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MaREI Retrofitting Homes Symposium

11th June 2020

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University of Limerick
Ollscoil Luimnigh

MaREI Retrofitting Homes Symposium

In the MaREI Retrofitting Homes Symposium, researchers from MaREI, the SFI Research Centre for Energy, Climate and Marine shared their insights into the challenges and opportunities faced to effectively retrofit the residential building stock in Ireland. With the ambitious targets for the achievement of 500,000 energy efficiency retrofits in Ireland by 2030 set in the Irish government's Climate Action Plan 2019, deep retrofitting of Ireland's building stock is viewed by many as a major economic and employment opportunity, as well as an opportunity to improve the quality of our homes. Since people typically spend approximately 90% of their time indoors, having safe, comfortable, healthy and energy efficient homes is of interest to most.

This document summarises the short presentations given by 13 researchers in the MaREI Centre, as well as presenting some of the results from some of the polls run during the symposium and answers to questions posed by the attendees during the event. There were over 150 questions and comments from attendees at the MaREI Retrofitting Homes Symposium. We hope that we have adequately addressed most of these during the live event and in this section.

There were over 500 people registered to attend the symposium. If you missed the symposium, you can watch the recording at https://bit.ly/3cnB3b2

MaREI Retrofitting Homes Symposium Agenda

Start Time	Title	Speaker
10:00	**Welcome Address**	Dr Jamie Goggins, Co-Principal Investigator MaREI, NUI Galway
	Thermal refurbishment status of the Irish residential building stock	Ciara Ahern (TU Dublin)
	Retrofitting residential properties and fuel choice: Moving to a new home	Gianluca Grilli (ESRI)
	The importance of timing: The impact of retrofit take-up rates on cumulative CO_2 emissions savings	Tomás Mac Uidhir (UCC)
	Beyond energy efficiency - A deeper insight into the multiple benefits of retrofitting homes under the SEAI's Better Energy Communities Scheme	Orlaith McGinley (NUI Galway)
	Data collection and analytics drive better insights into deep retrofitting programmes: SuperHomes case study	Maria Lopez Zambrano (NUI Galway)
	Monitoring action plan of NZEB refurbishment in H2020 Drive-0 project	Philippe Lemarchand (TU Dublin)
10:55	**Facilitated discussions**	Josephine Maguire, National Coordinator - Better Energy, Sustainable Energy Authority of Ireland
	The potential of retrofitting programmes to initiate socio-technical change toward sustainable lifestyles	Gary Goggins (NUI Galway)
	Can DEAP help us to predict the energy demand and indoor temperature of homes before and after renovation? A case study from Dublin	Paul Moran (NUI Galway)
	The impact of retrofitting on indoor radon levels	Marta Fuente Lastra (NUI Galway)
	Adaptive facade operation of a Solar Test Cell, testing methodology used for thermal efficiency and storage potential	Noel O'Neill (TU Dublin)
	Domestic Air Source Heat Pumps: Theoretical and In-use Performance	Adam O'Donovan (CIT)
	Developing a one-stop shop for deep retrofit of homes in Ireland	Johanna Varghese (IGBC)
11:50	**Facilitated discussions**	Prof. Brian Norton Co-Principal Investigator MaREI, TU Dublin
12:00	**END**	

SESSION 1: SYNOPSIS OF PRESENTATIONS

Dr Jamie Goggins (NUI Galway): Welcome address
There are approximately 2 million homes in Ireland, of which 1.7 million are occupied. The Building Energy Ratings (BERs) of homes are registered on the SEAI national BER database with over 900,000 entries to date. The average BER is a D1, which has a primary energy consumption according to the dwelling energy assessment procedure (DEAP) of about 5 times that of a new building built today to the current building regulations. The Irish government's Climate Action Plan 2019 set a target for completing 500,000 energy efficiency retrofits by 2030. That is 50,000 homes per annum on average receiving a retrofit (to BER rating of B2 or better), which is the equivalent to all occupied homes in all of Mayo or Cork City (there are ca 221,107 occupied homes in Dublin and ca 30,700 occupied homes in Galway city). [source data: 2016 census data CSO]. The estimated cost to retrofit a home is between approximately €25K and €75K (Average cost 54K from 325 houses on SEAI pilot deep retrofit programme going from average F to A3). To put the target of 50000 homes in context, since 2013 circa 23000 homes have been retrofitted in Ireland per annum. However, in 2019 only 2600 of these were retrofitted to a B2 or higher BER rating and that was the best year on record. Thus, despite circa 23000 homes being retrofitted in Ireland per annum since 2013, only circa one in ten of these homes were retrofitted to the current requirement of a BER of B2 or better. SEAI estimated that a sum of over €35 billion will be required over 35 years to make the existing housing stock in Ireland low carbon by 2050. Thus, deep retrofitting of Ireland's building stock is viewed by many as a major economic and employment opportunity, as well as an opportunity to improve the quality of our homes.

Dr Ciara Ahern (TU Dublin): Thermal refurbishment status of the Irish residential building stock
Energy Performance Certificates (EPCs) are issued for buildings constructed, sold or leased across the EU. Using a generalizable methodology this work exploits Ireland's EPC national dwelling stock database to determine the thermal refurbishment status of Ireland's housing stock. It is estimated in 2014 that; i) 58% of walls were insulated at a mean overall heat loss coefficient or U-value of 0.66 W/m 2 K, ii) 67% of roofs were insulated at a mean U-value 0.37 W/m 2 K, iii) 97% of windows were double-glazed, and iv) 53% of floors were insulated to a mean U-value of 0.59 W/m 2 K. The (i) extent of thermal refurbishments and (ii) high degree of energy-efficiency improvements in Ireland contribute significantly to household energy usage per square metre being 9% below the EU 27 average in 2010, and the average energy efficiency of Irish housing having improved by over 34% between 1995 and 2011 (2.5% per annum). The distinction between the thermal efficiency of pre-thermal building regulation and post-thermal building regulation dwellings, whilst still valid, is lessening. A strong association between dwelling age and energy efficiency often-made is diminishing as retrofits continue to be carried out. The long-held view that the majority of Irish dwellings are thermally sub-standard is no longer valid.

SESSION 1: SYNOPSIS OF PRESENTATIONS

Dr Gianluca Grilli (ESRI): Retrofitting residential properties and fuel choice: moving to a new home

Property refurbishment often occurs when moving to a new property. This research investigated factors affecting gas switching between 2011 and 2016.

Tomás Mac Uidhir (UCC): The importance of timing: the impact of retrofit take-up rates on cumulative CO_2 emissions savings

Energy efficiency (EE) improvements to the residential building stock will contribute significantly to Ireland's GHG targets for 2030. This is reflected in the ambitious retrofit targets which are outlined in the governments Climate Action Plan (CAP) – which aims to improve the efficiency of 500,000 dwellings to a minimum BER of B2 by 2030. While point in time targets like this are useful, implementation pathways are essential. Understanding how we can reach these targets provides insight into the scale of the challenge. This work analyses the impact of different CAP retrofit implementation pathways, quantifying the additional GHG savings which are possible due to early over delayed action.

Orlaith McGinley (NUI Galway): Beyond energy efficiency - A deeper insight into the multiple benefits of retrofitting homes under the SEAI's Better Energy Communities Scheme

Retrofitting existing dwellings has multiple benefits, beyond energy efficiency, within an economic, social, and environmental context. It is crucial that these wider benefits are quantified and demonstrated to stakeholders to drive retrofit uptake, investment, and policy design. This presentation demonstrated the economic, social, and environmental benefit obtained through retrofitting, in five case study dwellings retrofitted under the SEAI's Better Energy Communities Scheme.

