Interreg
North Sea Region
Stronghouse
European Regional Development Fund
EUROPEAN UNION

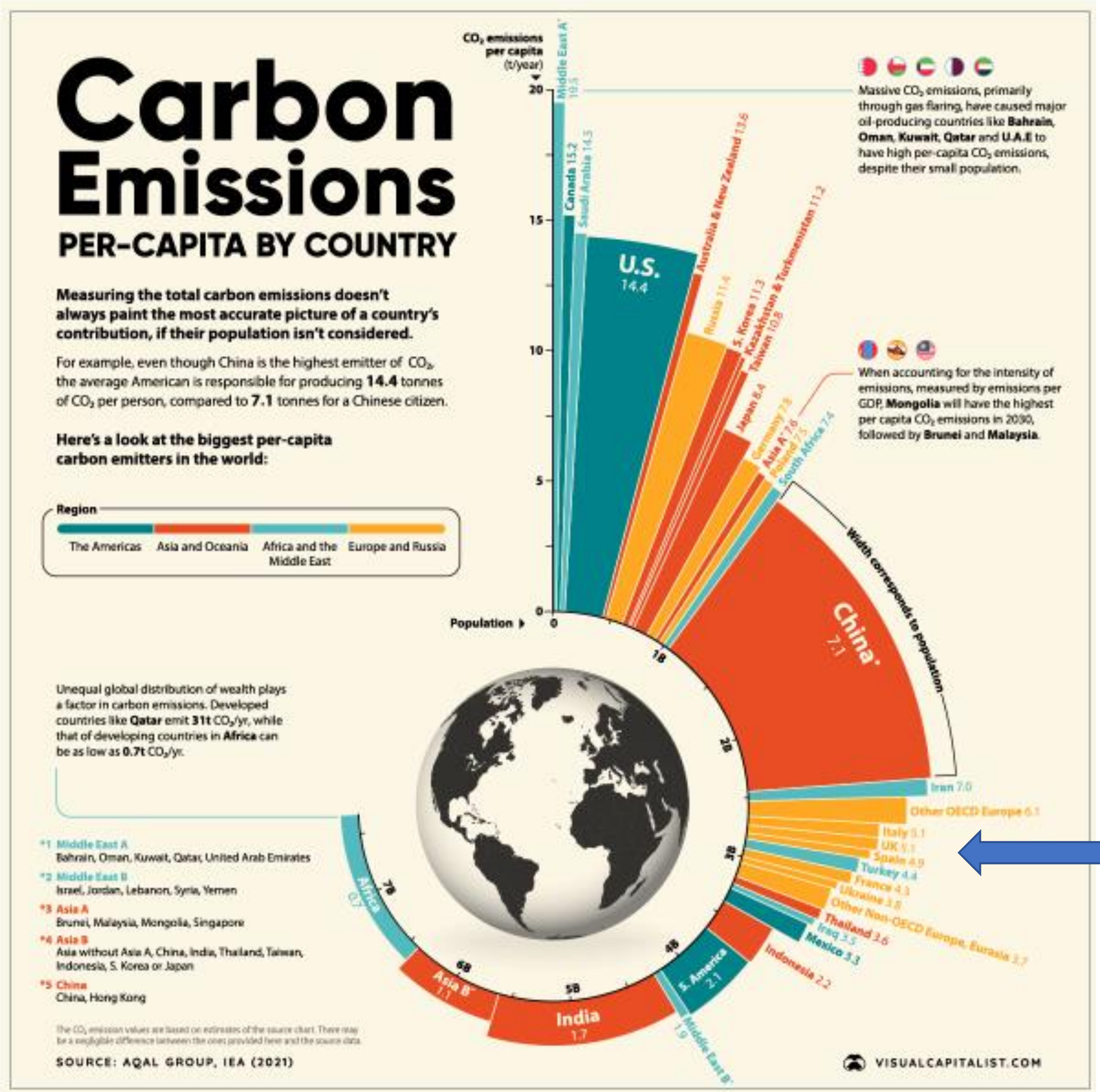
Stronghouse

26 partners shared experience

Amar Bennadji
Professor of Sustainable Built Environment

RGU ROBERT GORDON UNIVERSITY ABERDEEN

Hanzehogeschool Groningen
University of Applied Sciences

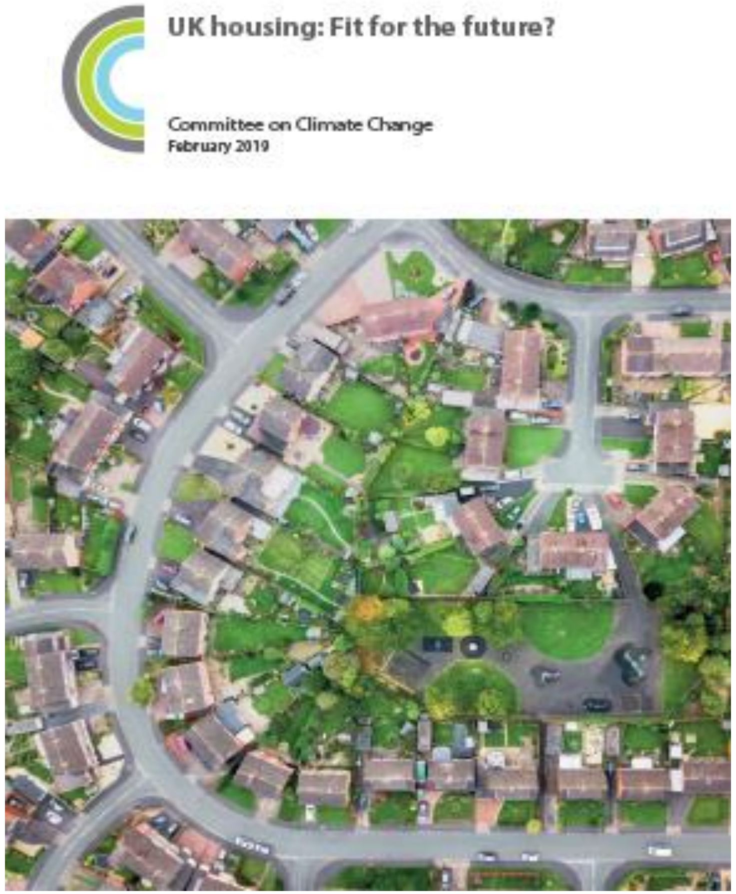


Carbon Emissions
PER-CAPITA BY COUNTRY
Measuring the total carbon emissions doesn't always paint the most accurate picture of a country's contribution, if their population isn't considered.
For example, even though China is the highest emitter of CO₂, the average American is responsible for producing 14.4 tonnes of CO₂ per person, compared to 7.1 tonnes for a Chinese citizen.
Here's a look at the biggest per-capita carbon emitters in the world:
Region
The Americas
Asia and Oceania
Africa and the Middle East
Europe and Russia
CO₂ emissions per capita (t/year)
Population
Massive CO₂ emissions, primarily through gas flaring, have caused major oil-producing countries like Bahrain, Oman, Kuwait, Qatar and U.A.E to have high per-capita CO₂ emissions, despite their small population.
When accounting for the intensity of emissions, measured by emissions per GDP, Mongolia will have the highest per capita CO₂ emissions in 2030, followed by Brunei and Malaysia.
Width corresponds to population
Middle East A 19.5
Canada 15.2
Saudi Arabia 14.5
U.S. 14.4
Australia & New Zealand 13.6
Russia 11.4
S. Korea 11.3
Kazakhstan & Turkmenistan 11.2
Taiwan 10.8
Japan 8.4
Germany 7.8
Asia A 7.6
Poland 7.5
South Africa 7.4
China 7.1
Iran 7.0
Other OECD Europe 6.1
Italy 5.1
UK 5.1
Spain 4.9
Turkey 4.4
France 4.3
Ukraine 3.8
Other Non-OECD Europe, Eurasia 3.7
Thailand 3.6
Iraq 3.5
Mexico 3.3
Indonesia 2.2
S. America 2.1
Middle East B 1.9
India 1.7
Asia B 1.1
Africa 0.7
Unequal global distribution of wealth plays a factor in carbon emissions. Developed countries like Qatar emit 31t CO₂/yr, while that of developing countries in Africa can be as low as 0.7t CO₂/yr.
*1 Middle East A
Bahrain, Oman, Kuwait, Qatar, United Arab Emirates
*2 Middle East B
Israel, Jordan, Lebanon, Syria, Yemen
*3 Asia A
Brunei, Malaysia, Mongolia, Singapore
*4 Asia B
Asia without Asia A, China, India, Thailand, Taiwan, Indonesia, S. Korea or Japan
*5 China
China, Hong Kong
SOURCE: AQAL GROUP, IEA (2021)
VISUALCAPITALIST.COM

Retrofit context

- The UK's built environment is responsible for 25% of the UK’s CO_2 emissions.
- 13% of households in England are classified as **fuel poor**, with 25% in Scotland, 12% in Wales, and 18% in Northern Ireland.
- 3000 people in the UK **die** every year due to the cold.

To meet its climate targets, the UK has the ambition to retrofit almost all homes (29M) to achieve at least the Energy Performance Certificate (EPC) band C by 2035.



Retrofit context

- Only 29% of homes in the UK meet this standard (EPC band C).

- **9000** improvements installed per week across the whole UK housing stock.
- This needs to increase by around **seven times** to reach the EPC band C standard by 2035.

