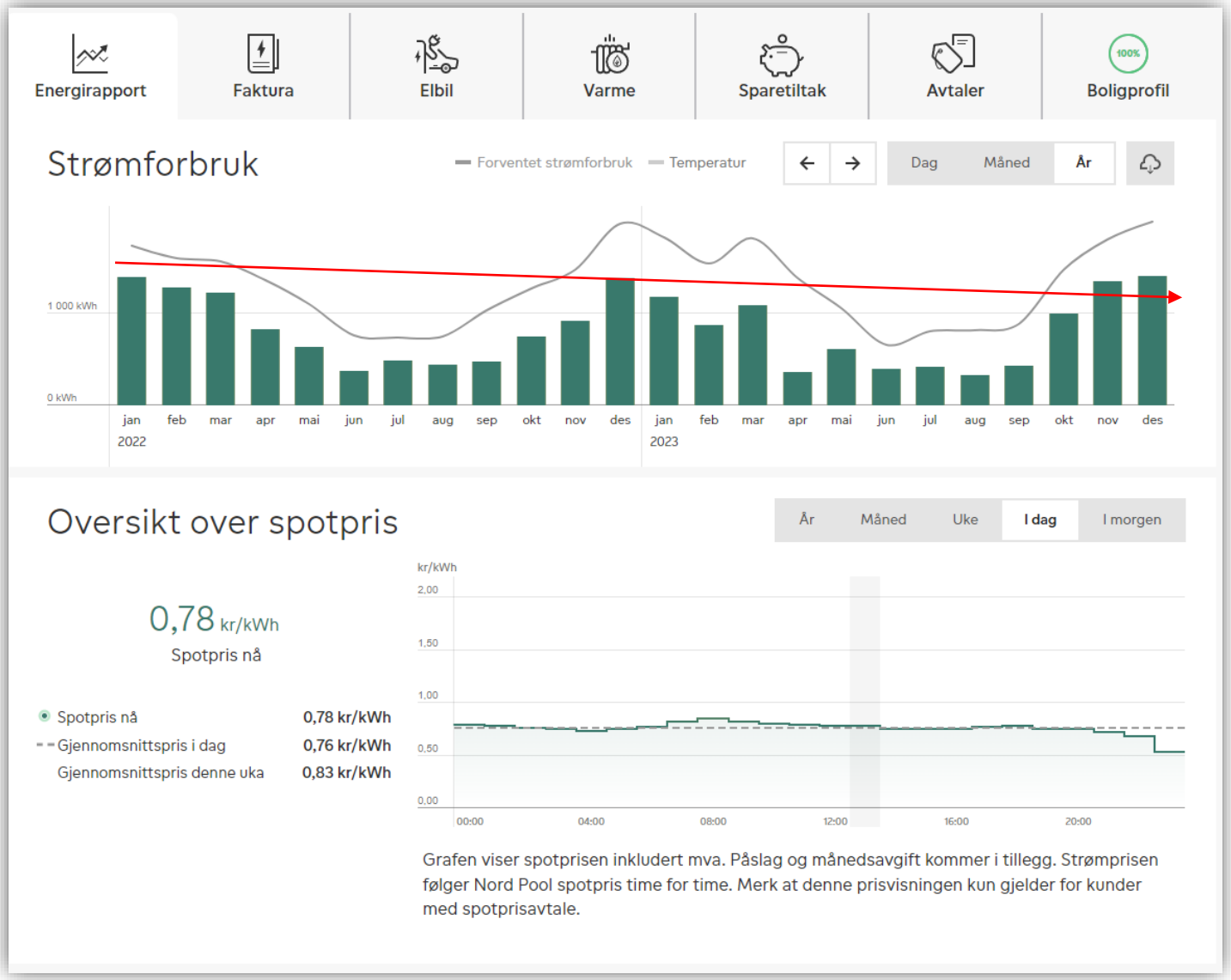
Window replacement

U-value:	2.4 to 1.3
Number:	2
Dimensions:	1.2x1.3m
Cost:	900 Euro
Total cost:	**>1500 Euro**

Adding insulation 50 mm wood fibre

U-value:	0.24 to 0.19
Area:	61 m2
Cost:	488 Euro

Retrofitting existing buildings – Energy savings



10-15% energy savings

Cost saved 90 Euro

Payback time?

6- Retrofitting Existing Buildings Case Study 2

Case study: Energy Efficient Retrofitting

Workflow for Energy Efficient Retrofitting

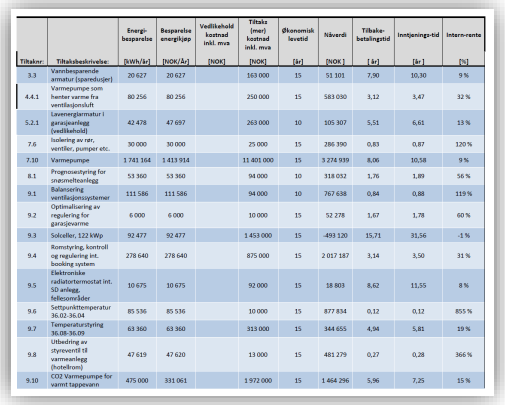
1 Collection of building data

2 Site visit

3 Energy modelling – annual simulation

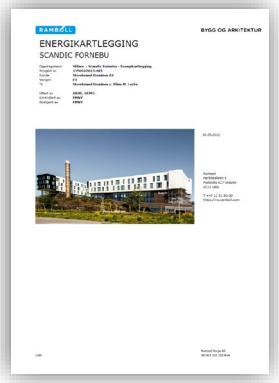
Energibudsjett		
Energipost	Energibehov	Spesifikt energibehov
1a Romoppvarming	641750 kWh	25,0 kWh/m²
1b Ventilasjonsvarme (varmebatterier)	405805 kWh	15,8 kWh/m²
2 Varmtvann (tappevann)	550001 kWh	21,4 kWh/m²
3a Vifter	534129 kWh	20,8 kWh/m²
3b Pumper	78364 kWh	3,1 kWh/m²
4 Belysning	1022267 kWh	39,8 kWh/m²
5 Teknisk utstyr	107859 kWh	4,2 kWh/m²
6a Romkjøling	482259 kWh	18,8 kWh/m²
6b Ventilasjonskjøling (kjølebatterier)	158146 kWh	6,2 kWh/m²
Totalt netto energibehov, sum 1-6	3980579 kWh	155,0 kWh/m²

4 Energy modelling – different efficiency strategies

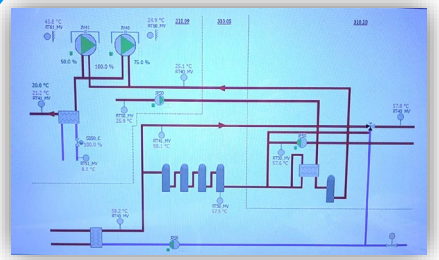


5 Lifecycle costing

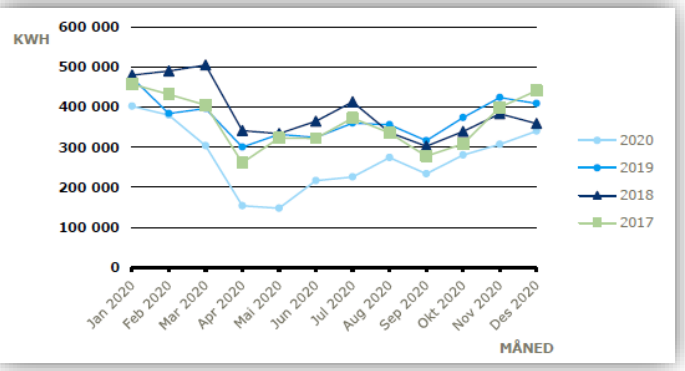
6 Report



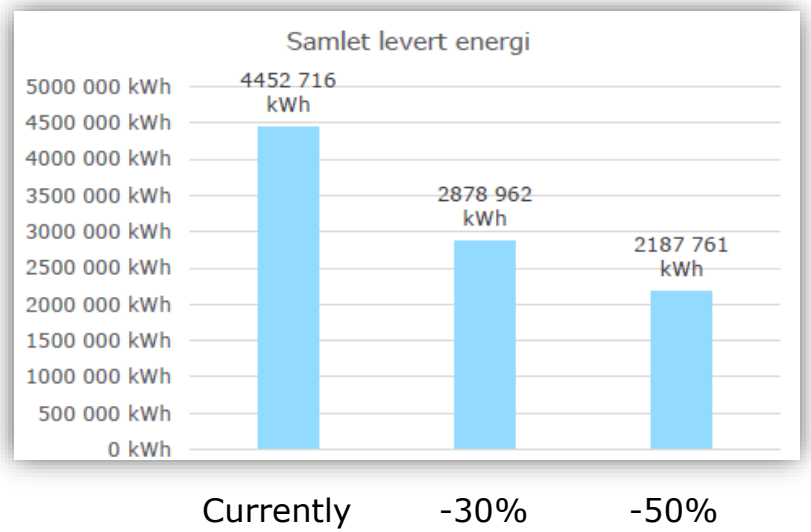
7 Training of FM



8 Energy monitoring



Case study: Results



	Energy use [kWh]	Energy use [kWh/m2]
Reference energy demand	4 450 000	173
Gross Floor Area	24 800	