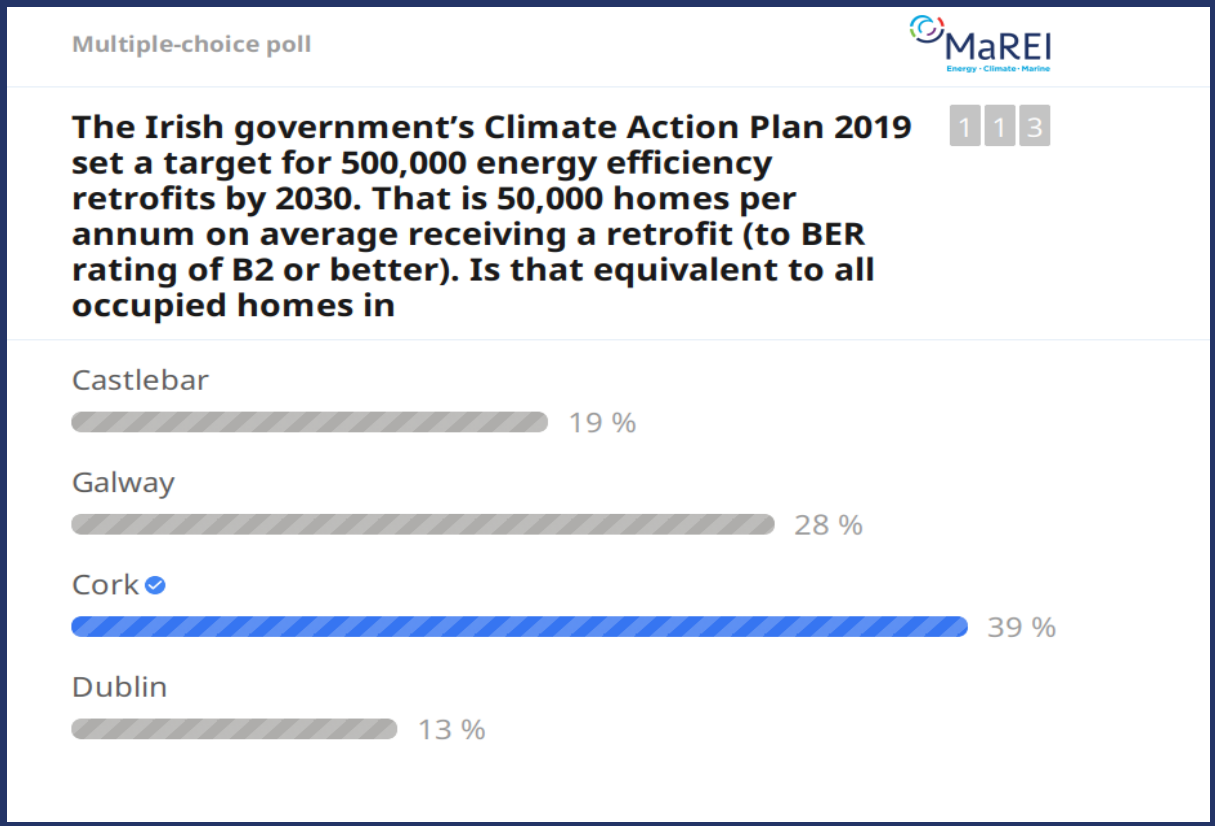
Dr Maria Lopez Zambrano (NUI Galway): Data collection and analytics drive better insights into deep retrofitting programmes: SuperHomes case study

In the information era, data analysis is a powerful ally in the transition to a future where most of our dwellings will be Near Zero Energy Buildings (NZEB). The presentation showed how this is being developed in a real case, the Superhomes deep retrofit program, in the frame of the research project SuperData to identify the most cost-effective solutions to achieve the new NZEB standards.

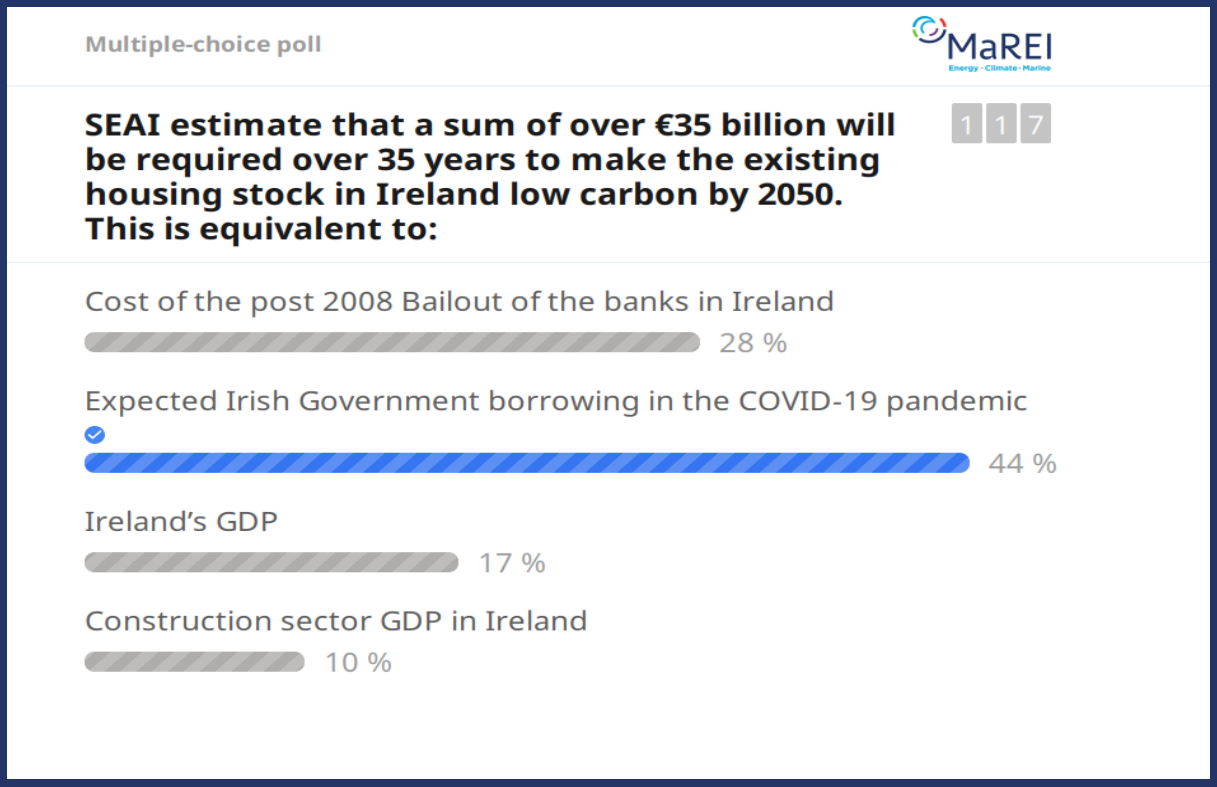
Dr Philippe Lemarchand (TU Dublin): Monitoring action plan of NZEB refurbishment in H2020 Drive-0 project

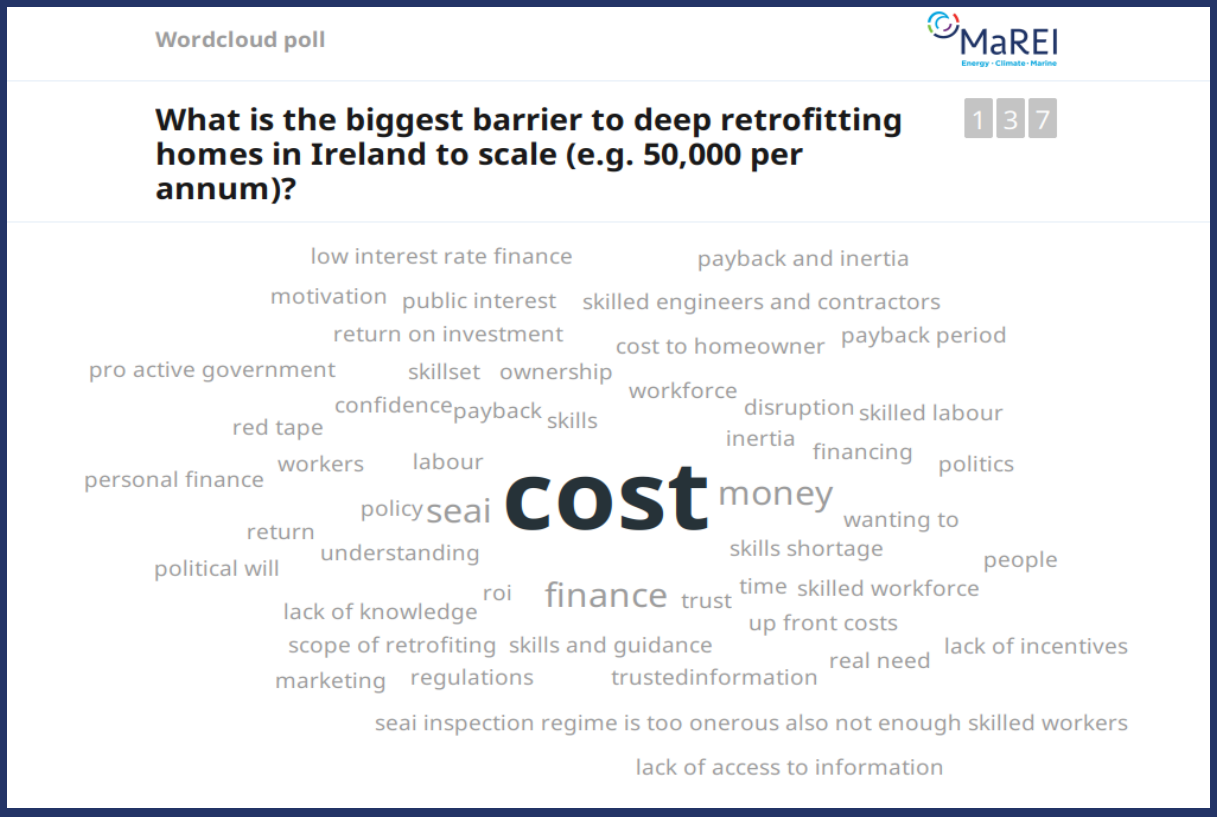
The DRIVE 0 concept is based on developing circular deep renovation solutions and supporting consumer centred business models for 7 specific study and demonstration cases as real environments. The selected cases are already in preparation and each of these cases have a specific local driver for the need of a holistic and circular deep renovation, which is translated in 'case specific challenges and tasks' and case specific key performance indicators.