Following home owners in their retrofitting journey

Experiencing with students and practitioners

Developing new courses

ROBERT GORDON UNIVERSITY ABERDEEN

ABOUT | STAFF | CURRENT STUDENTS |

Study | Life at RGU | Alumni & Supporters | Research | Business & Innova

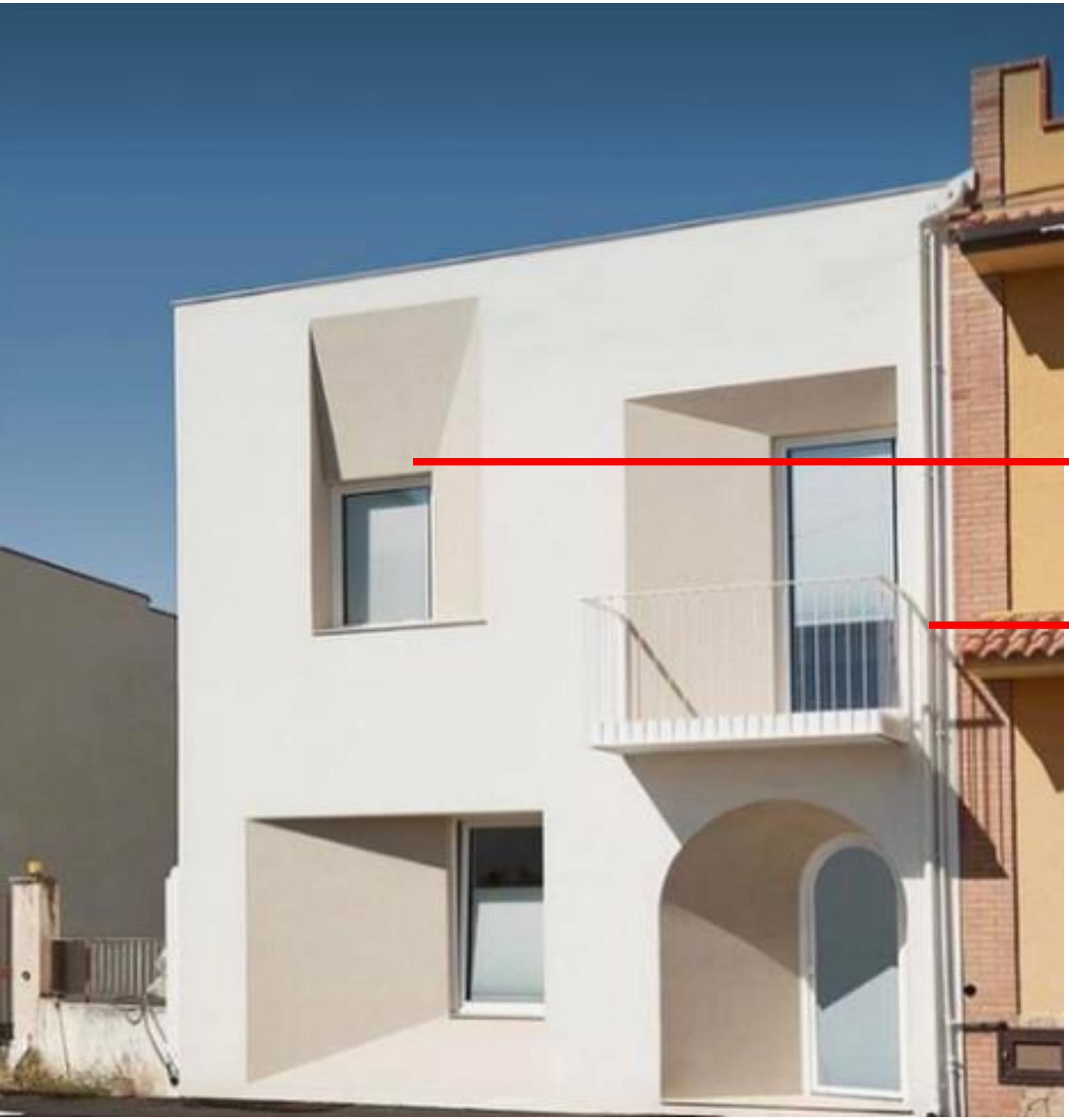
→ THE SCOTT SUTHERLAND SCHOOL OF ARCHITECTURE & BUILT ENVIRONMENT

Building Retrofit

PgCert

APPLY NOW AND START SEPTEMBER OR JANUARY → REGISTER INTEREST → APPLY

Beyond Building thermal Retrofitting



Thermal Retrofitting, open to thoughts

Retrofit radicals: housing can be energy efficient and beautiful

The UK's old homes leak heat and carbon. Meet the architects pioneering sustainable solutions with bold aesthetics

?

Form factor?

Wrong statement from the press.

Moisture risks



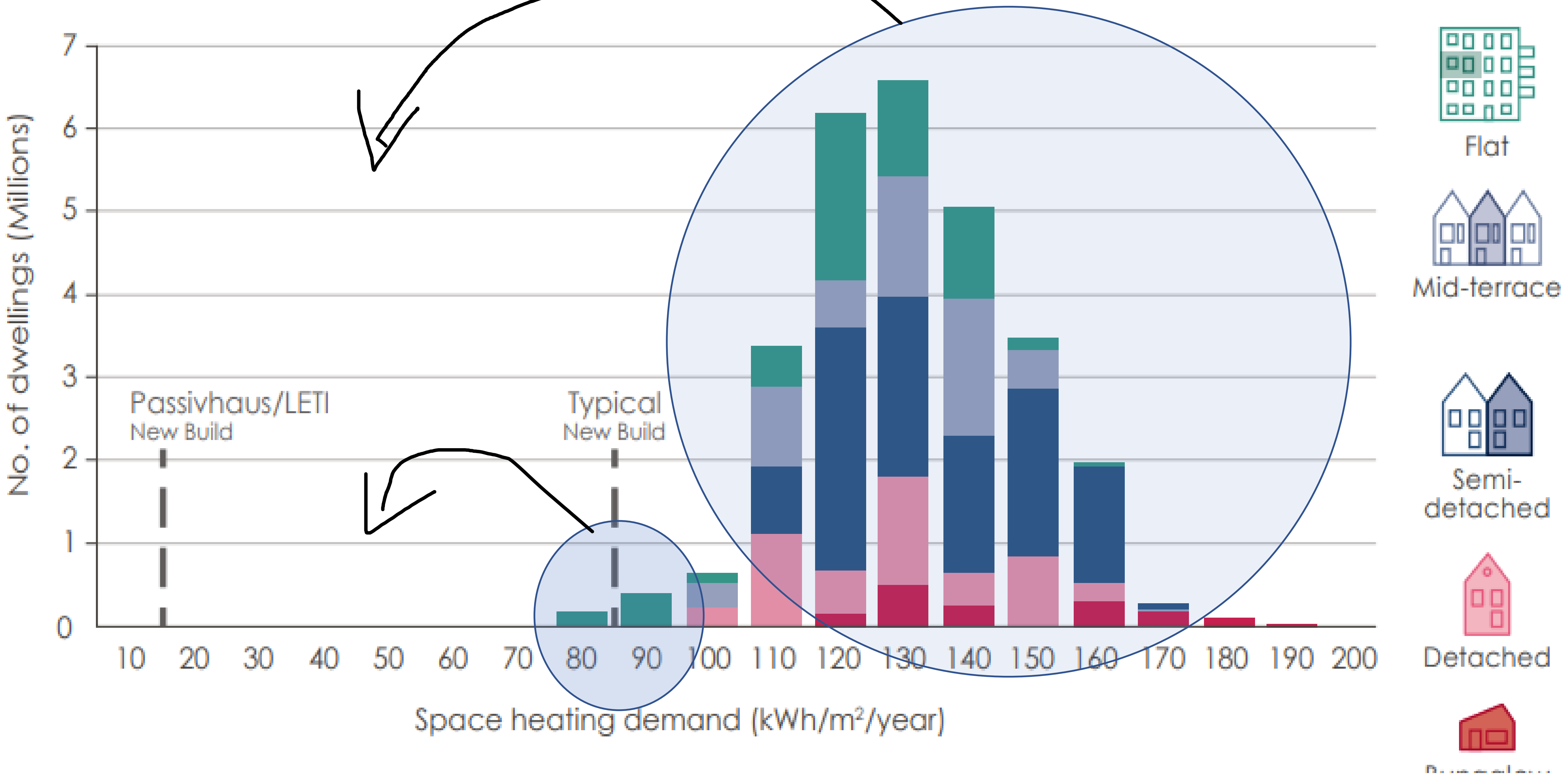

Evidence of water ingress and severe fungal growth inside the properties after the retrofit work.
Lessons from Preston project (UK) taken from Kate de Selincourt

Moisture risks (Preston)

it also costs a fortune to remove the applied measures and redo the work for already vulnerable householders having generally to rectify problems.

9.9% of retrofit measures installed between January 2013 and March 2015 haven't been fitted correctly.

UK domestic space heating demand



Professional and academic views on building retrofit challenges

- Deep retrofitting will be needed for most UK existing housing stock with both options step-by-step and whole-house renovation.
- An emphasis on the environmental and health benefits on retrofitting instead of focusing of cost-effectiveness and investment returns solely.
- The ideal approach is to start with the most vulnerable groups (users and buildings) to tackle fuel poverty, health and well-being of users and work on energy and carbon savings simultaneously.