Efficiency measure type	**Energy use [kWh]**	**Energy use [kWh/m2]**	**Energy saved [kWh]**	**Investment [Euro]**	**Payback [years]**
30% reduction package	2 880 000	112	1 573 000	390 000	3.6
50% reduction package	2 190 000	85	2 265 000	1 180 000	7.5

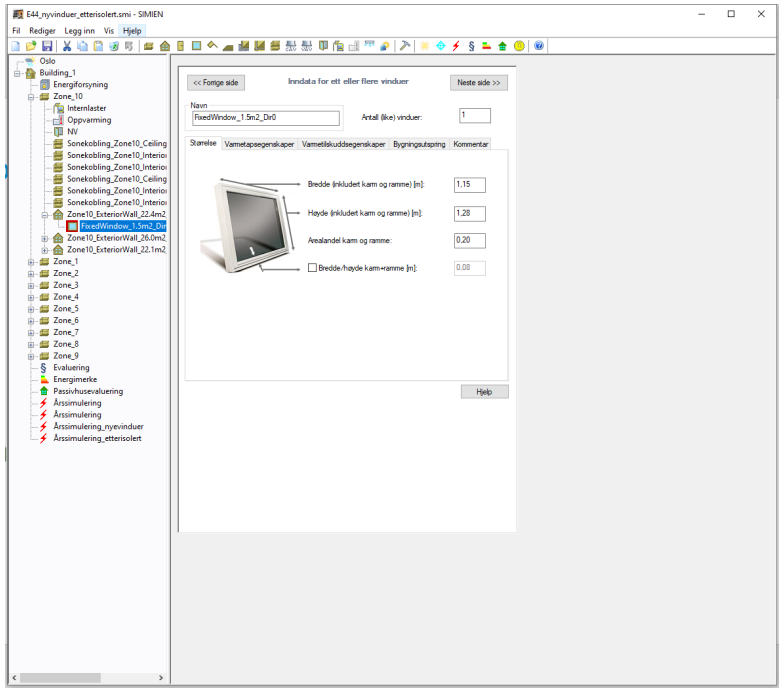
7- Tools for Energy Design

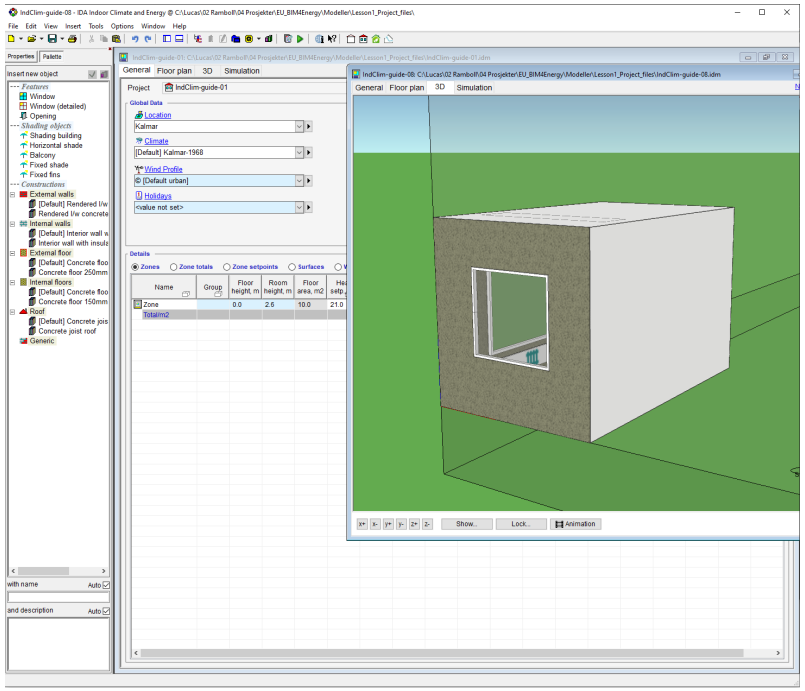
Tools for Energy Design

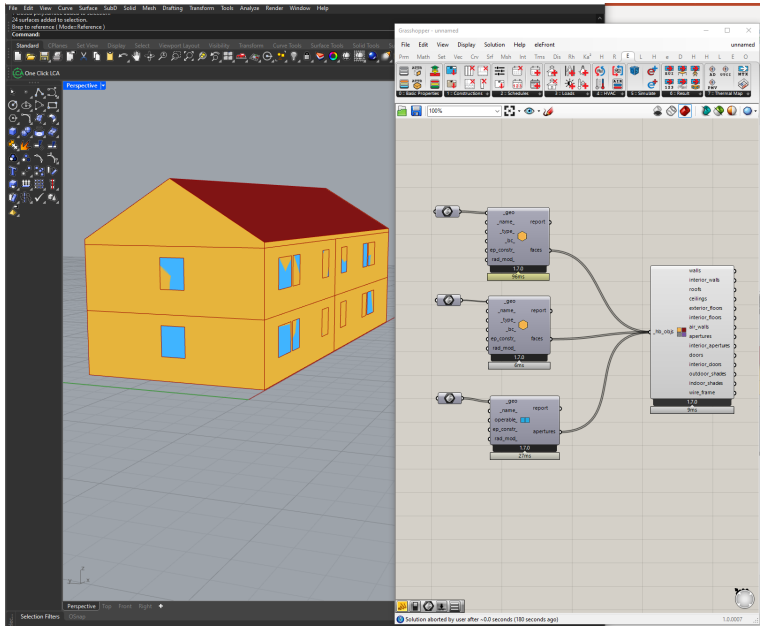
SIMIEN

IDA ICE

EnergyPlus







Simenergi

EQUA
SIMULATION TECHNOLOGY GROUP

U.S. DEPARTMENT OF ENERGY

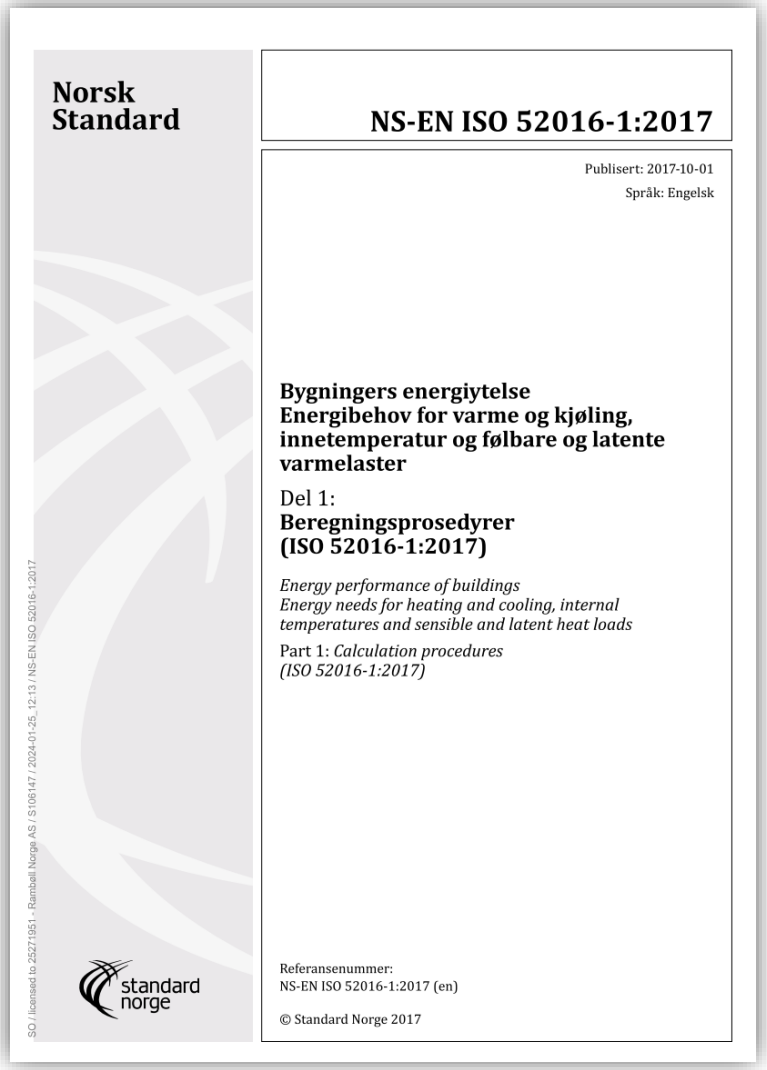
Ramboll

https://www.programbyggerne.no/SIMIEN/doku.php?id=eksempel_kontor

http://www.equaonline.com/iceuser/courses/lesson1.html

https://energyplus.net/

Building regulations and energy ISO 52016



Norsk Standard

NS-EN ISO 52016-1:2017

Publisert: 2017-10-01
Språk: Engelsk

Bygningers energiytelse
Energibehov for varme og kjøling, innetemperatur og følbare og latente varmelaster