RESULTS FROM POLLS



RESULTS FROM POLLS





RESULTS FROM POLLS

SESSION 1: QUESTION & ANSWERS

Asked to	Question	Answer
All	Will the event recording be shared with participants (i.e. shared by email?)	A recording of this event is now available here.
All	Will the CPD certification be dependent on accounts or the Eventbrite account when we booked?	Please email tara.reddington@ucc.ie to request CPD certificate, if required.
Dr Jamie Goggins	Paul Deane mentioned that there was some modelling work being done on the potential savings using low-carbon materials in retrofit. Can you elaborate?	New homes can have no greenhouse gas emissions associated with operating the building (e.g. if use 100% renewable energy). A bigger emphasis needs to be put on the environmental impact of materials used in building construction and renovation (e.g. embodied energy, global warming potential, eutrophication potential etc). The Irish EPD database contains Environmental Product Declarations (EPDs) for numerous construction products (see here). For some papers completed on this, see here.
Dr Ciara Ahern	How does your analysis account for the inherent bias that buildings with BERs are more likely to be better rated in the first place?	Please see full paper here. The work acknowledges that the EPC database presents a favourable characterisation of the dwelling stock because homeowners applying for grants are obliged to have an EPC. 20.3 % of dwellings contained in the EPC database examined were because of their sale, 4 % from a private letting and 75.7 % were certified for "unknown" reasons, making it impossible to separate grant aided dwellings from the data. Through analysis of grants awarded we estimated the percentage of state-granted thermally refurbished dwellings in the database was 24 %; reduced from 50 % in 2010. As dwellings get recertified and classified (grant/sale/private letting) we will be able to isolate grant aided from the data which is unfortunately not possible to do at this time and is thus acknowledged as a limitation of the work. We are currently researching how to automate the methodology used to enable quicker outputs, thus, as the data becomes more reliable so will the methodology outputs, it will also enable us to better analyse effectiveness of certain policy interventions over time.

Dr Ciara Ahern	Do your results suggest we have much less CO_2 emissions savings potential from retrofitting than previously estimated?	Yes, this is because energy modelling of the stock relies heavily on default data which does not relate to the real distribution of the thermal performance of the stock, the state of the Irish housing stock is report to Europe under TABULA using defaults. The following paper details the scale of difference from using defaults and more realistic data; Energy Performance Certification: Mis-assessment Due to Assuming Default Heat Losses. See here.
Dr Ciara Ahern	Has any effort been made to quantify unnecessary extra retrofit work arising from upgrading walls from DEFAULT R value to A rating versus ACTUAL R value?	Yes. Please see the following paper: Energy Performance Certification: Mis-assessment Due to Assuming Default Heat Losses found here.
Dr Ciara Ahern	That was great! Do you know if BER assessors are allowed to use those default values, or as I think, we are way more punitive on those figures?	Assessors use defaults more often than they should, even where it is relatively easy to establish the construction characteristics, defaults should only be used as a last resort. Overuse of default should be used as a trigger for audit as they lead to a poorer than merited energy rating for the owner. Moreover, the lead to the payback period being too short as the calculation is based on an unrealistic scale of improvement. Please see here for more detail on this.
Dr Gianluca Grilli	How does your research account for town gas systems? For example, in Dublin where heating is gas supplied by default?	Town gas system does not exist anymore. The assumption is that everybody can choose their heat supplier in a deregulated market.
Dr Gianluca Grilli	Many thanks for your presentation. Might electric heating (e.g. heat pumps) not be infrastructurally preferable? Helping to leap-frog gas heating?	I would say yes but heat pumps like any other fuel should be evaluated with respect to their cost. They are probably not equally convenient at present. Anyway, I believe that gas is one of the options, not the only option available.
Tomas Mac Uidhir	What are your assumptions on the carbon intensity of electricity and gas out of 2030?	One of the advantages of LEAP is the ability to analyse individual policy scenarios and understand their impact in isolation and in combination. A separate 70% RES-E scenario in LEAP provides insight into the carbon intensity of electricity generation in 2030 - The two scenarios presented during the webinar have an intensity of approximately 405gCO2/kWh in

		2018 but do not change significantly over the ten years. The scenarios were not combined with the 70% RES-E scenario given that it is the relative difference between the scenarios which was examined. Further improvements to the representation of electricity supply in the LEAP Ireland 2050 model are ongoing.
Tomas Mac Uidhir	The mobilisation of 20,000 deep retrofits from 1000 is not happening with the reduction in real funding in 2020. I think the analysis is not grounded in reality.	The Climate Action Plan (CAP) target of 500,000 dwelling retrofits (to B2 standard) would require 50,000 retrofits per annum between now and 2030. The analysis presented is not intended to test the feasibility of this, instead to provide insight into multiple pathways which deliver the CAP end-year-target, highlighting the difference between the pathways and clearly showing the extent of the challenge. As mentioned during the webinar, focusing on end-year-targets is useful but challenging, it is important to identify policies which can rapidly increase the retrofit up-take rates in the short term - to benefit from the energy efficiency savings over a longer time-horizon.
Tomas Mac Uidhir	To what extent are current retrofit programmes locking out B2 retrofits in the future. Will this be alleviated by building renovation passports as per EPBD?	I am uncertain to what extent the current retrofit programmes are locking out future B2 retrofits although renovation passports have a great potential to alleviate the concern in the absence of other policy measures. I do believe it is important to provide a robust retrofit framework which achieves lasting energy efficiency improvements and avoids excessive disruption to homes during renovation. I have previously quantified an additional 86% energy savings which could have been achieved through an improved retrofit choice scenario, this analysis is available freely here.
Tomas Mac Uidhir	How big of a jump is it in reality to get from where we are to the starting point of your retrofit pathways?	We cannot underestimate the scale of the challenge in delivering this step-up to 20,000 dwellings in the short term. This is highlighted in the analysis where we can see the jump in 2019 - 2020 in the early and delayed action scenarios. There is more work to be done in terms of analysing the feasibility of that target, which is why it is really important that we start the discussion and focus on pathways rather than point in time targets. We should not be overly focused on the 2030 target of 500,000 but instead explore policies which aid in delivering a sustainable increase in the number of retrofits as soon as possible.
Orlaith McGinley	Did you consider increased disposable income resulting to better occupancy satisfaction as well as health/comfort?	I did not assess this as a specific Key Performance Indicator in this study. However, this could be considered another retrofit benefit, and possibly be incorporated into the methodology and assessed in future studies.
Orlaith McGinley	What was the technology used for heating & ventilation? If no forced ventilation (DCV / MVHR) system, one	There was no forced ventilation installed in the dwellings as part of the retrofit works. Therefore, as you suggest, no major RH improvements would be expected from the works. Perhaps, the results showing the persistence of higher than recommended RH in the case studies could be used as an indication of an area for further improvement to the dwelling, given the health impacts associated with high relative humidity. This could

<table>
<tr><td></td><td>couldn’t expect relative humidity impact with natural ventilation.</td><td>also be a further justification for the need for installation of the likes of MVHR ventilation as a crucial part of retrofit works as mentioned.</td></tr>
<tr><td>Orlaith McGinley</td><td>Why did two dwellings see an increase in energy expenditure after the retrofit?</td><td>One case study (case study C) experienced an increase in energy consumption post-retrofit, due to increases in electricity, oil, wood, and turf consumption post-retrofit, despite the fact that a more efficient boiler was installed as part of the works. This case study, however, achieved comfort improvements, so perhaps, this may have contributed to the increased energy consumption post-retrofit. Another possibility, might be incorrect operation of the new heating controls installed as part of the works, resulting in higher oil consumption post-retrofit than pre-retrofit. We can't state specifically however the reason without further investigation. In the other dwelling (Case study E), the energy consumption increased post-retrofit, as a result of increased electricity consumption post-retrofit, given the change from a solid fuel to an electricity-based heating system. Considering the relative price of electricity compared to solid fuels, the householder spent more on energy post-retrofit.</td></tr>
<tr><td>Orlaith McGinley</td><td>For the payback, was this on the total cost or net of grant aid?</td><td>The pay back periods presented were based on net of the grant aid. However, the economic indicators (life cycle cost and payback period) were also assessed where grant aid was not present to determine the effect on the benefit received. If it was the case that grant aid was not present, dwellings which achieved life cycle cost (based over 30 years) savings post-retrofit (namely, case study A, B and D) with grant aid, still received post-retrofit LCC reductions if grant aid was not available. The PBPs were longer across all case study dwellings where grant aid was not present, however, those dwellings (namely case study A, B and D) which achieved PBP within 30 years with grant, still achieved payback within 30 years without grant applied.</td></tr>
<tr><td>Orlaith McGinley</td><td>Would it be possible to get more detail on the before and after fabric of the houses in each case study</td><td>Pre-retrofit building elements and heating system:
<table>
<tr><td>Case</td><td>A</td><td>B</td><td>C</td><td>D</td><td>E</td></tr>
<tr><td>Typology</td><td>Detached bungalow</td><td>Detached 2-storey house</td><td>Detached bungalow</td><td>Detached bungalow</td><td>Detached bungalow</td></tr>
<tr><td>Construction Year</td><td>1960</td><td>1920</td><td>1950</td><td>1980</td><td>1966</td></tr>
<tr><td>Floor area (m^2)</td><td>90</td><td>126</td><td>107</td><td>72</td><td>77</td></tr>
<tr><td>Walls</td><td>Solid walls with no insulation</td><td>Solid walls with no insulation and extension with partially filled cavity walls</td><td>Solid walls with no insulation and extension with partially filled cavity walls</td><td>Cavity walls with pumped polystyrene insulation</td><td>Solid walls externally insulated</td></tr>
</table></td></tr>
</table>