Renewable and Sustainable Energy Reviews 159 (2022) 112161

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A review on the energy retrofit policies and improvements of the UK existing buildings, challenges and benefits

Jamal Alabid *, Amar Bennadji, Mohammed Seddiki

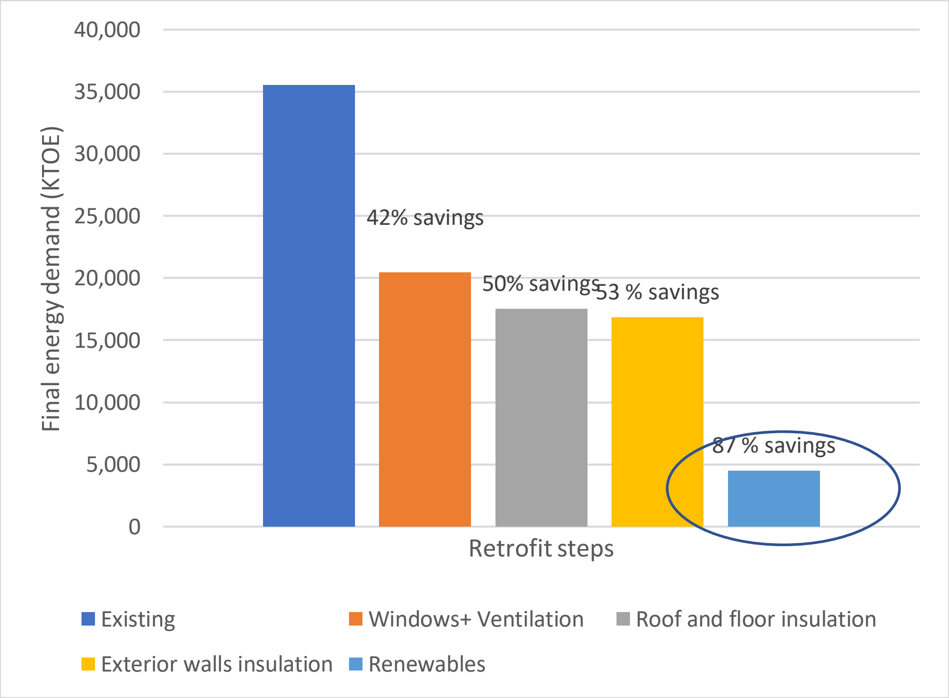
Scott Sutherland School of Architecture and Built Environment, Robert Gordon University, UK

ARTICLE INFO

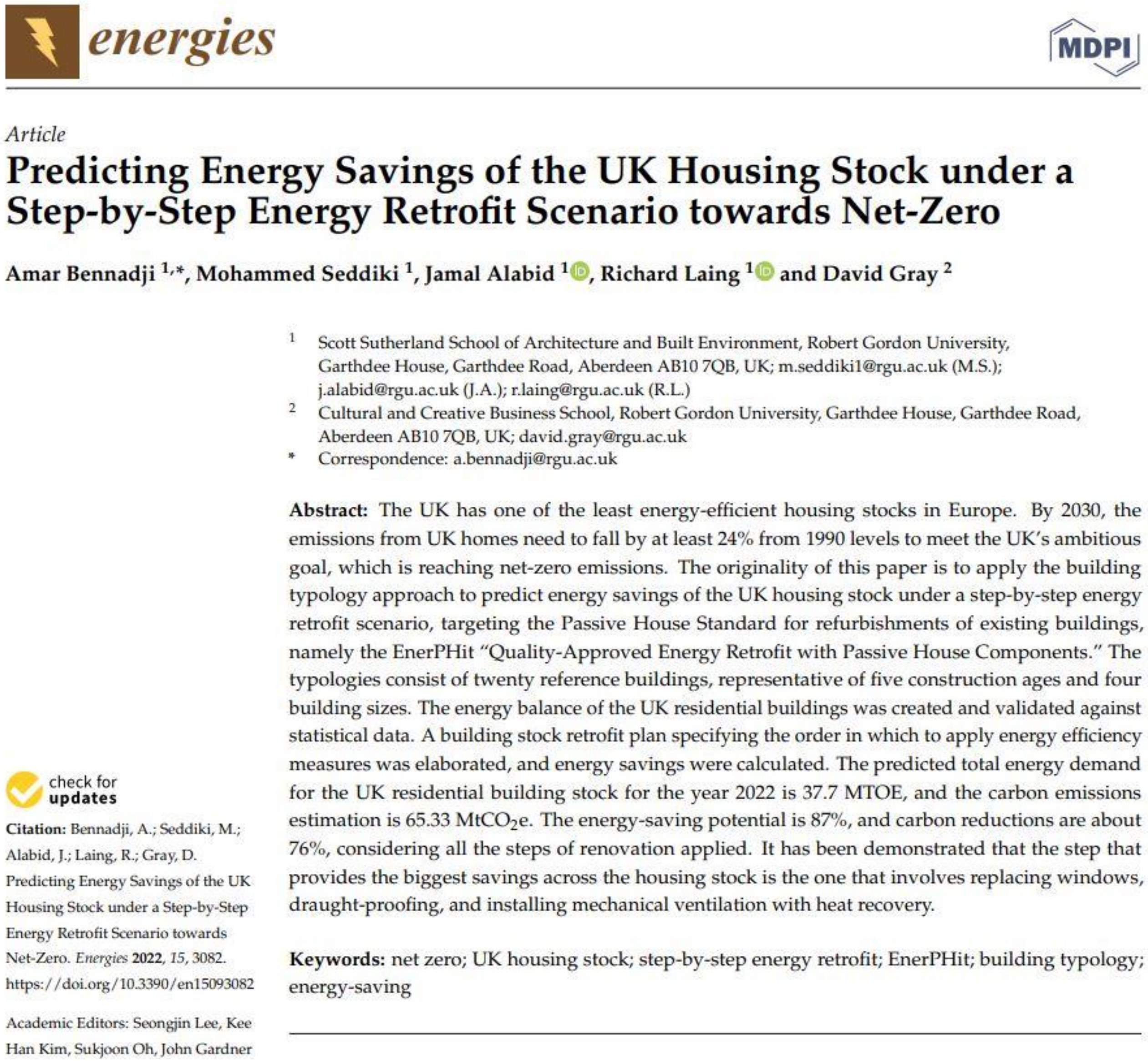
Keywords:
Building retrofit challenges
UK existing Retrofit incentives
UK carbon Reduction target 2050

ABSTRACT

There are inherited challenges and barriers the UK government faces in meeting the 80% carbon reduction target by 2050 compared to 1990 baseline. Technically research shows great opportunity to achieve this target through strategic mass-scale plan to include new and retrofit building schemes. This study aims at reviewing the current retrofit schemes and policies UK adopted since committed to reduce carbon emissions, with an emphasis on existing challenges and potential benefits brought to the construction industry. This will help identifying the gap performance between legislations, standards, and actual/anticipated deliverables. The review adopted secondary research method to allocate scientific research data published in journals and reports on building retrofits. Literature indicated insufficient guidance and information on existing UK housing stock to enable the decision-makers to implement realistic and achievable plans for reducing carbon emissions. The study signifies the understanding and dealing with individual cases as generic retrofitting packages will likely fail to address the complexity of the UK context. Great attention should be paid to some other factors such as social sustainability with great emphasis on using low embodied carbon and energy products. The review will be useful for home-owners and other stakeholders involved in decision-making or people interested in building retrofits.



The energy-saving potential is 87%, and carbon reductions are about 76%, considering all the steps of renovation applied targeting the EnerPHit standard.


energies

MDPI

Article

Predicting Energy Savings of the UK Housing Stock under a Step-by-Step Energy Retrofit Scenario towards Net-Zero

Amar Bennadji [1,*], Mohammed Seddiki [1], Jamal Alabid [1], Richard Laing [1] and David Gray [2]

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2 Cultural and Creative Business School, Robert Gordon University, Garthdee House, Garthdee Road, Aberdeen AB10 7QB, UK; david.gray@rgu.ac.uk
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Abstract: The UK has one of the least energy-efficient housing stocks in Europe. By 2030, the emissions from UK homes need to fall by at least 24% from 1990 levels to meet the UK's ambitious goal, which is reaching net-zero emissions. The originality of this paper is to apply the building typology approach to predict energy savings of the UK housing stock under a step-by-step energy retrofit scenario, targeting the Passive House Standard for refurbishments of existing buildings, namely the EnerPHit "Quality-Approved Energy Retrofit with Passive House Components." The typologies consist of twenty reference buildings, representative of five construction ages and four building sizes. The energy balance of the UK residential buildings was created and validated against statistical data. A building stock retrofit plan specifying the order in which to apply energy efficiency measures was elaborated, and energy savings were calculated. The predicted total energy demand for the UK residential building stock for the year 2022 is 37.7 MTOE, and the carbon emissions estimation is 65.33 $MtCO_2e$. The energy-saving potential is 87%, and carbon reductions are about 76%, considering all the steps of renovation applied. It has been demonstrated that the step that provides the biggest savings across the housing stock is the one that involves replacing windows, draught-proofing, and installing mechanical ventilation with heat recovery.