Del 1:
Beregningsprosedyrer
(ISO 52016-1:2017)

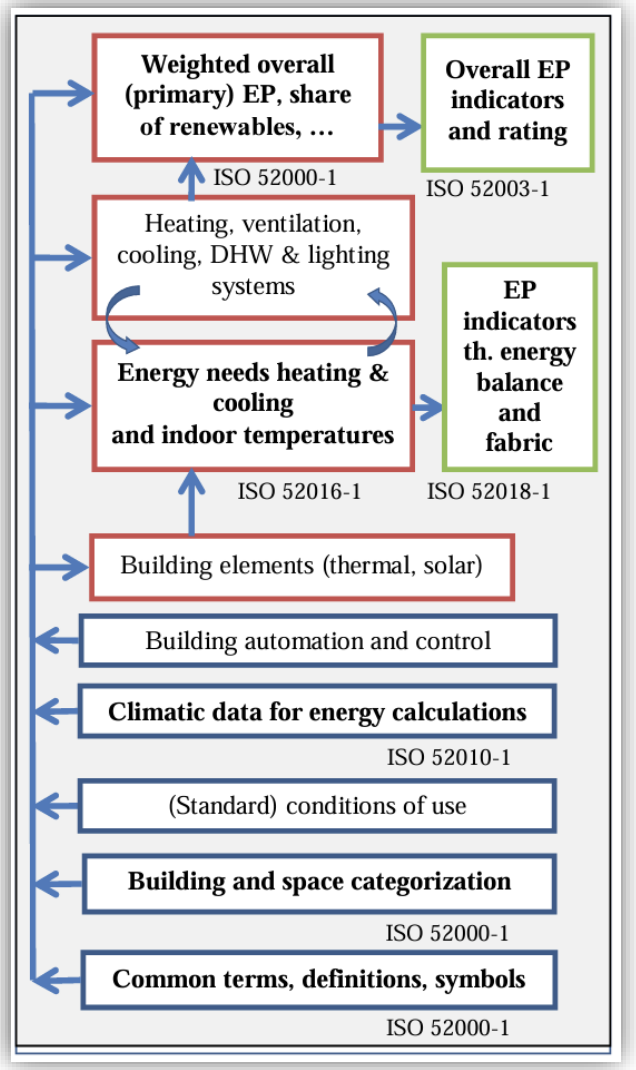
Energy performance of buildings
Energy needs for heating and cooling, internal temperatures and sensible and latent heat loads

Part 1: *Calculation procedures*
(ISO 52016-1:2017)

standard norge

Referansenummer:
NS-EN ISO 52016-1:2017 (en)

© Standard Norge 2017

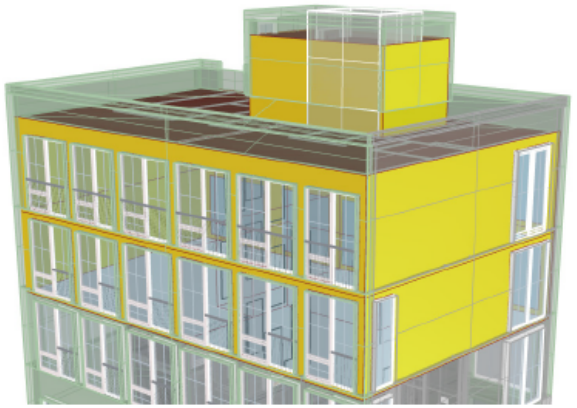


Is the ISO52016 also applied in all other EU countries?

BIM to SIMIEN potential

BIM model

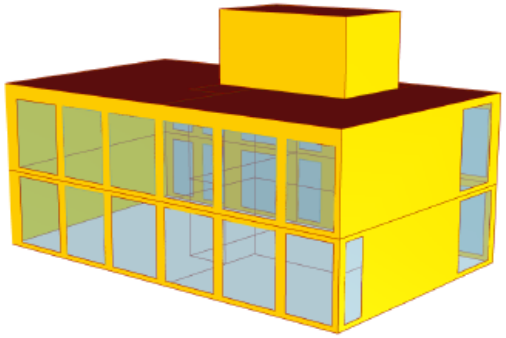
LIVE



Grasshopper integrated workflow

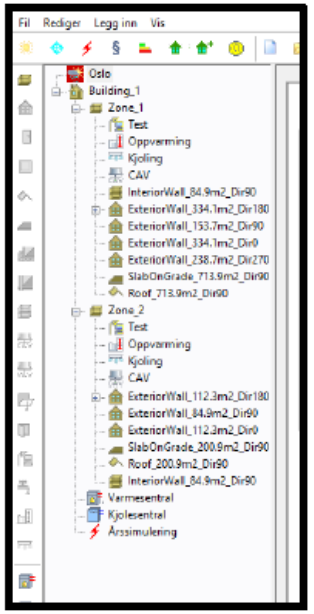
(rhino geo as a reference)