		Windows	Single glazed wooden windows	Double glazed uPVC windows	Double glazed uPVC windows	Double glazed uPVC windows	Double glazed uPVC windows
		Doors	Wooden door	uPVC door	uPVC door	uPVC door	Wooden Door
		Heating System	Primary: Electric storage heaters and electric immersion for DHW Secondary: Solid fuel stove	Primary: Central heating oil fired range Secondary: Solid fuel stove	Primary: Central heating oil boiler Secondary: Solid fuel stove	Primary: Central heating oil boiler Secondary: Solid fuel range and stove	Primary: Solid fuel stove

Retrofit measures

Case	A	B	C	D	E
Roof Insulation	N/A	N/A	300 mm thick earth wool insulation	N/A	N/A
Window and doors	uPVC windows and doors (1.2 W/m^2K)	N/A	N/A	N/A	N/A
Wall Insulation	100mm expanded polystyrene external insulation & acrylic render	N/A	N/A	Cavity wall insulation & wall vents	N/A
Heating System	Heat pump, radiators & heating controls	Heat pump & heating controls	Oil boiler, solid fuel stove, hot water tank, heating controls and three radiators	Oil boiler, hot water tank and heating controls	Heat pump & heating controls
Renewable Energy Technology	2kWp PV system & inverter	2kWp PV system & inverter	N/A	N/A	2kWp PV system & inverter

Orlaith McGinley	Thanks for presenting. Could you advise what technologies were used for these dwellings as part of their retrofit?	See above.
Orlaith McGinley	Under BEC schemes, a lot of the technology is paid for. Does this skew	Under the BEC schemes, the case studies in question achieved varying levels of grant aid, ranging from 35% grant aid to 90% grant aid. In terms of the economic benefit, in an attempt to account for the effect of such on the results, I assessed the indicators under both grant aid applied, and

	the customer and household feedback and perceived value / ROI?	grant aid not applied situations, as mentioned in the previous answer. As suggested in your question, it could be inferred that in terms of the householder feedback, those households who had much of the works paid for by the scheme (i.e. 90%) grant, may be less critical or view the benefit they have received in a more favourable light, given that they paid only a small amount of the overall cost. While we can't state based on our analysis conclusively that this affected results, looking at the householder feedback, the household which had only 35% grant aid, was overall more critical of various aspects of the retrofit works, process etc… as opposed to some householders who received 90% grant. Nonetheless, regardless of grant aid or not, most householders seemed to perceive the works as valuable in terms of the improvement to their quality of life within the home, comfort etc.
Orlaith McGinley	Do you have any ideas why there would be such difference in the post-retrofit emissions data between your case studies?	The case studies varied in terms of their characteristics and the retrofit measures applied to each case study. See above answers for details of these measures. In addition, the number of people living in the houses, and the amount of time they spent at home differed also.
Orlaith McGinley	Could you give some examples please of why people did not benefit from the retrofit?	In relation to cases whereby householders did not receive economic or environmental benefit, please refer to above question "Why did two dwellings see an increase in energy expenditure after the retrofit?" on reasons for increased energy consumption. In terms of some of the social indicators, one householder did not receive any comfort benefit post-retrofit, with their average household temperature actually decreasing post-retrofit. In this instance, we considered a change in occupancy post-retrofit to have played a big role in the decrease in temperature. An old member of the household was no longer living there post-retrofit resulting in different comfort needs of the remaining householder. The installation of the heating controls allowing the occupant more control over their comfort conditions may also have played a role in the decrease in temperature. In terms of the reasons as to why fuel poverty alleviations were not received in the case studies, please refer to answer to question "Why was there no ending of Fuel Poverty in your study?" below.
Orlaith McGinley	Did the occupant's behaviours around heating controls influence the payback period, particularly in those buildings that did not have payback?	Yes - It is suggested that this may have had influence in for example case study C, which did not achieve payback. In this dwelling, oil consumption increased post-retrofit, therefore it is suggested that this could have been due to incorrect use of the heating controls. Another dwelling which had heating controls installed as part of the works, stated that they were simply too difficult to use, and resulted to having her old heating controls reinstalled. There seemed to be a consistency across the case studies also that there was a lack of information given as how to operate such technologies. Further investigation into the particular occupant behaviour and use of the technologies would be needed to determine the extent of this impact, however.

Orlaith McGinley	Are the occupant's demographics and attitudes towards energy consumption a factor in the results of the study?	Both pre- and post-retrofit, face to face semi-structured surveys were conducted with an adult in each household. These surveys gathered information on the demographic profiles of all householders, their attitudes towards energy use and conservation, quality of life and the environment, which items were viewed to be necessities or luxuries in their home, their energy-related practices and their thermal satisfaction within their homes. Therefore, we do have this type of data available. For example, as highlighted in my answer to 'Could you give some examples please of why people did not benefit from the retrofit?', in terms of some of the social indicators, one householder did not receive any comfort benefit post-retrofit, with their average household temperature actually decreasing post-retrofit. In this instance, we considered a change in occupancy post-retrofit to have played a big role in the decrease in temperature. An old member of the household was no longer living there post-retrofit resulting in different comfort needs of the remaining householder. The lower temperature demand would have resulted in a lower energy demand to heat the home. However, a detailed analysis into the effect of occupants' demographics and attitudes towards energy consumption on the results was not conducted in this particular study. A larger sample size might also be necessary to determine the significance of factors. Some research work on this has been carried out on the housing units presented by Paul Moran. See here.
Orlaith McGinley	How did you determine whether energy poverty was alleviated or not?	The extent of fuel poverty, if any, suffered by the householders both pre and post-retrofit was determined using the expenditure method, whereby householders were considered to be suffering fuel poverty if their estimated annual fuel expenditure was greater than 10% of their annual income. Predictions were also determined as to whether householders would experience fuel poverty alleviations over 30 years, at the pre- and post-retrofit fuel consumption levels, taking into consideration the annual average percentage increase in fuel costs over 30 years and the annual rate of income inflation.
Orlaith McGinley	Why was there no ending of fuel poverty in your study?	Three case studies (A, B, and E) were not considered to be experiencing fuel poverty pre or post-retrofit, given that their annual fuel expenditure was less than 10% of their annual household income). Therefore, fuel poverty alleviations did not apply in these studies. Cases C and D, however, were experiencing fuel poverty pre-retrofit. However, both cases remained in fuel poverty both in the first-year post-retrofit and over the 30-year period assessed. This is largely since in both cases the post-retrofit fuel expenditure rates remained higher than 10% of their annual household income, despite the fact that Case D experienced energy consumption reductions as a result of the retrofit works.
Dr Maria Lopez Zambrano	While you give the cost per m^2 per measure, which measures in your study are the most	We are currently analysing this aspect, and we plan to have the results in detail by the end of Summer. It is hard to respond in a few words. As an example, lighting is one of the best measures because, in this study, you can save on average of 4 kWh/m^2 for each euro invested, but in these dwellings, lighting only accounts for 13% of the total consumption of the