Keywords: net zero; UK housing stock; step-by-step energy retrofit; EnerPHit; building typology; energy-saving

check for updates

Citation: Bennadji, A.; Seddiki, M.; Alabid, J.; Laing, R.; Gray, D. Predicting Energy Savings of the UK Housing Stock under a Step-by-Step Energy Retrofit Scenario towards Net-Zero. *Energies* **2022**, *15*, 3082. https://doi.org/10.3390/en15093082

Academic Editors: Seongjin Lee, Kee Han Kim, Sukjoon Oh, John Gardner

Digital tools

- Insufficient support measures hinder homeowners from investing in energy renovations.
- Information on the amount of energy savings is very strong incentive.
- Digital tools to assist homeowners in their renovation projects.
- 19 tools from 10 different countries that were analysed.

sustainability

MDPI

Review

Review of Existing Energy Retrofit Decision Tools for Homeowners

Mohammed Seddiki [1,*], Amar Bennadji [1], Richard Laing [1], David Gray [2] and Jamal M. Alabid [1]

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[2] Cultural and Creative Business School, Robert Gordon University, Aberdeen AB10 7QB, UK; david.gray@rgu.ac.uk
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Abstract: Energy retrofit tools are considered by many countries as one of the strongest incentives to encourage homeowners to invest in energy renovation. These tools help homeowners to get an initial overview of suitable retrofit measures. Although a large number of energy retrofit tools have been developed to inspire and educate homeowners, energy renovation by individual homeowners is still lagging and the impact of current tools is insufficient as awareness and information issues remain one of main obstacles that hinder the uptake of energy retrofitting schemes. This research extends the current knowledge by analysing the characteristics of 19 tools from 10 different countries. The selected tools were analysed in terms of energy calculation methods, features, generation and range of retrofit measures, evaluation criteria, and indications on financial support. The review indicates that: (1) most toolkits use empirical data-driven methods, pre-simulated databases, and normative calculation methods; (2) few tools generate long-term integrated renovation packages; (3) technological, social, and aesthetic aspects are rarely taken into consideration; (4) the generation of funding options varies between the existing tools; (5) most toolkits do not suggest specific retrofit solutions adapted to traditional buildings; and (6) preferences of homeowners in terms of evaluation criteria are often neglected.

Keywords: energy retrofit; decision tools; homeowners; energy efficiency; web-based applications; energy calculations

check for updates

Citation: Seddiki, M.; Bennadji, A.; Laing, R.; Gray, D.; Alabid, J.M. Review of Existing Energy Retrofit Decision Tools for Homeowners. *Sustainability* **2021**, *13*, 10189. https://doi.org/10.3390/su131810189

Definition of building typologies

Digital tool

- 20 building typologies split into five construction periods (pre–1919, 1919–1944, 1945–1964, 1965–1980, post–1980) and four building sizes, including single-family house (SFH), terraced house (TH), multi-family house (MFH), and apartment block (AB)

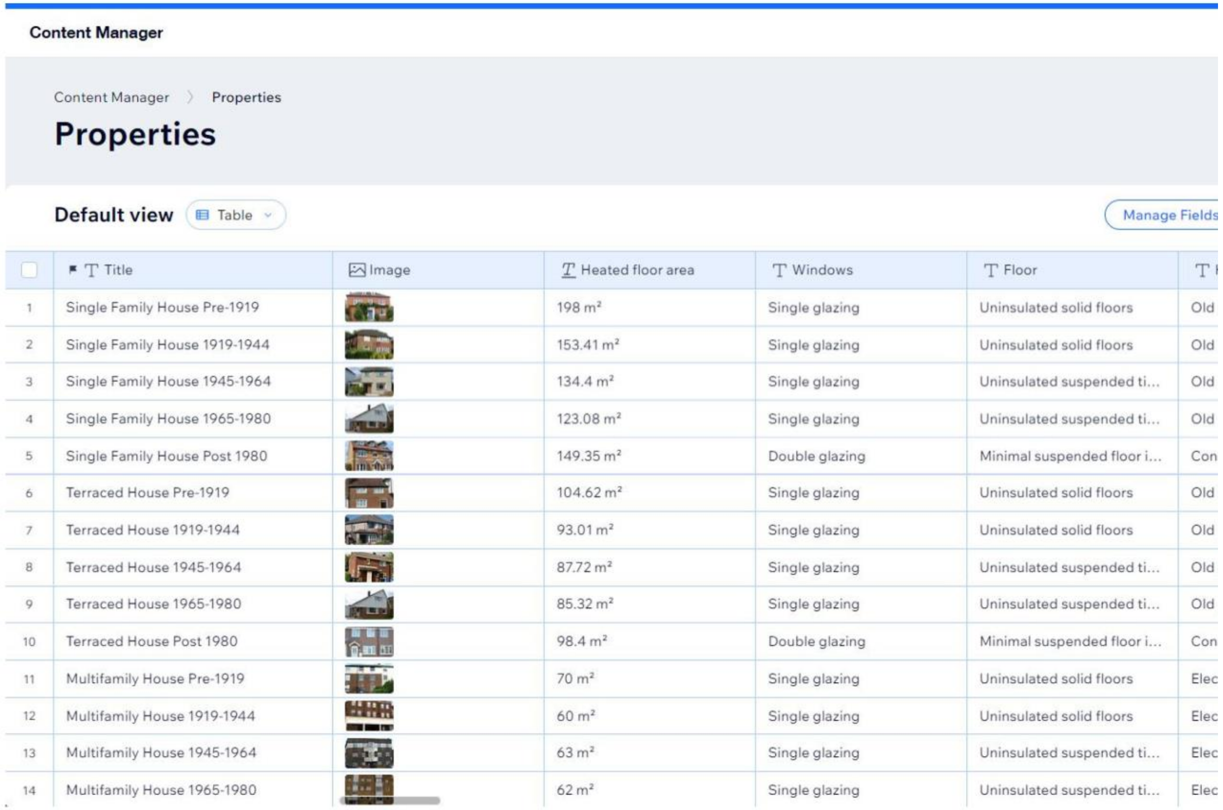
	Type dimensions														Fabric			
Dwelling type	(conditioned floor area / conditioned net floor area) (m2)	Conditioned building volume (m3)	number of apartments	Room hight (m)	number of complete storeys	Roof surface area (m2)	Wall surface area (m2)	Floor Surface area (m2)	Total surface of windows (m2)	Door surface area	Window East area (m2)	Window South area (m2)	Window West area (m2)	Window North area (m2)	Roof/ U-value W/(m2K)	wall/U-value W/(m2K)	floor/ U-value W/(m2K)	Door/ U-v W/(m2K)
SFH Pre 1919	198.00/198.00	491.3	1	2.5	2	113.45	200.3	113.45	46.5	3.8	22.7	0	23.8	0	Pitched with gables/ 2,3	Solid brick(as built) /2,1	single family house/0.59	Softwood door/ 3
SFH 1919-1944	153.41/153.41	384.22	1	2.5	2	97.57	155.32	97.57	40.36	3.8	20.03	0	20.03	0	Pitched with gables/ 2,3	Solid brick(as built) /2,1	single family house/0.59	Softwood door/ 3
SFH 1945-1964	134.40/134.40	325.1	1	2.5	2	97.32	134.1	97.32	35.3	3.8	17.2	0	18.1	0	Pitched with gables 2,3	Masonry cavity wall / 1.6	single family house/0.59	Softwood door/ 3
SFH 1965-1980	123.08/123.08	294.02	1	2.5	2	86.89	138.1	86.89	31.7	3.8	15.7	0	16	0	pitched (SAP age band 67 to 75)/1.5	Masonry cavity wall / 1.6	single family house/0.59	pvc door/
SFH Post 1980	149.35/149.35	358.87	1	2.5	2	86.92	168.76	86.92	35.51	3.8	18.11	0	17.4	0	pitched (SAP post 2004)/0.2	cavity walls with insulation/0.35	post 2002 floor/0.23	pvc door/
TH Pre-1919	104.62/104.62	269.75	1	2.5	2	56.35	89.1	56.35	24	3.8	11.2	0	12.7	0	Pitched with gables/ 2,3	Solid brick(as built) /2,1	Terraced/ 0.50	Softwood door/ 3
TH 1919-1944	93.01/93.01	232.01	1	2.5	2	53.46	87.6	53.46	25.4	3.8	13.6	0	11.8	0	Pitched with gables/ 2,3	Solid brick(as built) /2,1	Terraced/ 0.50	Softwood door/ 3
TH 1945-1964	87.72/87.72	210.42	1	2.5	2	52.96	84.8	52.96	23.1	3.8	12.4	0	10.8	0	Pitched with gables 2,3	Masonry cavity wall / 1.6	Terraced/ 0.50	Softwood door/ 3
TH 1965-1980	85.32/85.32	200.68	1	2.5	2	51.94	77.8	51.94	20.8	3.8	10.8	0	10	0	pitched (SAP age band 67 to 75)/1.5	Masonry cavity wall / 1.6	Terraced/ 0.50	pvc door/
TH Post 1980	98.40/98.40	234.34	1	2.5	2	47.27	87.49	47.27	19.39	3.8	10.39	0	9	0	pitched (SAP post 2004)/0.2	cavity walls with insulation/0.35	post 2002 floor/0.23	pvc door/

Generation of Retrofit Measures

- Building envelope, the building services, and renewable energies
- The measures targeted a level close to nearly zero building energy requirements
- Retrofit measures were evaluated individually and in packages to take into consideration the integrated effect
- Total of about **157 simulations.**
- Retrofitting measures were **customised** to each building typology