LIVE



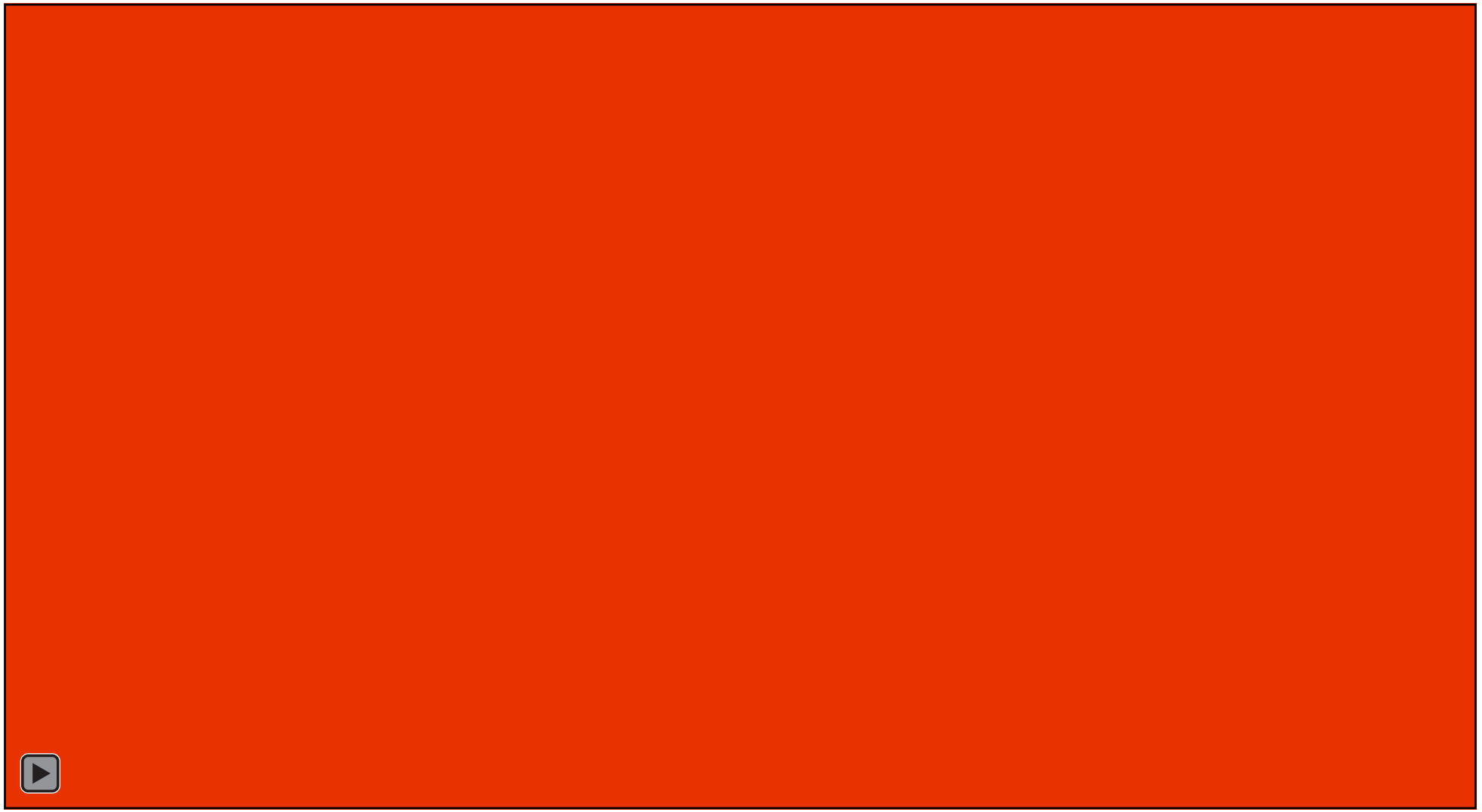
Honeybee Energy Model

LIVE

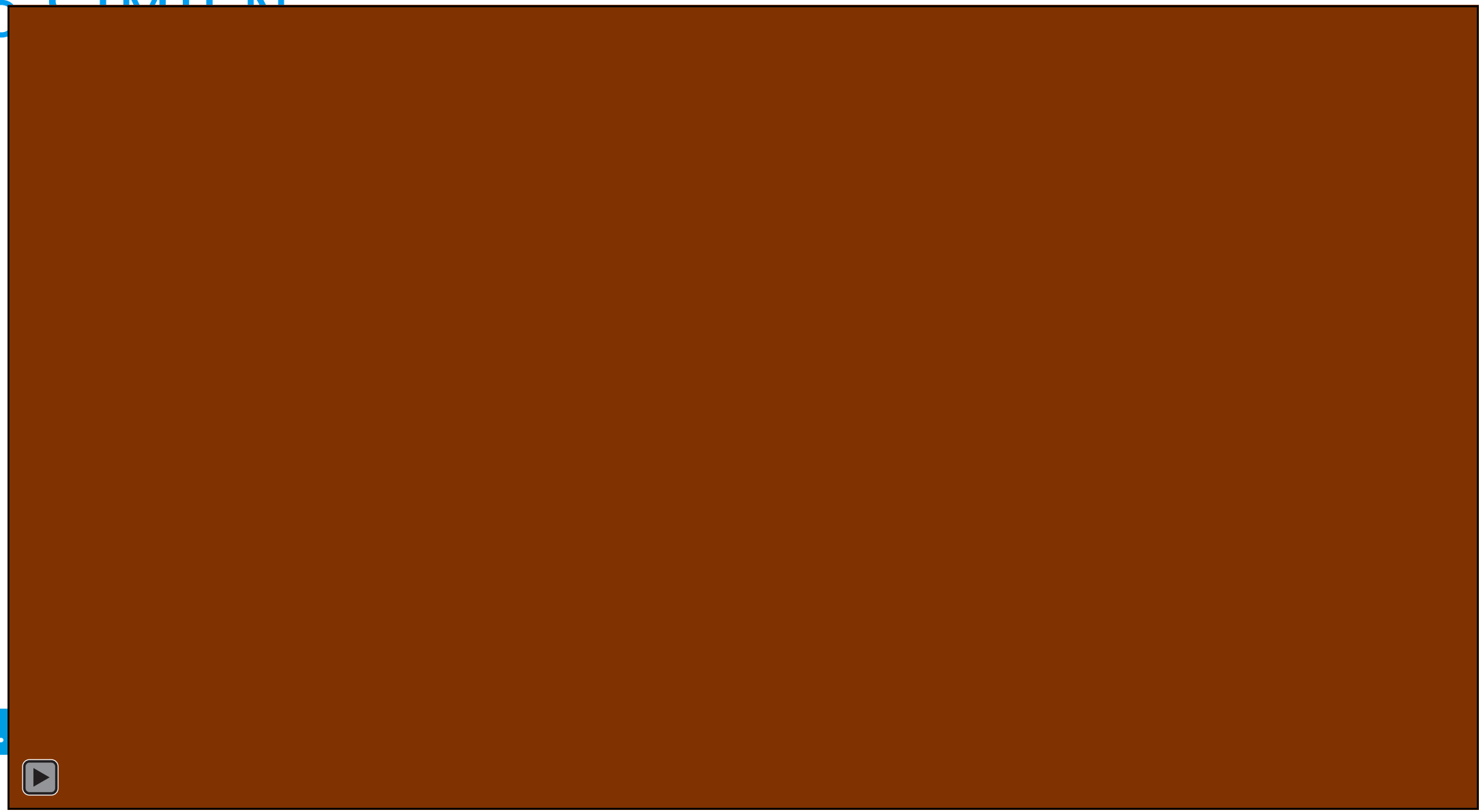


SIMIEN Energy Model

Manual workflow - example

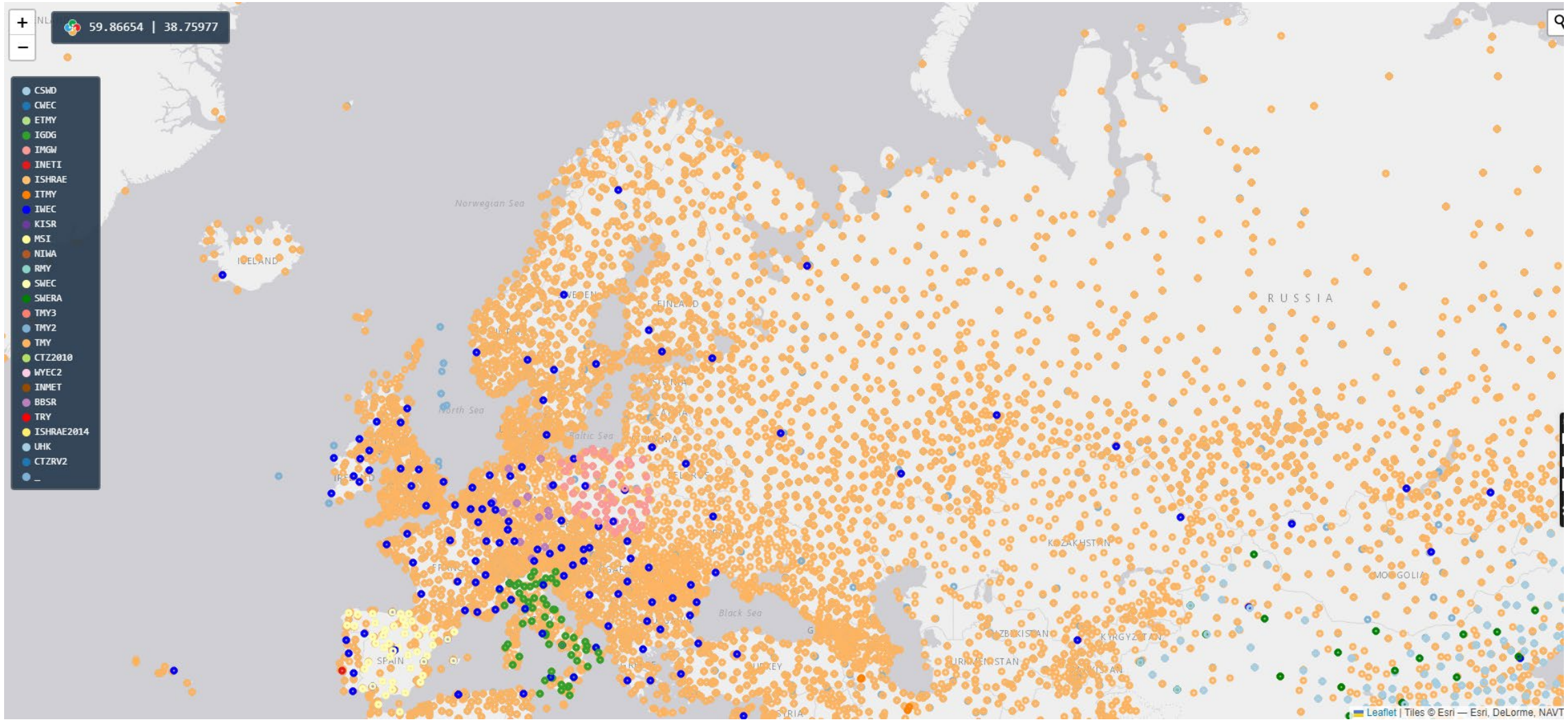


Rhino to SIMIEN

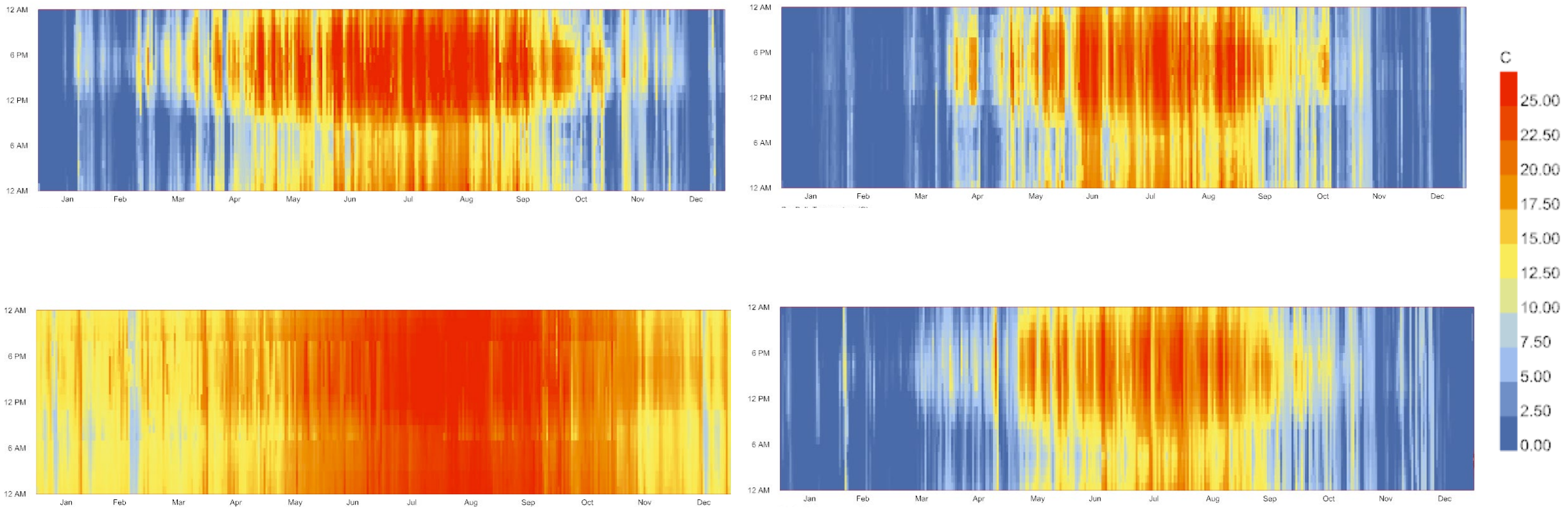