	cost effective for delivering energy savings?	house. Other measures are very interconnected, like improving the thermal envelope and installing a heat pump. A better thermal envelope means fewer kWh consumed by the heat pump, so at this point, we are disaggregating these to know exactly the savings from each one.
Dr Maria Lopez Zambrano	Would it be very costly (approx. how much) for a household to jump from a D category to a B or A, and would that be affordable for them?	The mean original BER of the houses of SuperData was E2 and all achieve the minimum of A3. The average cost was around 53000 euros in total VAT and grants not including. Therefore, in theory, to jump from D to B or A must be cheaper because the start point is better, but each dwelling is different, and it is necessary to study the circumstances. It is not the same for a detached house compared to an apartment, for example, or if there are some limitations like protected facades, etc
All	As buildings get more efficient, and DHW becomes the biggest demand, will this harm the case for heat pumps which are inefficient at producing hot water? CoP < 2?	**Adam O'Donovan:** This is a great question and one that needs further investigation. From our analysis you can see that efficiency values for hot water are consistently lower than space heating with SPFs of 2.3 on average. In some studies, this value is lower like you mentioned. This can be as a result of the excess use of backup immersion heaters to maintain (e.g. 55°C) flow temperatures for hot water. Another cause for poor DHW efficiency is the inclusion or exclusion of the storage losses in the tank as part of the efficiency. This can lead to some situations where reported system efficiencies can be very low and below that of electric immersion heating. The correct sizing of heat pumps and the use of variable speed compressors may assist in improving COP values for DHW. That being said, more work is needed to find low GWP refrigerants that allow for sink temperatures (55-65°C) without negative effects on overall system performance. **Dr Philippe Lemarchand:** Also, refer to the answer on the question "Why are air to water heat pumps the only option for heating?". Also, manufacturers (such as Nilan) provide compact heat pump systems for ventilation and DHW. The COP for heating up the storage tank vary from 2.1 to 3.4 depending on the testing point. With a Heat Recovery of 77%, electric efficiency of 0.43Wh/m^3 and a total primary energy demand <55kWh/m^2.annum such system is a Passive House Suitable Component.
All	What do you think the impact of the use of natural / biobased materials is on the circular economy of energy retrofitting traditional homes?	**Dr Philippe Lemarchand:** We have experienced glass wool versus cellulose, and the comfort of the air quality in the space is noticeably different. That in addition to the discomfort installing some glass wool would certainly be an argument. There is yet to be a long enough study to complete the argument for longevity in reality versus theory. The reality of the benefits are that the product would be something natural, giving us comfort that the air quality is not detrimental to our health. There have been studies carried out to highlight the obnoxious and health damaging V02 and formaldehyde which is exhausted from new materials including furniture. This may be a consideration for us when considering wood-based insulations / finishes. Wood is known to contain and emit volatile organic compounds including formaldehyde; however, the emission levels

		of formaldehyde depend on factors such as wood species, moisture content, outside temperature, and time of storage.
All	Is using a thermal energy storage system using phase change material in building walls/roofs a feasible option for Irish buildings for heating purposes	**Dr Paul Moran:** The use of PCM in the building fabric is still only at an early stage and needs further research and product development before it can be known for sure, however, the use of fabric PCM's will unlikely remove a need for heating of buildings, but be used as a potential to supplement it.
All	Listening to the results of this research, it seems that we need to be putting solar on every roof.	**Dr Maria Lopez Zambrano**: In the case of the SuperData, this was true because of two principal reasons: to achieve an NZEB Standard as required by Part L, a renewable source is mandatory to comply with Renewable Energy Ratio (RER) of 0.20, and improving the envelope and installing a Heat Pump is not enough in most cases to achieve the energy demand required in an NZEB. Consequently, the PV panels help to achieve the standard with the kWh produced.
All	Why isn't sheep's wool, which is an environmentally sustainable solution to insulation utilised more across the Irish construction sector?	**Dr Phillipe Lemarchand**: Ireland currently does not have a manufacturer to develop home grown sheep wool insulation. It is presently exported and manufactured in the UK, then shipped back to Ireland and sold. To make it more sustainable, would require a local manufacturer – similar to the more mainstream suppliers. Compared to mineral wool insulants, sheep wool appears to have a good capacity to deal with moisture without collapse and is found to be more pleasant in terms of Indoor Air Quality in attics. Issues to the use of sheep wool may include cost and cases of moth infestation. **Dr Jamie Goggins:** Even though you need more per mm of sheep wool compared to other insulation products on the market (as it does not have as high of an insulating value as beads, hd foam etc), with an estimated net cost of €2.40-€2.55/sheep to shear wool (based on cost per sheep to shear of €3 and €0.45-€0.60 per sheep for fleece when market opens), then using sheep wool as an insulating material should be strongly considered. New homes can have no greenhouse gas emissions associated with operating the building (e.g. if using 100% renewable energy). A bigger emphasis needs to be put on the environmental impact of materials used in building construction and renovation (e.g. embodied energy, global warming potential, eutrophication potential etc.). The Irish EPD database contains Environmental Product Declarations (EPDs) for numerous construction products (see here). Sheep's wool, if used as an insulation material in homes, should meet European standards, National Standards, European Technical Assessments and Agrément Certificate, as required by the Building Regulations.
All	Is hemp not potentially a better option than sheep's wool?	**Dr Philippe Lemarchand**: Hemp is an option and is sold here, but it is not manufactured in Ireland. This is in Drive0 materials inventory, but to make something take off, the market demand must be there. Many construction sectors proceed how they know. So, companies like Knauf,

		Isover and Rockwool continue to have a strong market hold. Our aim here is to change the standard and make an informed decision.
All	No BCAR certification for sheep wool installation into buildings!	**Dr Philippe Lemarchand:** Thermafleece is BBA certified.
Dr Gianluca Grilli	Surely gas consideration is a long way from NZEB?	Gas is not NZEB but less polluting than oil, peat, and coal, and equally cheap. It should be considered as an intermediate solution to mitigate emissions.
Dr Gianluca Grilli	We should not be retrofitting houses with gas, this is another fossil fuel and will need to be retrofitted again to meet the 2030/50 targets, unless it is biogas.	Gas is a low-cost option for emission reduction, many other systems are more expensive. In the medium-long run gas can be replaced by biogas using the same pipelines, what is important is having the infrastructure installed.
All	What is the current number of construction workers in Ireland and what should be the proposed number of workers to achieve a target of 500K retrofitting by 2030?	**Dr Jamie Goggins:** The number of persons engaged in construction enterprises in Ireland in 2016 was 120,341[1]. Employment in the construction sector represents 6.4 percent of total employment in the Irish economy[2]. Approximately 50000 SMEs employ over 90% if people in the construction sector in Ireland and are responsible for over 90% of Gross Value Added[3]. Depending on the scale and complexity of the retrofit project, there could be over 20 people involved in the retrofitting of a home. In the UK, it was estimated that in 2015 there were 0.98 million people working in the UK's house building trades and professions involved in the likely completion of 148,000 new homes – that is 6.61 workers per completed home[4]. Using that number as a ballpark (could be conservative as retrofitting could be more labour intensive), then to complete a deep retrofit of 50,000 homes per year would require over 330,000 people involved in the completion of these retrofits.
All	What are the current technologies for retrofitting used currently in Ireland?	**Dr Paul Moran:** NSAI has a code of practice for retrofitting dwellings in Ireland, which discusses the range of measures and appropriate instances of when to install the retrofit measures. See here.
All	Were there any pre and post-	**Dr Ciara Ahern:** No, large scale measurement of actual U-values would be welcome, in the absence of measurement we established vernacular

[1] https://www.cso.ie/en/releasesandpublications/er/sbs/structuralbusinessstatistics2016/
[2] https://assets.gov.ie/6659/3312cd28edf04f4c83666ac76b534c45.pdf
[3] https://www.cso.ie/en/statistics/construction/
[4] **https://www.randstad.co.uk/s3fs-media/uk/public/2019-10/age-of-house-building-report.pdf**

	refurbishment U-values (e.g. for walls) actually measured?	construction characteristics and likely calculated U-value associated - this was used to confirm structural error of defaults. Non-default data is calculated and assumed accurate, please see here for more detail. **Dr Philippe Lemarchand:** Within our case study in Drive0, U-value pre-retrofit u-value will be calculated further to inspections and measured with instruments with some degrees of uncertainty. Prior to retrofitting, the U-values of modules will be calculated, and small sample can potentially be tested in TU Dublin laboratory using a calibrated hot-box. Papers from Cormac Flood addressed the discrepancy between calculated vs in-situ U-values. While the U-value is a common figure which can provide a gauge between the construction stock, it can be very inaccurate, not just between dwellings, but applied to each orientation on a dwelling.
All	Why are air to water heat pumps the only option for heating? They are expensive to maintain and install. There are other solutions such as IR Panels.	**Dr Philippe Lemarchand:** They are not the only option. They are the most cost-efficient option. Ground source has been confirmed as more expensive, and air to air requires huge units to recycle enough air to heat the dwelling. What is usually cheaper is air to water supplemented by recycled air an MVHR system. This prevents huge temperature swings in the air and keeps the air to water running at a lower temperature and capacity meaning less energy required. Infrared panels cannot be considered as a renewable heating source. They are electrically powered, and the renewable aspects only come from the type of electricity supplied to panels. Air-to-air heat pumps are renewable sources, extracting ambient heat to the building, thereby operating at a much lower running cost, and reducing carbon emission. However, installing such system in existing buildings require extensive, costly, and disturbing work to the owners and occupant. Infrared panels have the advantage to only require an electrical connection; panels can be easily installed on walls or on ceilings. Similar to solar radiation, infrared radiations emitted by panels are directive and can be felt instantaneously by occupants. They enable to free space and provide further access. Dust difficultly accumulate on such panels (particularly when installed on ceilings) and therefore no smell of burnt durst emanate from such system. Since they are no moving part, they generate no noise and require minimum maintenance. Although they are said to covert power to heat more efficiently than typical convective radiators, further studies are required. Infrared panels are typically provided with a smart/programmable controller that monitor the room temperature and enable to lower running costs. **Adam O'Donovan:** I would agree to some extent, there is a view that heat pumps are only solution which is not true. The push for heat pump technologies is largely driven by efficiencies reported by manufacturers, the industry support, the financial and policy incentives and the expectation that our national grids primary energy factor will be reducing over time and becoming more renewable. That being said, in my view all sustainable alternatives need to be considered as well as methods to