1945-1964 TFA = 134.40m^2 Height=2.5 m 2 storey house	Existing	**Suspended Floor:** Soft Wood/Plywood/Chipboard (Softwood) (20 mm) + Polyurethane foam (50 mm) + Unventilated Cavity 650mm + ground U-value 0.24 W/m^{2}K. **Pitched roof:** Tiles (Clay) (12 mm) + Woodfibre 30mm + Plasterboard Standard (20 mm) U-value 0.6 W/m^{2}K. **Cavity wall:** Render - Gypsum and Sand (20 mm) + Brickwork Outer Leaf - BRE (102.5 mm) + Polyurethane foam (40 mm) + Brickwork Inner Leaf - BRE (102.5 mm) + Plaster (Dense) (20 mm) total U-value 0.49 W/m^{2}K. **Windows:** PVCU Double glazed 12mm U-value = 1.85 W/m^{2}K **Door:** Half-Double glazed 12mm PVCU U-value 1.85 W/m^{2}k **System:** Natural ventilation, combi-gas boiler with radiators for heating and hot water storage tank in loft 250L.
	Windows + ventilation	**Windows:** Triple-glazed argon filled 16mm or more U-value of 1.4 W/m^{2}K, windows half opened 50%. **System:** Decentralised mechanical whole house extract ventilation and ASHP installed to existing radiators, electric heat pump and DHW storage 250L provided with full insulation of 100mm for pipework.
	Roof & floor insulation	**Suspended Floor:** Soft Wood/Plywood/Chipboard (Softwood) (20 mm) + Foil-Tec Double VCL (1 mm) + Polyurethane foam (150 mm) + Unventilated Cavity 450mm + ground (U-value 0.13 W/m^{2}K). **Pitched roof:** Tiles (Clay) (12 mm) + Felt/Bitumen Layers (1 mm) + Mineral Wool Batt (300 mm) + Foil-Tec Double VCL (1 mm) + Plasterboard Standard (20 mm) U-value 0.12 W/m^{2}K.
	EWI/CWI/IWI + Ex-door	**External wall:** Render - Gypsum and Sand (20 mm) + Brickwork Outer Leaf - BRE (102.5 mm) + Extruded Polystyrene (80 mm) + Brickwork Inner Leaf - BRE (102.5 mm) + Expanded Polystyrene (100 mm) + Foil-Tec Double VCL (1 mm) + Plaster standard (20 mm) Total U-value 0.15 W/m^{2}K. **External door:** Half triple-glazed PVCU argon filled 16mm or more U-value 1.5 W/m^{2}K.
	Renewables	4 KWp of PV added to the roof oriented south with tilted angle of 45°.

Prototype website development



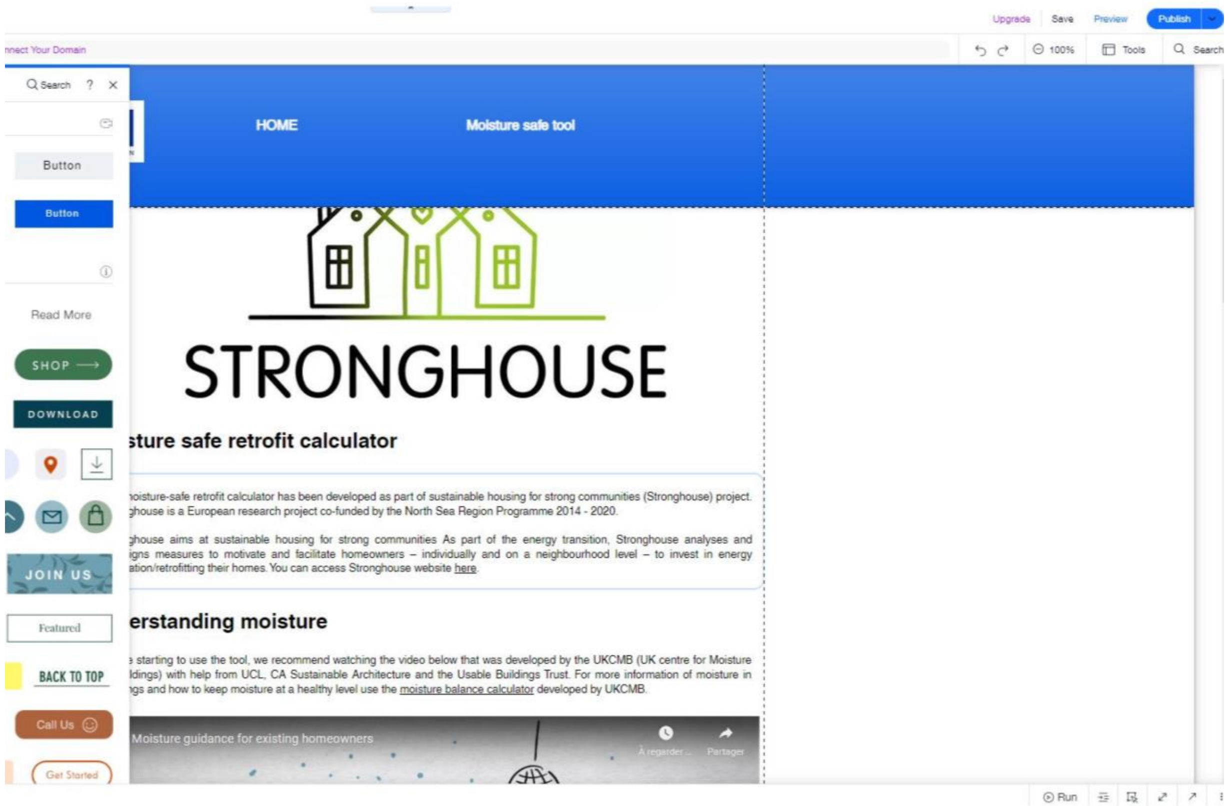
Content Manager

Content Manager > Properties

Properties

Default view Table Manage Fields

	Title	Image	Heated floor area	Windows	Floor	
1	Single Family House Pre-1919		198 m²	Single glazing	Uninsulated solid floors	Old
2	Single Family House 1919-1944		153.41 m²	Single glazing	Uninsulated solid floors	Old
3	Single Family House 1945-1964		134.4 m²	Single glazing	Uninsulated suspended ti...	Old
4	Single Family House 1965-1980		123.08 m²	Single glazing	Uninsulated suspended ti...	Old
5	Single Family House Post 1980		149.35 m²	Double glazing	Minimal suspended floor i...	Con
6	Terraced House Pre-1919		104.62 m²	Single glazing	Uninsulated solid floors	Old
7	Terraced House 1919-1944		93.01 m²	Single glazing	Uninsulated solid floors	Old
8	Terraced House 1945-1964		87.72 m²	Single glazing	Uninsulated suspended ti...	Old
9	Terraced House 1965-1980		85.32 m²	Single glazing	Uninsulated suspended ti...	Old
10	Terraced House Post 1980		98.4 m²	Double glazing	Minimal suspended floor i...	Con
11	Multifamily House Pre-1919		70 m²	Single glazing	Uninsulated solid floors	Elec
12	Multifamily House 1919-1944		60 m²	Single glazing	Uninsulated solid floors	Elec
13	Multifamily House 1945-1964		63 m²	Single glazing	Uninsulated suspended ti...	Elec
14	Multifamily House 1965-1980		62 m²	Single glazing	Uninsulated suspended ti...	Elec



Pilot study by homeowners

- Include co-benefits associated with a retrofit in the financial evaluation, which will enable retrofit tools to make a stronger case for investment in retrofitting.
- Provide users with the opportunity to select between a range of retrofit measures (e.g., various thicknesses of insulation, different window types, etc.) from the most efficient to the least efficient solutions in order not to scare homeowners with high investment costs of measures targeting high energy standards.
- Use simple language, a clear design, and use graphics to clarify information.
- Facilitate easy and quick data entry without asking users for technical details. This can be done by using automated data collection.
- Use a responsive layout to adapt to various screen sizes.

buildings

MDPI

Article

Development and Pilot Evaluation of an Online Retrofit Decision-Making Tool for Homeowners

Mohammed Seddiki [1,*], Amar Bennadji [1], Jamal Alabid [2], David Gray [3] and Gokay Deveci [1]

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3 Cultural and Creative Business School, Robert Gordon University, Aberdeen AB10 7QB, UK
* Correspondence: m.seddiki1@rgu.ac.uk

Abstract: Many retrofit projects went wrong in the UK principally because of the application of inappropriate retrofit solutions, which resulted in damp issues, with some leaving houses in worse conditions than pre-retrofit. Various online tools were developed to inform homeowners about the benefits of retrofitting. Prior to this study, little was known about users' evaluation of these tools and the effects of calculator use. Furthermore, no retrofit tool aims to raise the awareness of homeowners about moisture risks in a retrofit project. The originality of this study is to develop and evaluate an online moisture-safe retrofit decision-making tool for homeowners. The adopted methodology consisted of two phases. Phase one aimed to develop the tool. In phase two, semi-structured interviews were conducted to evaluate the tool. The results indicate that the tool has been well received by homeowners. The tool significantly increased participants' awareness of moisture risks related to a retrofit project. Most participants considered the tool an eye-opener, while few of them found it scary. However, the tool did not result in an increased willingness to invest in energy efficiency measures. The discouragement was related to high investment costs and long payback periods of some retrofit measures. Based on our findings, we formulate a set of design recommendations to improve the proposed tool and help retrofit calculators, in general, overcome challenges.