RAMBOLL

Climate data from Ladybug tools EPW map



Climate data



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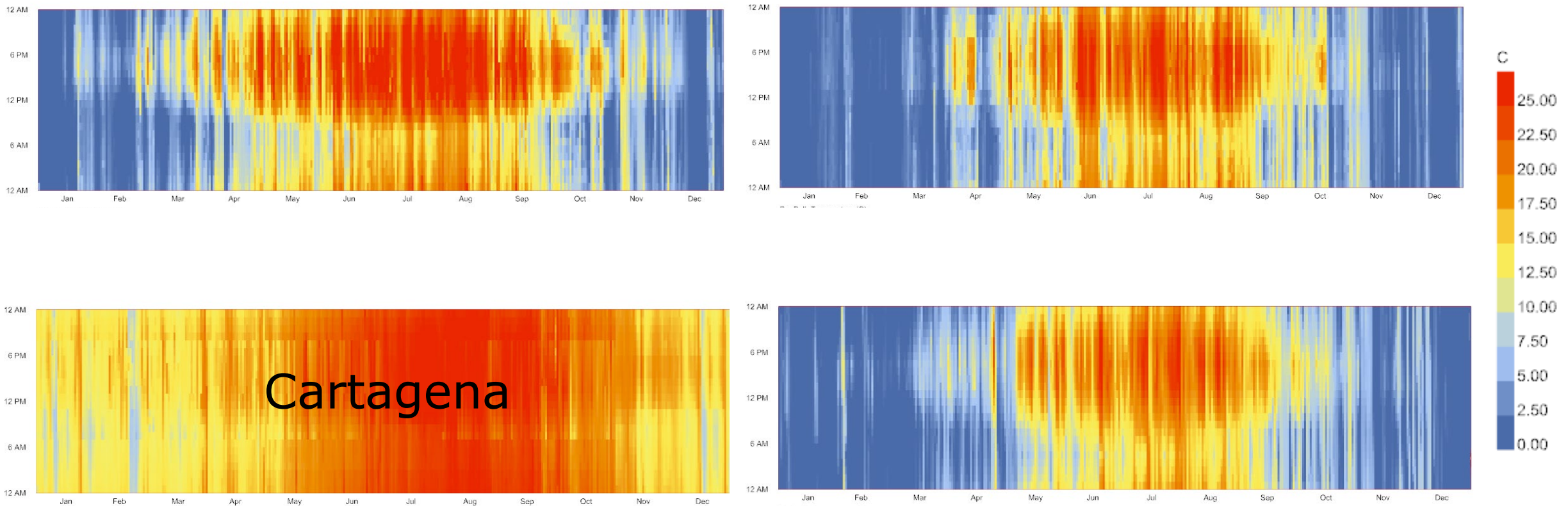

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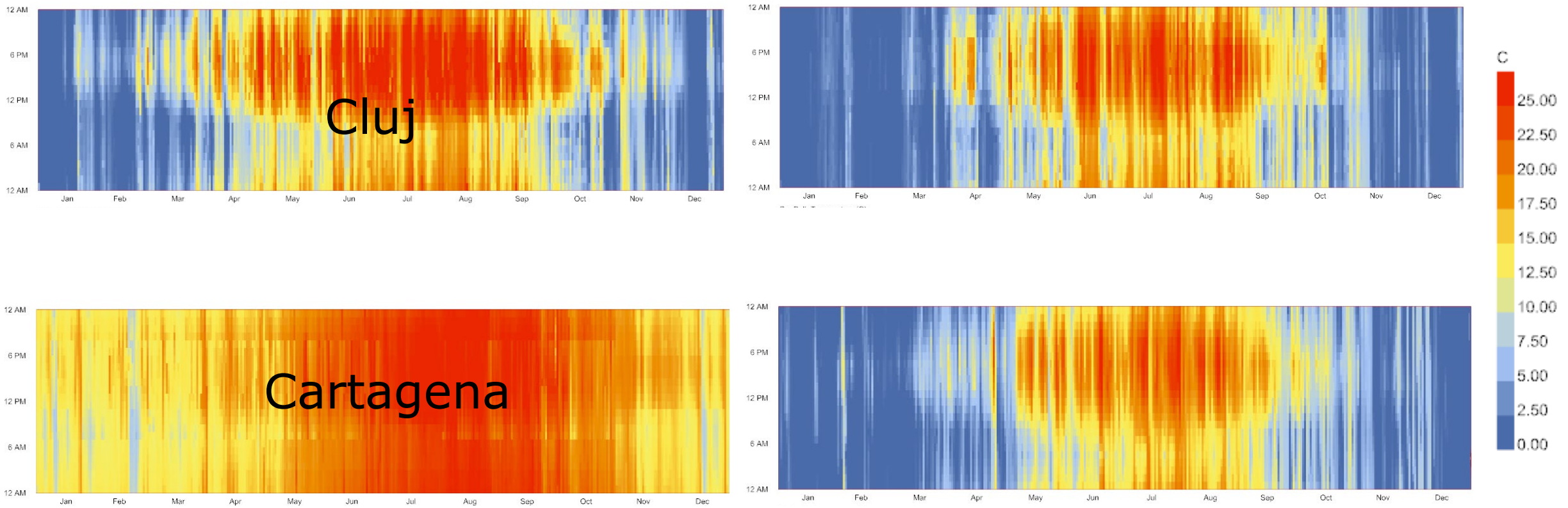