		extend the lifecycle or all sustainable energy systems, as the upfront costs (environmentally and economically) are significant for these systems.
All	Is there a study which shows the difference between BER model heat consumption and as-built heat consumption? Actual consumption is generally high in new buildings.	**Dr Paul Moran:** Studies have examined the difference between BER model heat consumption and as-built heat consumption (e.g. here and here). However, none have examined the accuracy depending on the theoretical energy performance level of the home potentially due to the sample sizes of the studies. A study with one of the largest sample sizes I have come across is based on buildings in the Netherlands. The study compared the theoretical and actual energy consumption of dwellings in the Netherlands. The study had a sample size of 193,856 housing units and examined the accuracy of the energy rating (A-G) in estimating the energy consumption of buildings with gas and electricity-based heating systems. For buildings with gas-based heating systems, buildings with a theoretical energy performance level of A or B used more energy than expected. For buildings with gas-based heating systems, buildings with a theoretical energy performance level of C to G used less energy than expected with the gap between theoretical and actual energy demand increasing as the building energy label worsened. See here.

SESSION 2: SYNOPSIS OF PRESENTATIONS

Dr Gary Goggins (NUI Galway): The potential of retrofitting programmes to initiate socio-technical change toward sustainable lifestyles
This presentation puts forward an argument for greater attention to the social dimension of energy use. It demonstrates how retrofitting schemes might take advantage of ruptures in household routines as an opportunity to introduce more sustainable practices.

Dr Paul Moran (NUI Galway): Can DEAP help us to predict the energy demand and indoor temperature of homes before and after renovation? A case study from Dublin
Does DEAP give an accurate representation of the energy demand and indoor temperature of homes in Ireland? Paul Moran presented the theoretical and actual gas demand and indoor temperature levels for a group of retrofitted social housing units in Ireland. The results highlight the need for the data that we input into these formulae/models (e.g. default U-values for building elements, heating duration) need to be assessed as to whether they are an accurate representation of housing units in Ireland.

Dr Marta Fuente Lastra (NUI Galway): The impact of retrofitting on indoor radon levels
Energy retrofitting interventions in buildings have an impact on indoor radon concentration. The alteration of the building envelope and the controlled ventilation systems affect radon entry and the evacuation of pollutants. Radon needs to be assessed when planning energy retrofit in housing because retrofitting measures do not guarantee low indoor radon levels.

Noel O'Neill (TU Dublin): Adaptive facade operation of a Solar Test Cell, testing methodology used for thermal efficiency and storage potential
The project involves the research in the potential use of a multi-functional façade for the collection and storage of solar thermal energy for use in net zero energy buildings.

Adam O'Donovan (CIT): Domestic Air Source Heat Pumps: theoretical and in-use performance
There is an expectation that 600,000 heat pumps will be installed in Irish dwellings by 2030. Given scale of the installation ambitions and the investment in heat pumps it is critical that we understand how these systems perform and if they perform to expectations. This presentation compares the in-use performance of air source heat pumps systems from field studies to values reported in the National BER database and those reported by manufacturers. Causes for differences between these sources are also considered.

Dr Johanna Varghese (IGBC): Developing a one-stop shop for deep retrofit of homes in Ireland
The TURNKEY RETROFIT project is developing one-stop shops for France, Ireland and Spain. The Turnkey Retrofit service is being developed as a homeowner-centric renovation journey, transforming the complex and fragmented renovation process into a simple, straightforward and attractive process: all providers on one platform – Solutions4Renovation, where trust is key.

SESSION 1: QUESTION & ANSWERS

Asked to	Question	Answer
Dr Gary Goggins	To get a systemic change means changing perception of the ownership of energy from buying it to selling it (REFIT!)	It involves restructuring our entire systems of production and consumption, addressing the structural causes of unsustainable energy use, and developing new forms of governance that include diverse actors, including prosumership for example.
Dr Gary Goggins	Excellent presentation Gary. So, my mother was right? "Put on another jumper if you are cold".	Yes, put on a jumper if cold was a 'normal' response for your mother, but we increasingly see standardisation of temperatures across time (winter/summer, etc.) and space (heating entire homes rather than separate spaces; heating cars/homes/offices/shops, etc. to standardized temps...) so now it is considered 'normal' to wear a t-shirt/shirt in your home or office in winter regardless of outdoor temperature. So, in short, we are not trying to change individual behaviour, but challenge social and cultural norms around comfort.
Dr Gary Goggins	Very interesting work. Socio-cultural factors very important. Soft barriers are the ones to crack in retrofit – can we do this in Ireland?	Yes. But this requires integrated approaches that are culturally sensitive and which target changes in the physical environment but also take seriously the social context. We need to include civil society in decision-making at all stages. Ireland has a strong culture of community and we could capitalise on this to promote sustainable transformation and diffusion of good practice.
Dr Gary Goggins	How would your approach be scaled up?	We have produced a (user-friendly!) project summary handbook with some recommendations for up-scaling. See ENERGISE project summary handbook.
Dr Gary Goggins	Great presentation, thanks. Was there any assessment 'energy literacy' through the living lab approach?	Yes, in a practice-based approach we considered energy literacy under 'skills and competencies'. One key finding was that many people did not know how their home energy system worked. 'Smart' systems often try to edit out or side-line people rather than place them at the centre of smart technologies. Through our study people started to try to discover how their energy system worked but many people were frustrated by automated systems over which they had little control or understanding.
Dr Gary Goggins	Gary, you raise a good question that I'd like your thought on – who should introduce these new societal and behavioural elements into retrofit programmes?	We try to initiate change at the societal level, so it is not about just changing the behaviour of people who undertake retrofits, but instead challenging social norms around unsustainable practices. My point is that the govt. plan to retrofit 500,000 homes provides an opportunity to reach a large cohort of the population. We found that when you provide people with new ideas and challenge them to question their ways of living, they tend to share and discuss their experiences with others. So, people then influence their friends, families, communities, etc. and we start to change our collective consciousness. Who exactly should be involved and in what capacity is open, but a multi-actor approach is preferable involving different government departments,

		households, community groups, NGOs, academics, policymakers, building professionals, media, etc. As a starting point we need to take the social dimension of energy seriously and try to better understand how and why people perform certain practices.
Dr Gary Goggins	Gary – great…people can change behaviour. Corona lockdown offers great opportunity encourage a behavioural change…and a chance to kick start the economy.	Agree. Another lesson from the Covid-19 crisis is that we can effectively shut down or stall our systems of production overnight if required. There has long been an argument that this was not possible in a capitalist system, but this has been proven false. If we can do this to address Covid-19 (and do it with strong public support) we can also do something on this scale to address climate change. The problem is lack of political will and unequal distribution of power so that vested interests continue to prioritise their own agenda and people are left with confusing or conflicting information.
Dr Gary Goggins	Do you think that enough focus is put on the persons behaviour? Similar to Orlaith's findings, end users are not able to use the technology retrofitted.	Yes, there is not enough focus on people, but not just their behaviour, which is difficult to predict and difficult to change, but also their needs, wants, desires, etc. We need to give people the skills and access to materials needed to live sustainable lifestyles but also address the meanings associated with different ways of living. Technology should respond to people's needs, rather than the other way around. We need to design technological systems with people at the centre, not design a system and then wonder how we can get social acceptance or uptake.
Dr Gary Goggins	The graphs are not clearly understandable to the layman.	Practice approaches are complicated, but more simplistic approaches such as the information-deficit models have not delivered the reductions in emissions and material use required to ensure a sustainable future. Complex problems require complex solutions, and human behaviour is extremely complicated. But if we leave people out of the question, we will never achieve our climate targets.
Dr Gary Goggins	Although people could get used to 18 degree indoors, what are the regulatory implications? NZEB retrofit but use less electricity by keeping thermostat low?	We still need all the help from technology we can get. But as well as decarbonisation, we should also be thinking about dematerialisation as current use of material resources is completely unsustainable. Collectively, we have to be smart about how we use our limited resources.
Dr Gary Goggins	Should access to grants incorporate mandatory ex-ante and ex-poste perception surveys to help measure behavioural data?	It might be an idea to tie in education and awareness as well as capacity building into the grant process so that people understand the urgency in addressing climate change and are equipped with the skills necessary to take action.
Dr Paul Moran	How well does DEAP compare to equivalent tools for EPCs in other European Member	I have not examined the formulae/data used by each country for producing their EPC but yes, they are all meant to follow the same directive and standards. I would be particularly interested in default values used by each country as going by one the diagrams shown in