Keywords: decision-making; online tool; retrofit; pilot evaluation; homeowners; moisture-safe

check for updates

Citation: Seddiki, M.; Bennadji, A.; Alabid, J.; Gray, D.; Deveci, G. Development and Pilot Evaluation of an Online Retrofit Decision-Making Tool for Homeowners. *Buildings* **2022**, *12*, 1513. https://doi.org/10.3390/buildings12101513

Rijksoverheid

nten >

Beleidsprogramma versnelling verduurzaming gebouwde omgeving

Rapport | 01-06-2022

Dit beleidsprogramma beschrijft hoe de verduurzaming van woningen, scholen. winkels en kantoren wordt versneld.

Policy programme accelerating sustainability of the Built Environment

Amongst 9M dwelling, **187,000 homes** are vacant.

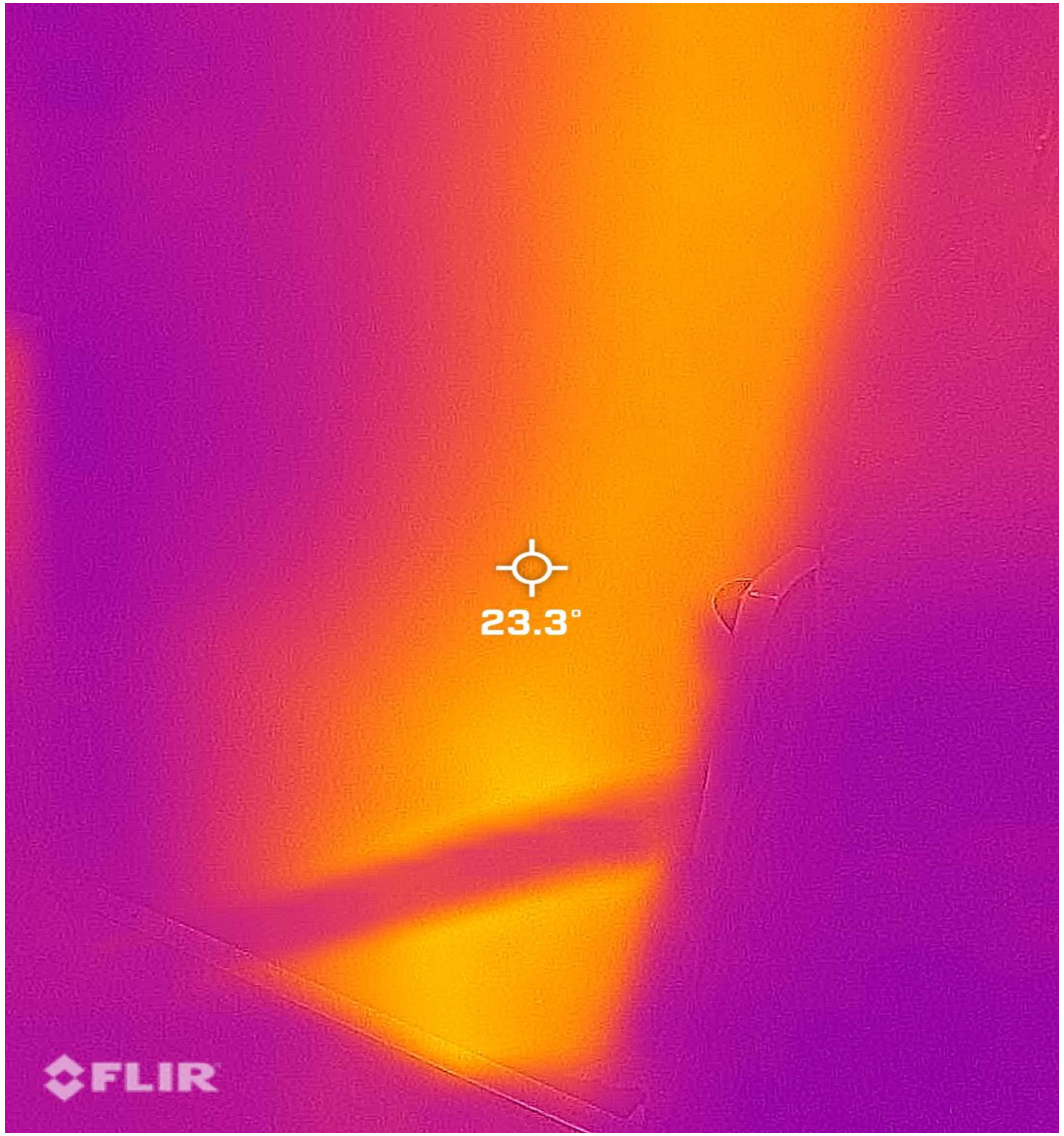
- Retrofitting them represent a saving of 9.5M t CO_2

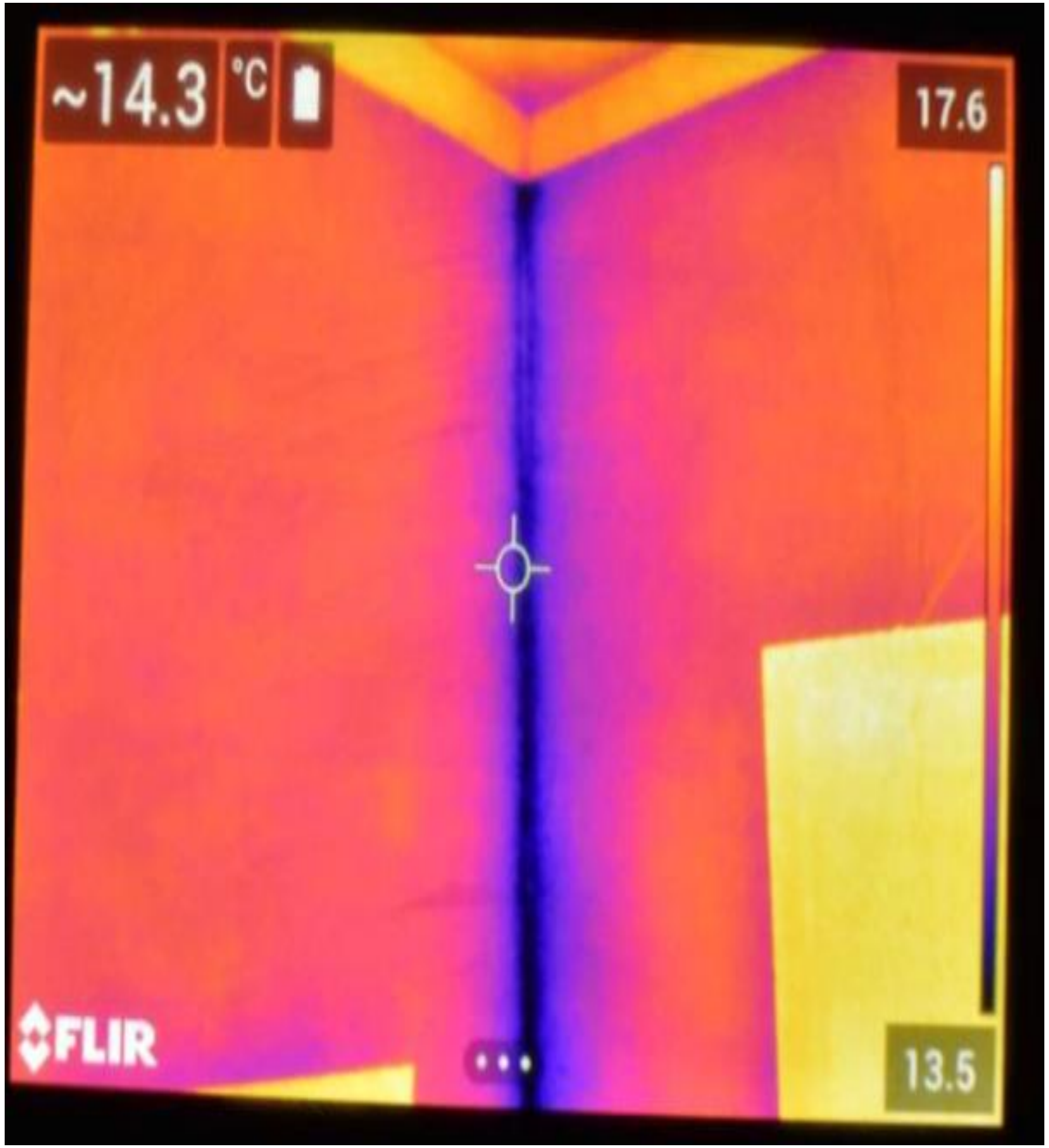
- Representing 1.5M people's CO_2 emission for 1 year

- That's 1/10 of Dutch population

Hanzehogeschool Groningen
University of Applied Sciences

The state of our housing stock, heat leakage from neighbours (not only to the outside)