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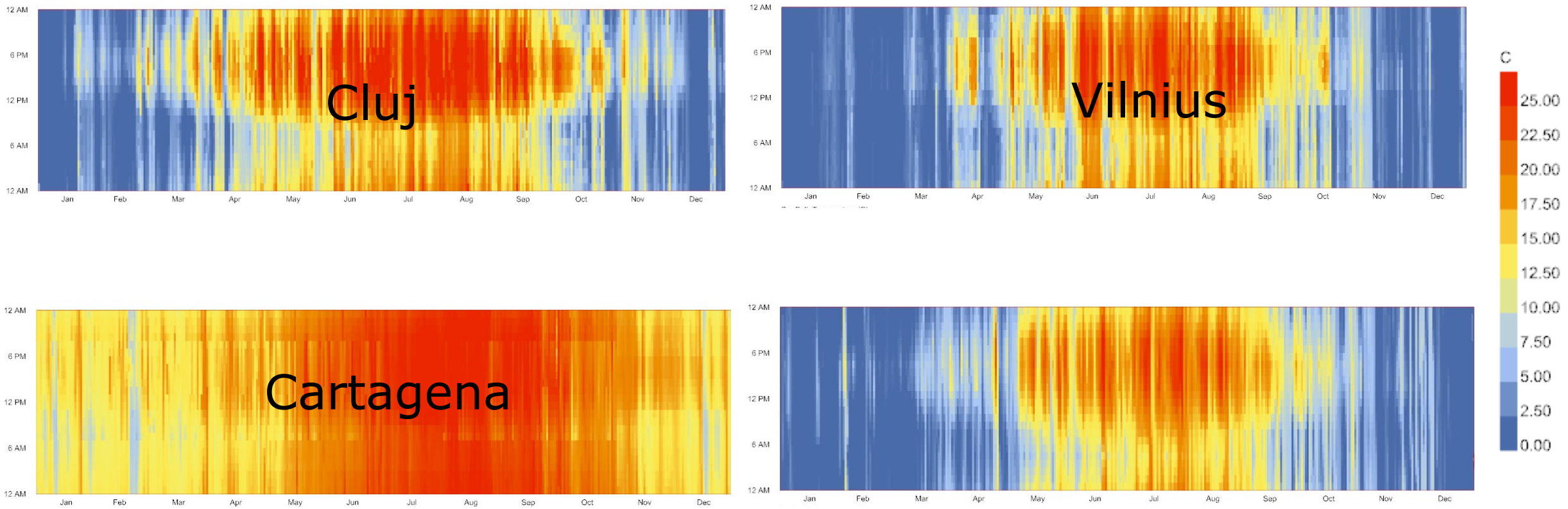

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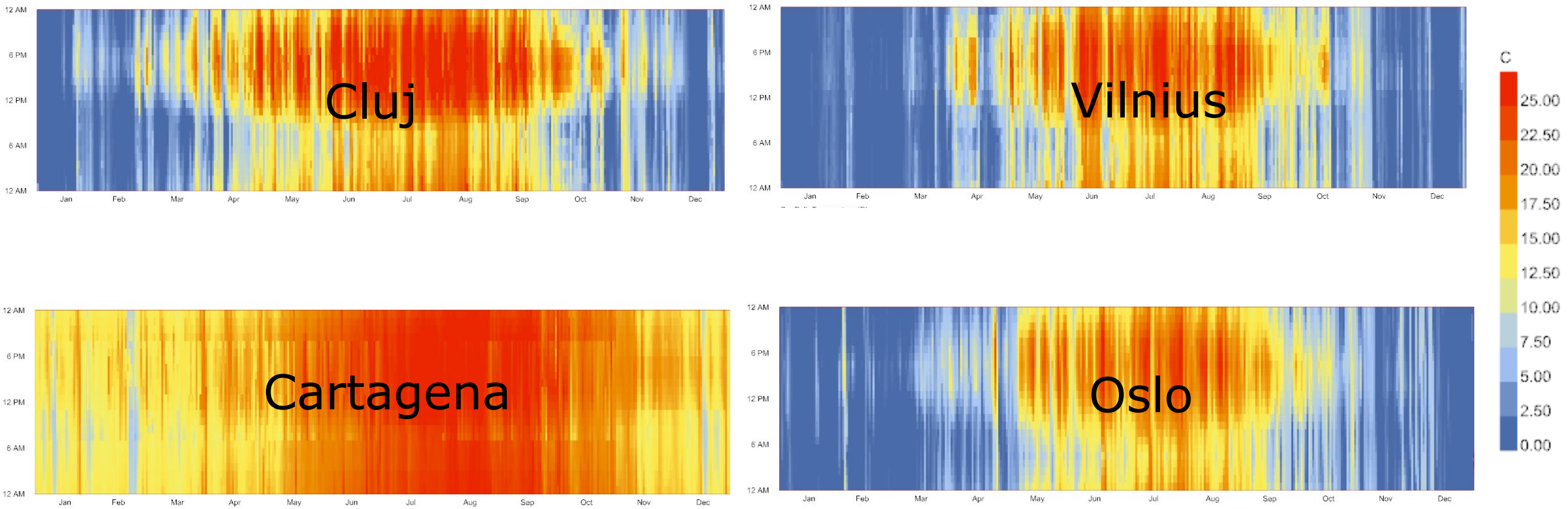
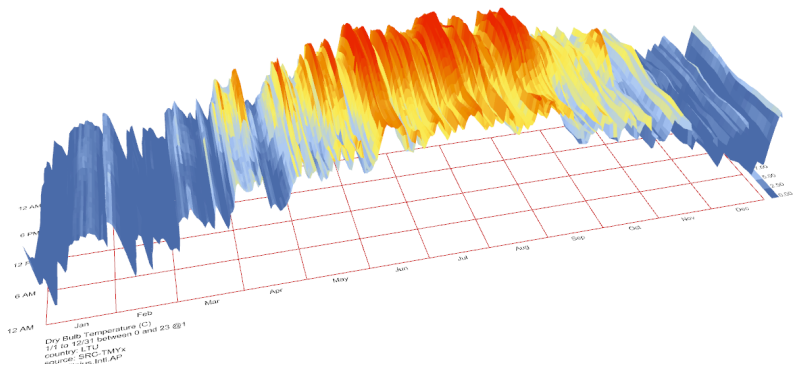