	States? All are meant to comply with the same directive and standards.	Ciara's presentation, the default U-values countries use for external walls can vary significantly.
Dr Paul Moran & Dr Ciara Ahern	Both Ciara and Paul's presentations suggest that the baseline assumptions for building energy performance are significantly inaccurate. How do we address this?	**Dr Ciara Ahern:** We need to update defaults so that they are statistically representative and only use where absolutely necessary. Please see the following references for more detail see here and here. **Dr Paul Moran:** The formulae used to estimate the energy demand of homes that is used in DEAP has been found to accurately predict the energy demand of homes in studies I have examined. However, other studies have also found the estimates of energy demand to inaccurate. The data that we input into these formulae/models (e.g. default U-values for building elements, heating duration) need to be assessed as to whether they are an accurate representation of housing units in Ireland. My study only contained 16 households. Larger study on what assumptions in DEAP are driving the difference between theoretical and actual energy demand of homes is needed to assess if there is or the size of the difference between baseline estimates.
Dr Paul Moran	Paul, did you discover any unforeseen circumstances upon building fabric of the retrofits such as enhanced cold bridging / condensation points?	Homes reported draft/mould/damp/condensation problems before the retrofit. Many seen improvements with these problems following the retrofit, particularly with mould/dampness problems around the windows. However, a few householders still reported some issues but not as severe as before the retrofit. For one house in particular, the presence of mould is believed to have been caused by the way the attic insulation was installed.
Dr Paul Moran	What is the scope for using Phase Change Material for building heating?	We are currently examining the use of phase change material as part of a trombe wall in residential buildings in Ireland. Our analysis is examining the impact of phase change material on the energy demand, indoor temperature profile and life cycle cost of the building. The results of our study will be available towards the end of 2020.
Dr Paul Moran	Have you looked at any ways of adjusting the values from DEAP / BER so that they better reflect the actual energy demand?	I adjusted the standardised external temperature and solar radiation values assumed by DEAP to be more representative of the weather conditions during the data collection periods. The external weather conditions were based on data collected at Dublin Airport.
Dr Paul Moran	The temperatures post- retrofit were higher than pre-retrofit. What effect would this have on actual versus theoretical energy savings?	Yes, the average temperature of the homes increased by 0.9 °C on average during the three months post-retrofit. This temperature take back impacted the energy savings achieved. However, without verified information on the factors contributing to the heating demand (e.g. performance of the building fabric), it was not possible to assess how much of the unachieved energy savings was related to this temperature take back.

Dr Paul Moran	Could you see a post-occupancy monitored BER being introduced in the future to validate the preliminary BER as a measure to address gaps?	It is a possibility. Sweden collects monitored energy consumption as part of their EPC (see here). However, collecting monitored energy consumption may be part of the reason why the cost for an EPC in Sweden is amongst the highest in Europe (see here). Collecting monitored energy consumption may potentially increase the price of getting an EPC in Ireland if introduced.
Dr Paul Moran	Does the study have a breakdown between electricity, DHW and space heating? Are there plans to do this for different residential building types (flats, etc)	For the houses monitored, the primary space and water heating energy requirements were provided through gas. Gas consumption was monitored but it was unable to be disaggregated into space and water heating demand. This was accounted for in my analysis by including theoretical estimates for the DHW needs. Electricity consumption was also monitored but was not able to be disaggregated into its end use. At this moment in time, our equipment is not installed in any homes, but we are open to collaborating with people to monitor more residential buildings.
Dr Paul Moran	DEAP overestimates pre-retrofit energy use. Might people actually be experts in using their existing (inefficient) heating system efficiently?	Yes, many householders in the houses that were monitored reported that they manually switched on/off the space heating system depending on their own personal needs. These householders are not expected to have followed the heating hours schedule assumed in DEAP which is from 7am-9am and 5pm-11pm (8 hrs in total).
Dr Paul Moran	If DEAP overestimates demand, and many houses have better insulation than reported in the BER database, and rebound is large, is retrofitting the best way to reduce emissions?	**Tomas Mac Uidhir:** Energy system models are crucial to understanding energy service demands and quantifying the impact of policy measures. They provide a replicable framework which is transparent and can improve the evidence base which support policy measures - "All models are wrong, but some are useful.". While many models focus on the technical energy/ emissions reductions which are possible (due to retrofitting in this case), it is important to note that many of the co-benefits of retrofitting are not captured e.g. more comfortable warmer homes, better air quality, health benefits etc., these factors should be given due consideration and encouraged. Large scale deep retrofitting can contribute significantly to emissions reductions but like most sectors it is only one piece of the larger puzzle. **Dr Paul Moran:** The formulae used to estimate the energy demand of homes that is used in DEAP has been found to accurately predict the energy demand of homes in studies I have examined. However, other studies have also found the estimates of energy demand to inaccurate. The data that we input into these formulae/models (e.g. default U-values for building elements, heating duration) need to be assessed as to whether they are an accurate representation of housing units in Ireland. As shown in presentations during the event, there are other benefits to retrofitting other that emission savings alone. The households in Paul Moran's study seen an average temperature

		increase of 0.9°C which would account for a certain proportion of the energy savings which were not experienced. However, how much the temperature take back accounted for unachieved energy savings is unknown.
Dr Marta Fuente Lastra	Use of radon barriers can increase hygrothermal stress on historic solid walls when IWI retrofitted. Do you agree where Bq/m^3 is very low, that a sump is not enough?	A sump alone is not enough if there is not a mechanism for extraction, that can be active, e.g. a mechanical fan, or passive, e.g. a chimney cowl.
Dr Marta Fuente Lastra	Can positive pressure ventilation reduce radon concentration? E.g. solar air system	There is a radon mitigation technique which is pressurisation, that consist in using the parts of an active soil depressurisation system, i.e. suction point, pipe, mechanical ventilation, to create positive pressure instead of depressurisation. By creating an indoor overpressure compared to that in the soil beneath the building by means of a mechanical fan, the normal airflow from soil gas into the building is reversed and radon is forced to reach the surface through other routes far from the building.
Dr Marta Fuente Lastra	Did any of the research that you reported consider the type of ground floor construction of the dwellings, i.e. solid concrete, or suspended timber?	Some of the studies I reported, from the review of recent journal publications, did consider the type of construction, including materials, type of foundation, etc. You can find more information checking the references on the summary table I presented.
Dr Marta Fuente Lastra	Radon needs to be part of factors assessed prior to planning energy retrofit in housing given the evidence in Marta's presentation.	Totally agree. It is very important to consider radon when retrofitting, otherwise, it could result in the increase of indoor radon levels.
Dr Marta Fuente Lastra	Yes, to mechanical ventilation, but implications in terms of radon penetration into dwellings need to be better understood.	Agree, radon and other pollutants should be considered when retrofitting both using mechanical ventilation and other measures.
Dr Marta Fuente Lastra	Radon barriers can increase hygrothermal stress on historic solid walls when IWI retrofitted. Comment on positive pressure	To obtain low radon levels after remediation, the building characteristics are key when designing what mitigation technique to be used. A radon barrier can be enough - if well installed- in some cases, or a combination of mechanical ventilation and a barrier. Overall, active soil depressurisation systems are the most effective technique,