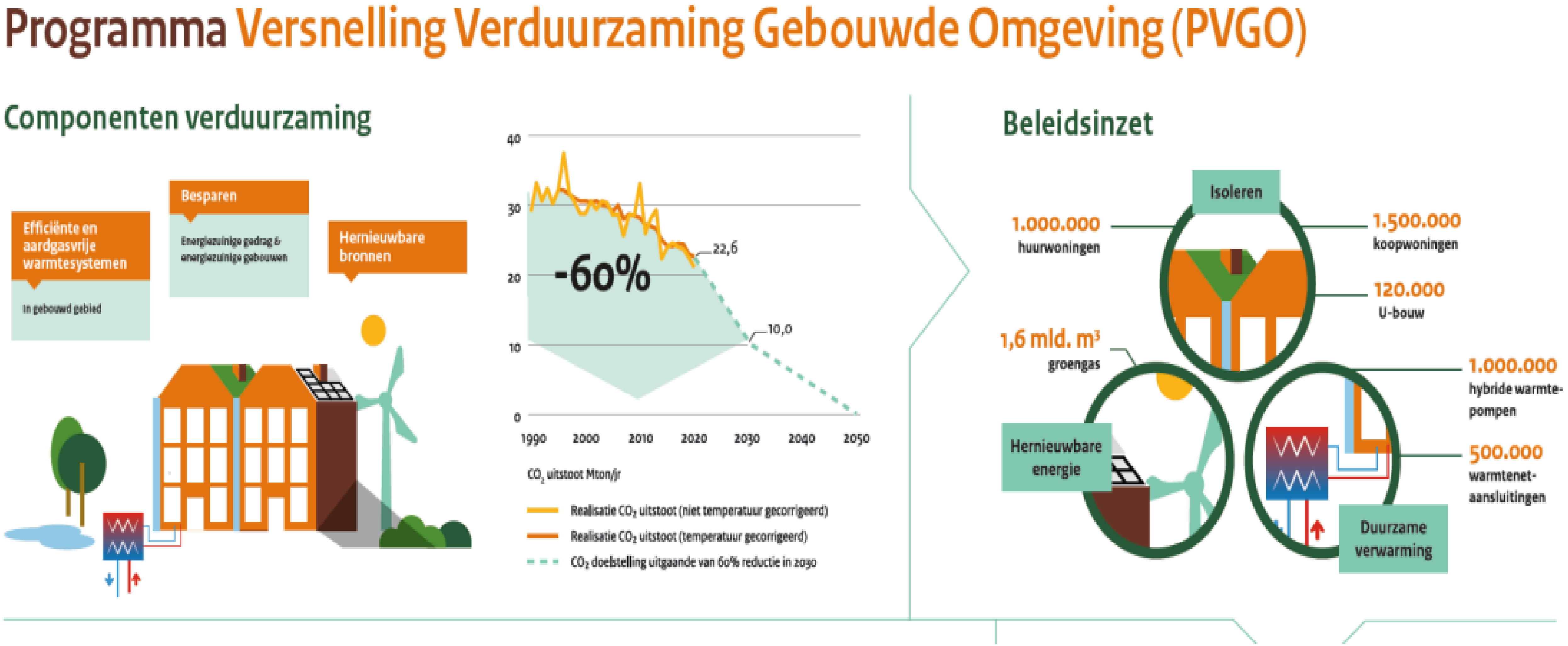


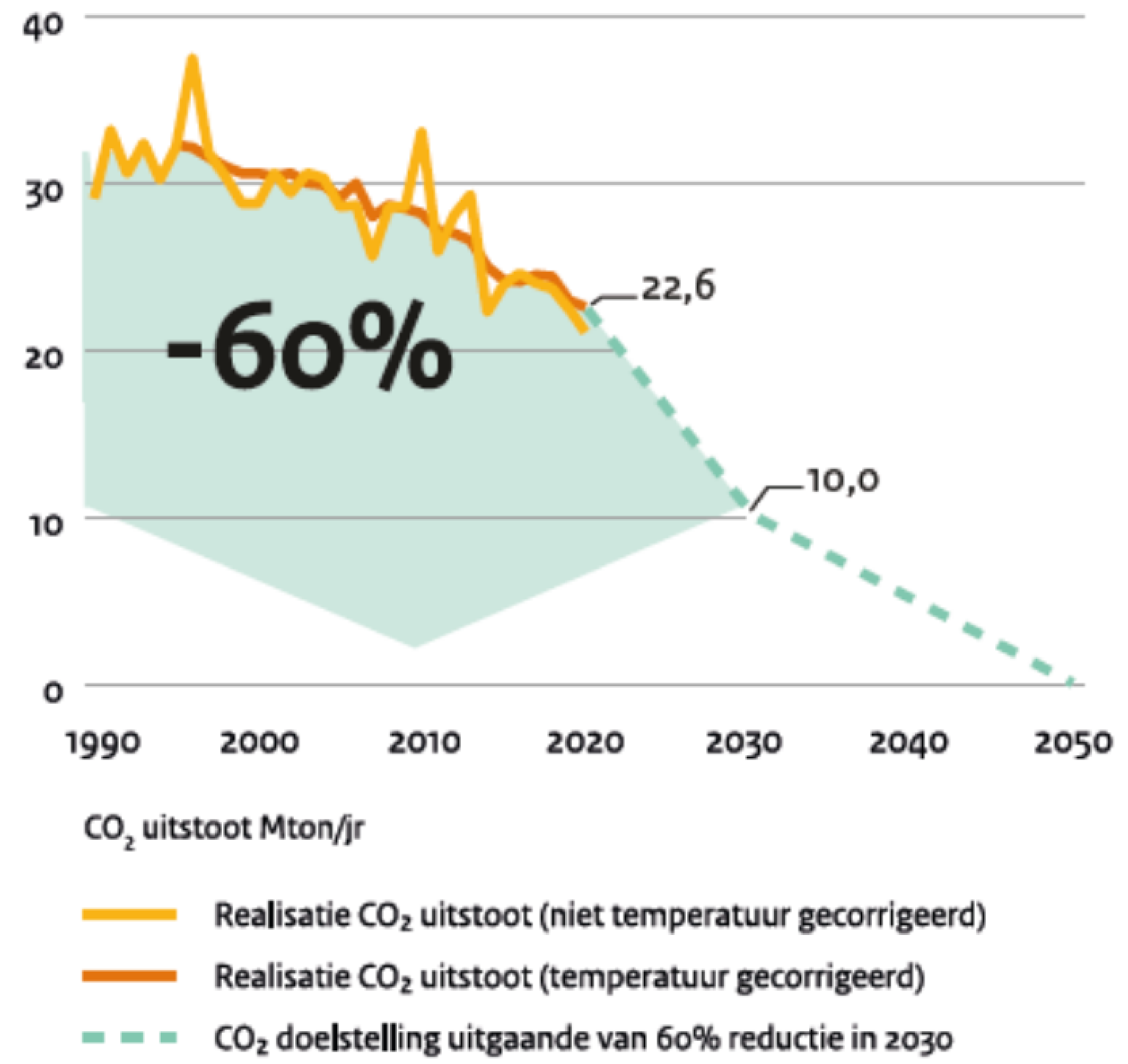

~14.3
°C
17.6
FLIR
13.5

The Nationale Prestatieafspraken

Housing associations are faced with the task of making 450,000 existing homes gas-free by 2030 at the latest. They do this as part of the district-oriented approach, in which municipalities are the first to take the initiative to create support for natural gas-free districts among all residents.

Dutch government policy for the built environment





Dutch journey to net zero.

A long way to go and require everyone’s effort

Hanzehogeschool Groningen
University of Applied Sciences

Groningen is one of the Sustainable cities.
We must honor this assignment.