Climate data

Vilnius



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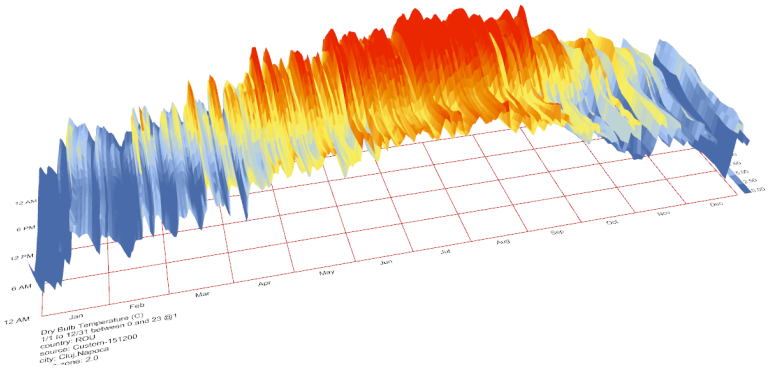
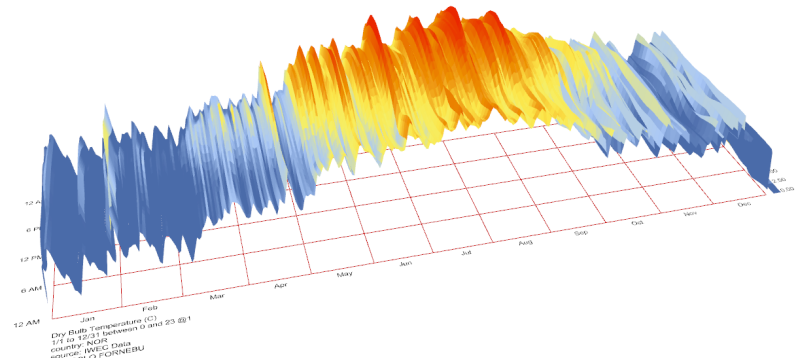
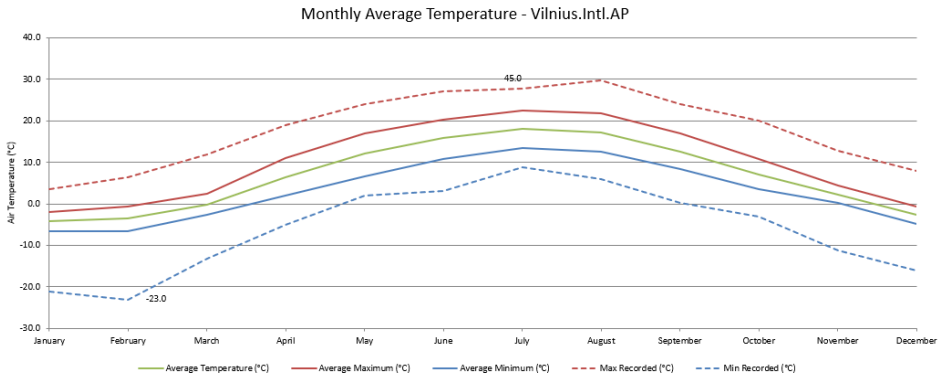
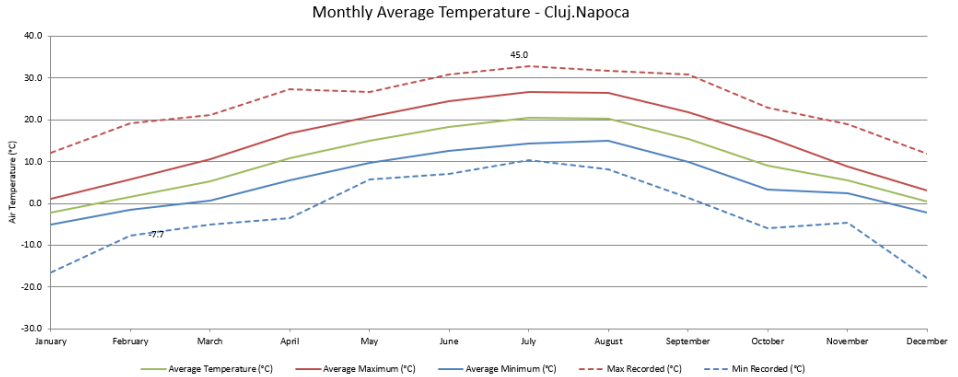
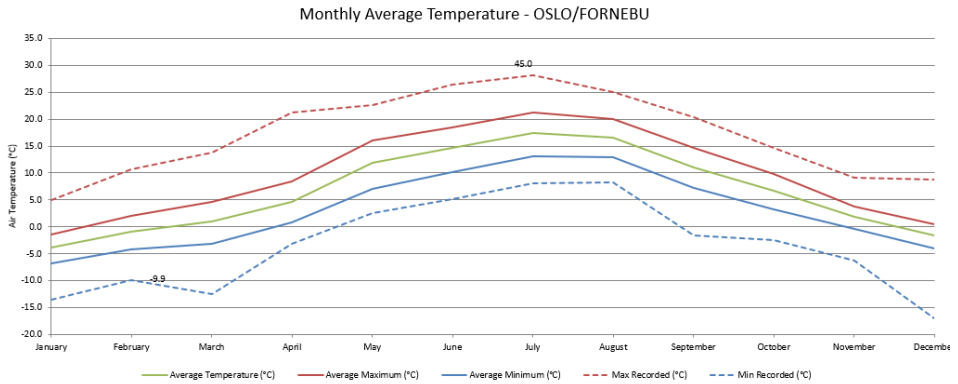