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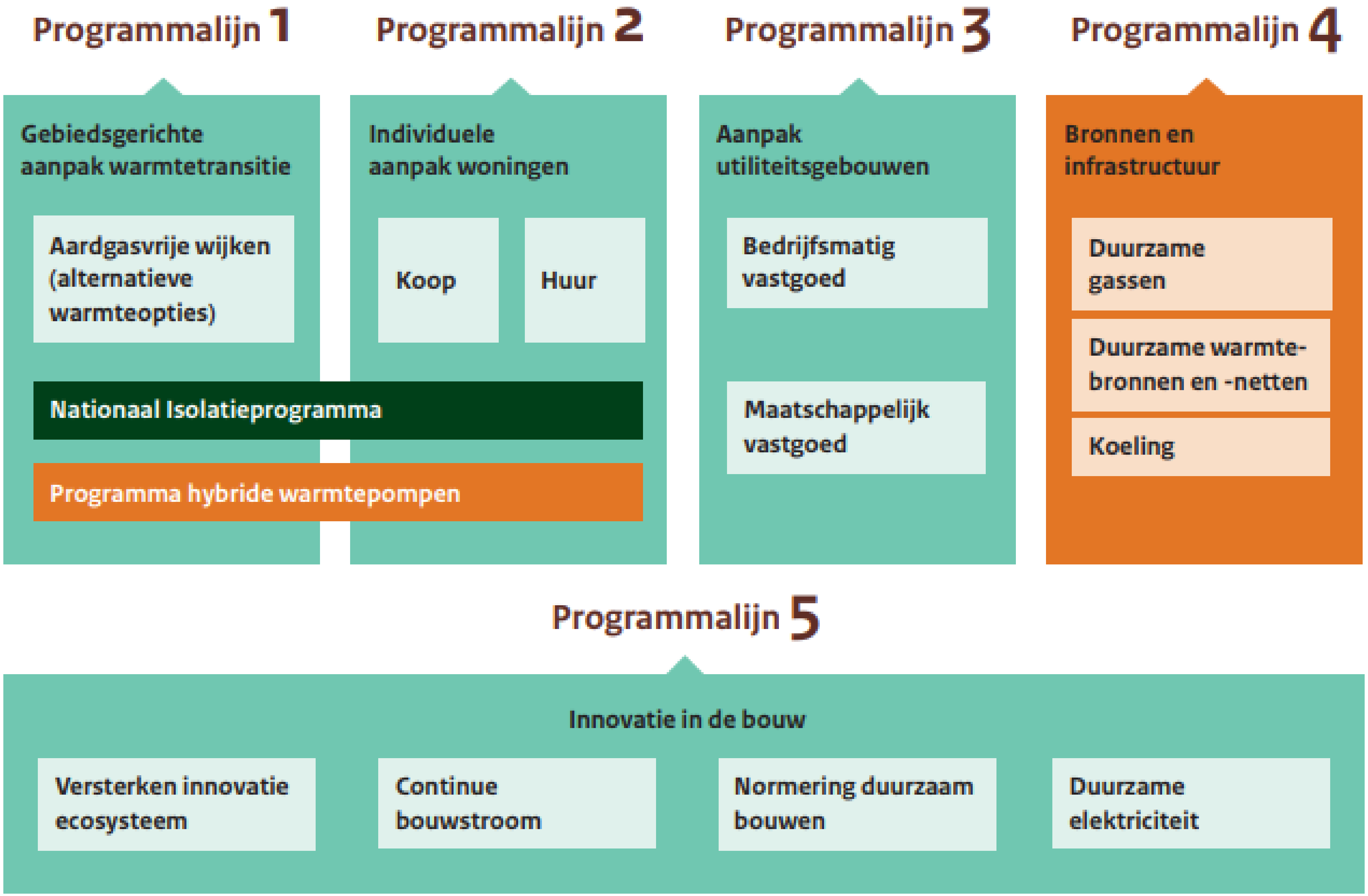
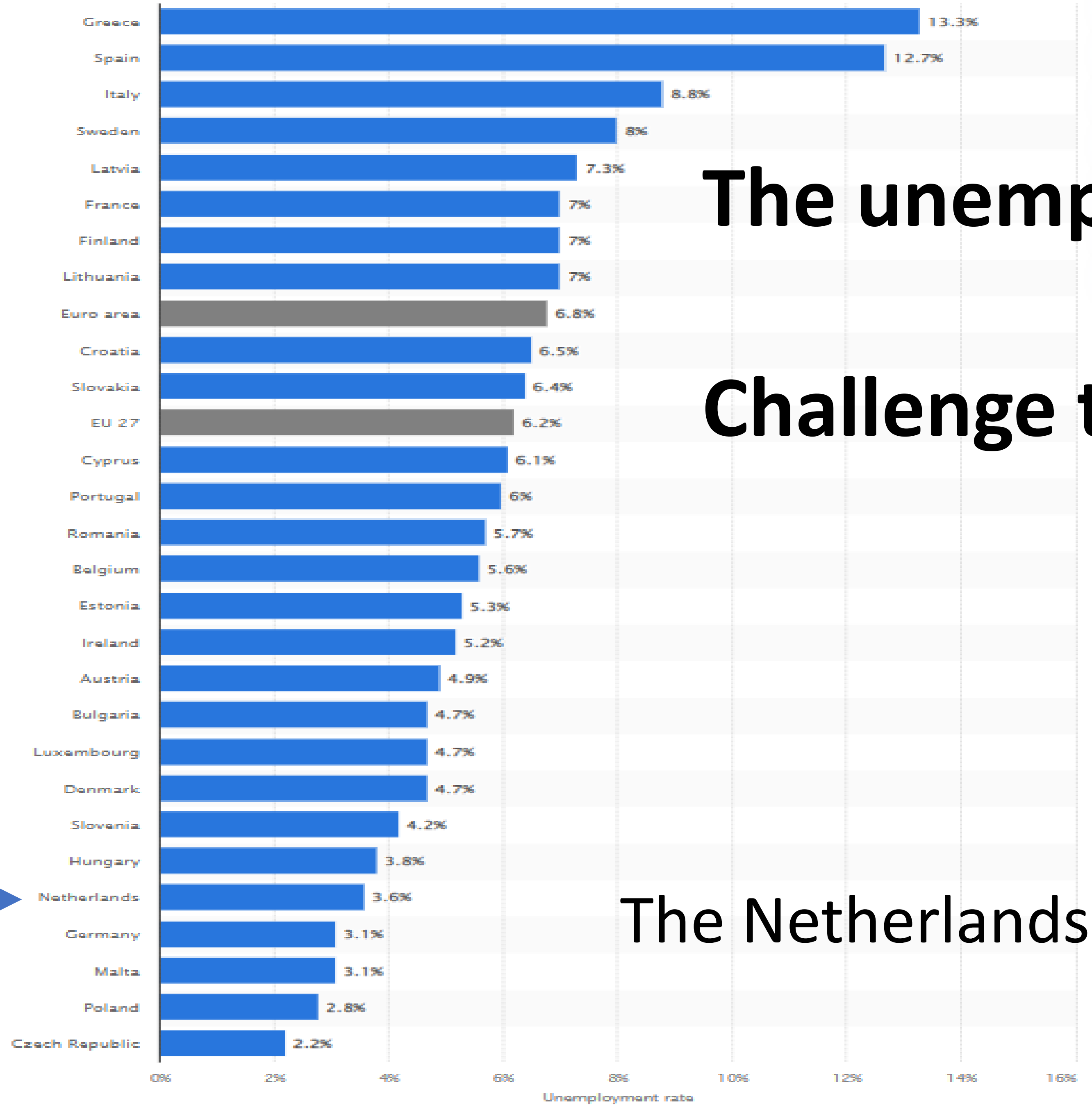
University of Applied Sciences



Let's concentrate on 1 aspect (housing)

The unemployment rate in EU

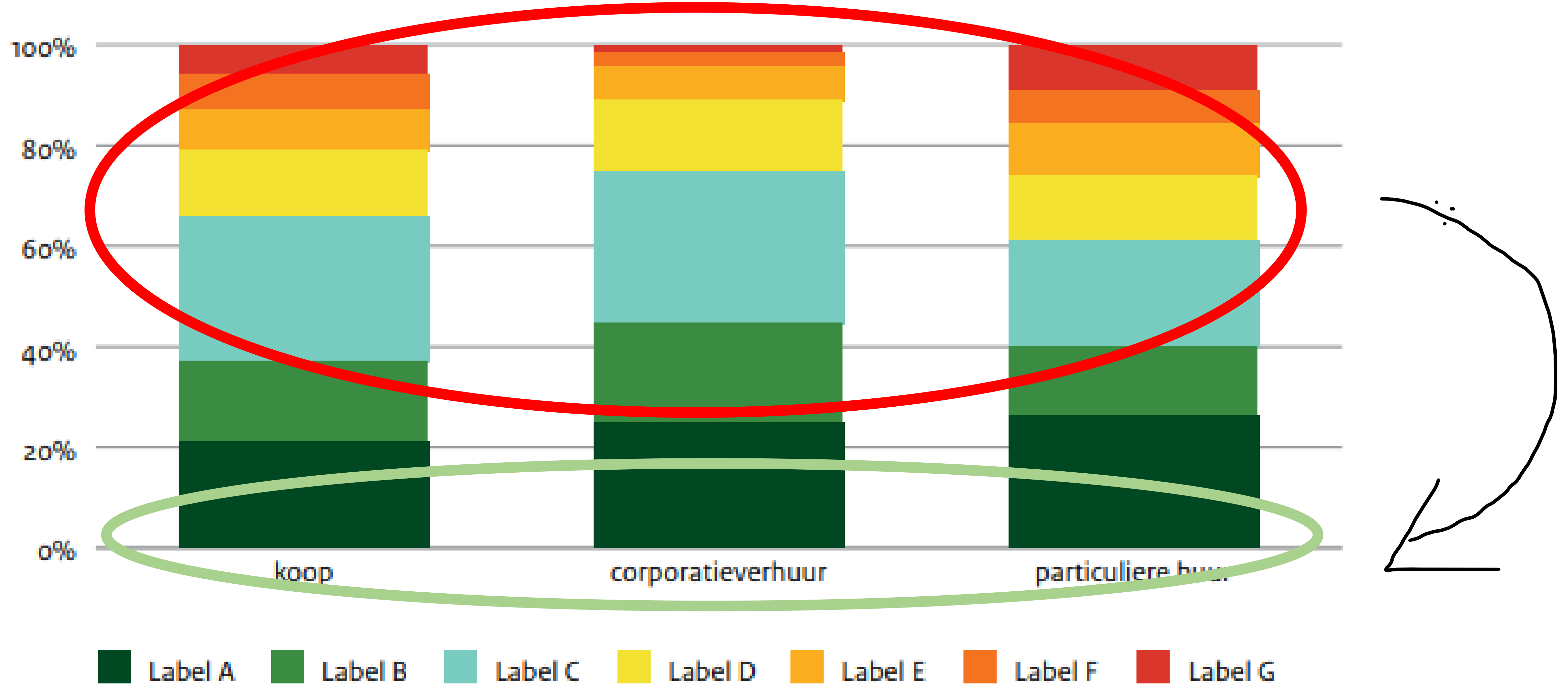
Challenge to the Netherlands



NL

The Netherlands is very low, is that good?

Afbeelding 3: Koop en huurwoningen | Er zijn in Nederland circa 1,5 miljoen woningen met een energielabel E, F of G.



Thank you
Wishing you a nice stay in Groningen