Oslo



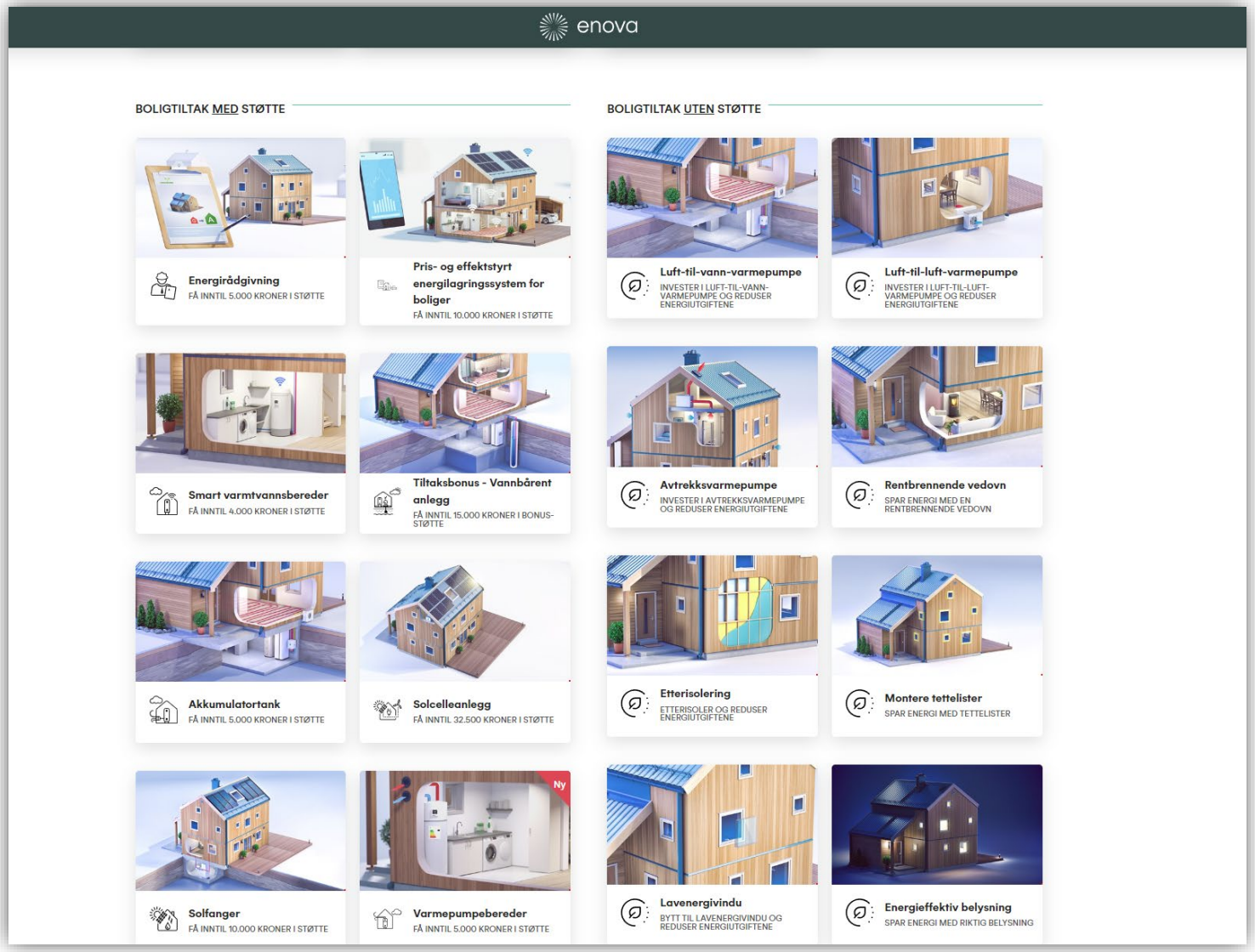






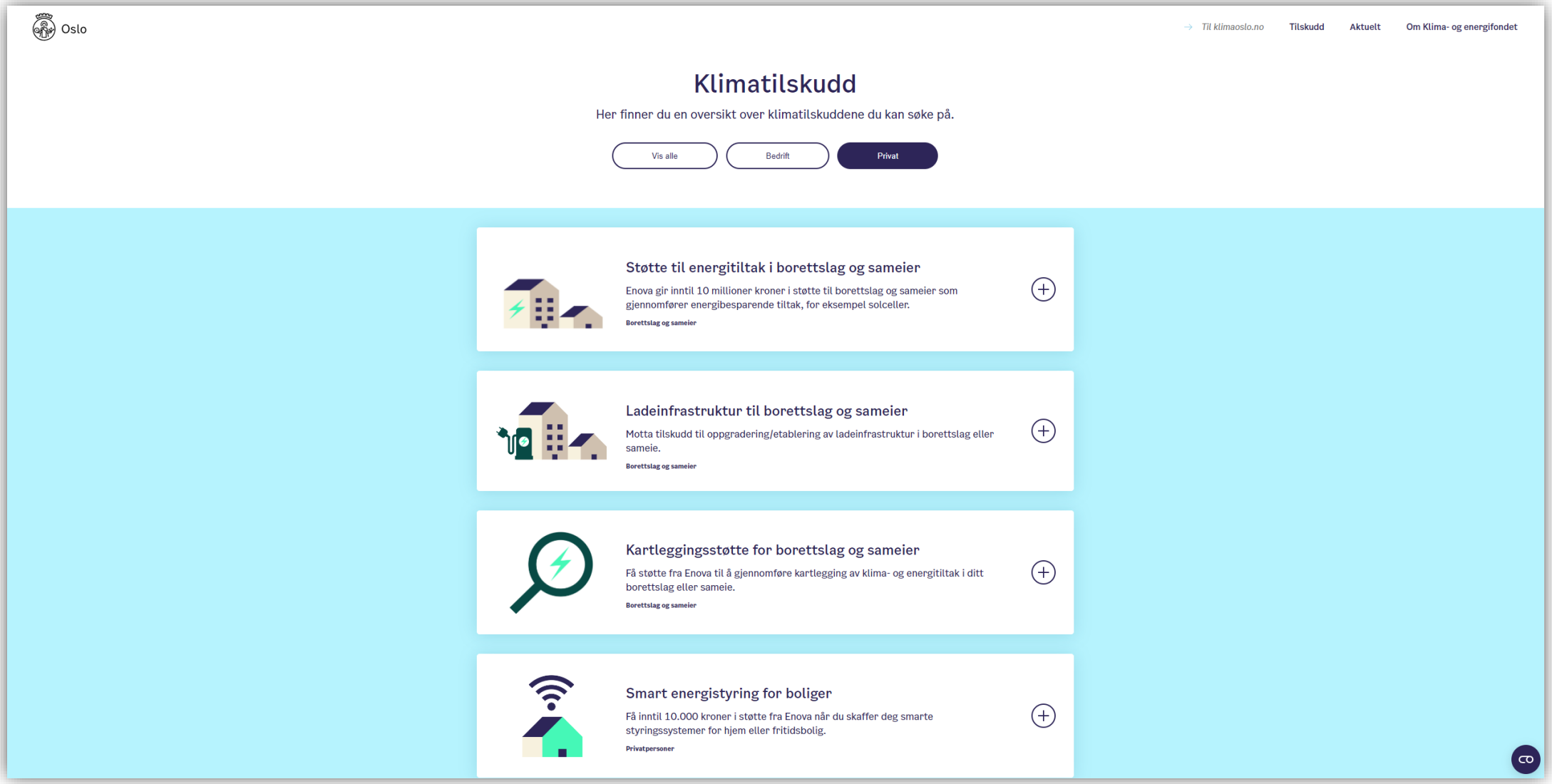
8- Subsidies in Norway

Subsidies from ENOVA



Source: https://www.enova.no/privat/alle-energitiltak/

Subsidies from local municipalities: Oslo



Source: https://klimatilskudd.no/?gclid=EAIaIQobChMIy4Gll9qRhAMV5BiiAx3qQADVEAAYASABEgImsvD_BwE

Bright ideas. Sustainable change.

RAMBØLL

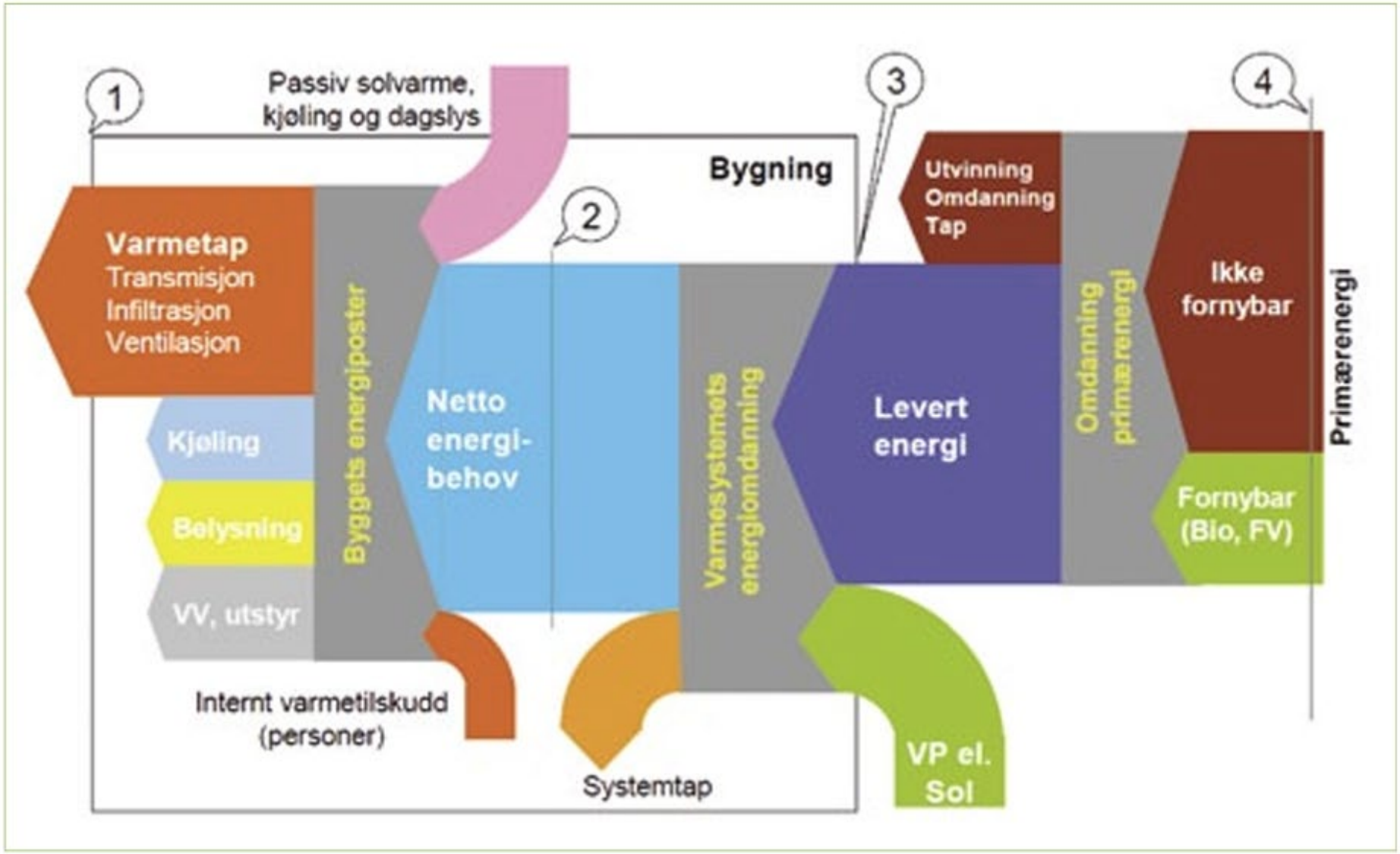
53:2 Isolering mot varmetap

Gjennomsnittlig varmegjennomgangskoeffisient (U-verdi) for bygningsdeler skal ikke overstige verdiene i tabell 53:2.

Tabellverdiene for yttervegg gjelder når vindusarealet utgjør høyst 15 % av bygningens bruttoareal etter NS 3940 inntil 5 m fra yttervegg. For bygninger som er bredere enn 10 m kan vindusarealet økes med 3 % av den del av bruttoarealet som ligger mer enn 5 m fra yttervegg.

Tabell 53:2 Varmegjennomgangskoeffisient (U-verdi) for bygningsdeler.

Bygningsdeler	U-verdi i W/(m^2·K) ved innetemperatur			
		> 18 °C	10 – 18 °C	0 – 10 °C
		1	2	3
Fasader:	yttervegg	0,30	0,60	0,80
	vindu	2,40	3,00	–
	dør, port	2,00	2,60	–
Tak:		0,20	0,40	0,60
Golv:	mot det fri	0,20	0,30	0,40
	mot ikke			
	oppvarmet rom	0,30	0,50	0,60
	på grunnen[1)]	0,30	0,50	0,60


1
Passiv solvarme, kjøling og dagslys
Bygning
2
3
4
Utvinning
Omdanning
Tap
Varmetap
Transmisjon
Infiltrasjon
Ventilasjon
Kjøling
Belysning
VV, utstyr
Byggets energiposter
Netto energi-behov
Varmesystemets energiomdanning
Levert energi
Omdanning primærenergi
Ikke fornybar
Fornybar (Bio, FV)
Primærenergi
Internt varmetilskudd (personer)
Systemtap
VP el. Sol