	MVHR & sump without barrier where (Bq/m3) is very low.	and based on literature, combination of radon mitigation techniques is the best to reduce indoor radon levels.
Noel O'Neill	Are the modes automated? How challenging will it be for the people to operate this technology?	Yes, the modes are automated, they mainly controlled on a combination of internal, external and façade air gap temperatures, it can also be controlled on light / daylighting levels also. The control can be set up using a user interface.
Noel O'Neill	Could you give an approximate estimate of the payback time if a homeowner was to invest in STTC-MFF?	This study initially is not looking at costs or payback. The study is just focused if it is possible and if there is a potential for the use of a MFF for the collection and storage of solar thermal energy. As the materials used are at a very early development stage for use in buildings the materials are currently expensive in particular for items such as the switchable glazing and PCM. The cost will ultimately be compared to the future cost of fossil fuel alternatives and carbon taxes.
Noel O'Neill	Is this similar to what we did in Elm Park offices?	Elm Park uses a double skin ventilated façade. This project looks at using new materials in a novel way to develop the MFF for the collection and storage of solar thermal energy.
Adam O'Donovan	Are there any studies that show how solar thermal and PV can enhance the performance of heat pumps especially for hot water provision in summer?	This is an interesting question. I am not aware of any studies specifically on this matter. However, it is a question which would require investigation. In Ireland, we might expect more homes that have these combinations of systems (Solar PV, thermal, heat pumps) in the future to achieve A-rated status. From our existing case studies in DesignforIU it is not clear to which extend other systems (like the solar thermal and PV systems) are contributing to enhancing the performance of heat pumps. As air source heat pumps can be more efficient at higher external temperatures the expectation is that performance would be improved in the summer. Our monitoring may reveal if this is the case.
Adam O'Donovan	Did you notice any widening or shortening between the actual and rated performance gap during the shoulder seasons?	Interesting question. As we have been monitoring for the winter period, and now into the shoulder seasons this would be an area of interest. As our analysis is not complete, I cannot say whether this is the case or not. The results of the DesignforIU project may provide some insight into this.
Adam O'Donovan	Bear in mind that BER HP efficiency relies on the dwelling load and heat distribution not reflected in the SCOP. EN 15316 analysis is used in DEAP.	It is true that DEAP uses an alternative method to determine the heating and hot water system efficiencies. The results presented are illustrative of the differences between methods. SCOP is best compared with a system boundary of H3, however, there is no easy direct comparison between values reported by manufacturers, values entered into DEAP and those that are recorded in reality. However, there is still a clear disparity between actual and predicted or expected performance of these systems. The spread of reported values in the BER database for different heat pumps shows a lot more variance than other technologies, which can indicate a level of uncertainty that requires further investigation.

Adam O'Donovan	I believe that HPs operate more efficiently at a lower heating flow and return deltaT of 7 degrees. Does your study look at the COP difference system F and R temps?	Thank you for this question. Yes, we are looking at extracting as much system level information as is feasible. Generally speaking, yes, lower temperature heating systems have better efficiencies as the lift temperature required to achieve flow set-points is lower. We are looking also illustrating the differences between different system configurations with different sink temperatures (low and high temperatures) radiators or underfloor.
Adam O'Donovan	Will heat pumps have a higher efficiency due to higher humidity in Ireland?	Interesting question. based on our current review it would appear that higher humidity levels lead to lower efficiencies. In the Irish context where there are high levels of relative humidity (i.e. >70%) for large portions of the year this may lead to lower efficiencies than those reported by manufacturers
Adam O'Donovan	Has the end user's behaviour been considered in your study? From design conditions to on-site performance heating is easier to change	Interesting question. As part of our study we are calibrating a whole building energy model for a few case studies. In these case studies we are documenting the interaction of occupants with energy systems. At this point in time it is too early to say exactly what effect the end-users are having on the overall efficiency of the system, but early indications would suggest that there is minimal interaction with energy systems due to lack of knowledge.
Adam O'Donovan	Why isn't the fabric performance of the dwelling highlighted as a contributor to ASHP performance gaps? The UK has issues that are not relevant to Ireland.	It is true that the fabric performance of a building will significantly affect the heat demand and therefore the energy consumption of a building. One issue related to this is heat pump sizing and emitter sizing. Sizing of heat pumps (over and under sizing specifically) has been identified by many studies as influencing factor in the performance of heat pump systems. The performance gap we refer to is the in-use efficiency of the heating system. While this is not wholly independent of the building in theory the heating system will deliver heat a certain efficiency. The fabric performance of the building that is being studied will influence the in-use energy consumption but may not directly influence the efficiency. There are also many relevant issues between the UK and Ireland. The results presented illustrate the gap that may exist, there may also be issues in Ireland that are not relevant to the UK. If you are an industry professional in the air source heat pump area, we would be delighted to gather your experience of heat pumps with our ASHP heat pump survey (see here).
Adam O'Donovan	Are you aware of any effort from ASHP manufacturers to develop user training but more than a user manual?	This is a very interesting and important question, one that our work hopes to shed some light on but may also be a question for manufacturers. From the case studies that we have been investigating it would seem that occupants are often uneducated as to the operation of energy systems and remain reluctant to interact with them. More user training is required during the handover of technologies like heat pumps. If you are an industry professional in the air source heat pump area, we would be delighted to gather your experience of heat pumps with our ASHP heat pump survey (see here).

Adam O'Donovan	Superhomes 2.0 study completed by LIT gave SPF of 3.1 average, with 3.4-3.8 for space heating and 2.4-2.6 for DHW.	Thank you for this information we will be sure to include in our ongoing literature review. We would be delighted to gather your experience of heat pumps with our ASHP heat pump survey (see here).
Jamie Goggins	Given the small size of the Irish market, is there any benefit in having a market (versus a state monopoly) of one stop shops?	There are approximately 2 million homes in Ireland, of which 1.7 million are occupied. The Building Energy Ratings (BERs) of homes are registered on the SEAI national BER database with over 900,000 entries to date. The average BER is a D1, which has a primary energy consumption according to the dwelling energy assessment procedure (DEAP) of about 5 times that of a new building built today to the current building regulations. The Irish government's Climate Action Plan 2019 set a target for completing 500,000 energy efficiency retrofits by 2030. That is 50,000 homes per annum on average receiving a retrofit (to BER rating of B2 or better), which is the equivalent to all occupied homes in all of Mayo or Cork City (there are ca 221,107 occupied homes in Dublin and ca 30,700 occupied homes in Galway city). [source data: 2016 census data CSO]. The estimated cost to retrofit a home is between approximately €25K and €75K (Average cost 54K from 325 houses on SEAI pilot deep retrofit programme going from average F to A3). To put the target of 50000 homes in context, since 2013 circa 23000 homes have been retrofitted in Ireland per annum. However, in 2019 only 2600 of these were retrofitted to a B2 or higher BER rating and that was the best year on record. SEAI estimated that a sum of over €35 billion will be required over 35 years to make the existing housing stock in Ireland low carbon by 2050. Thus, with the substantial increase in the number of and complexity of retrofit projects, it is felt that a first level advice to households should be centralised in one location to minimise costs and the centralised platform should direct customers to local one stop shops. So, effectively having a one-stop-shop for one-stop-shops!
Johanna Varghese	The DCCAE have a Retrofit Task Force to develop a new model to support the building retrofit ambition. Is the IGBC proposal feeding into this process?	The TURNKEY RETROFIT project team in Ireland (IGBC and NUI Galway) are engaged with the Department of Communications, Climate Action and Environment (DCCAE) and the Climate Change Unit at the Department of Public Expenditure and Reform (DPER).
Johanna Varghese	Your tool is a vital piece of retrofit infrastructure in Ireland. Who will host this long term?	This is yet to be decided.
All	Those that can afford it with the support of	**Dr Jamie Goggins:** There are many different models out there. For example, the Better Energy Communities (BEC) programme run by the

	grant aid are probably better than the majority. How can retrofitting be supported in lower income households?	SEAI provides different levels of grant aid to different households (e.g. lower income households have received grants covering 90% of the cost of retrofitting).
All	Can you tell me do you feel that there will be employment prospects going forward for BER assessors with all that needs to be done to achieve annual targets?	**Dr Jamie Goggins:** With the Irish government's Climate Action Plan 2019 set target for completing 500,000 energy efficiency retrofits by 2030, there should be a lot of work across the country in retrofitting. Wouldn't it be fantastic if construction workers could find sustainable work in their local communities rather than many of them having to commute to (or relocate to) Dublin to work on large office block construction projects?
All	When talking about monitoring post-works: that validates post-works performance but does little to validate savings. Pre-works monitoring would be needed also.	**Dr Paul Moran:** Pre-works monitoring is very useful to better understand the performance of a building and how the occupants use a building. Not only does it validate the savings from retrofitting, but helps inform the most appropriate retrofit interventions.
All	Can we develop a national repository for all energy monitoring studies? There is a real gap in information nationally, and we need to collate all studies.	**Adam O'Donovan:** I would agree, there is a need for a more centralised approach, especially as studies are at a point in time, data sharing may be an issue and will in most cases require informed consent from various parties. This database would be large and hard to maintain without the correct level of funding. However, there needs to be more connected thinking on this matter.
All	Mechanical ventilation systems (DCV, PIV, MVHR) should be mandatory for all retrofits from a health point of view. RH, Radon, and other pollutants. COVID impact.	**Dr Paul Moran:** I agree that mechanical ventilation systems are very important for buildings where high air tightness is achieved.
All	Heat pump (grants) require specific certified performance. Many exist. Homes can't certify DEAP telling lots of people	**Adam O'Donovan:** This is true, there are some requirements such as a minimum heat loss indicator requirement to avail of heat pump grants. To a large extent, it is reasonable to set this requirement as the reduction in heat demand will lead to a reduction (in most cases) in energy consumption. Heat pump systems are currently best suited to low temperature heating (where they are more efficient). This type of heating may not be sufficient in poorly insulated buildings. If you are

	their home is unsuitable when it is.	an industry professional in this area we would be delighted to gather your experience of heat pumps with our ASHP heat pump survey (see here).
All	Research on the difference between BER calculations and actual energy use is well established: why are resulting weightings not promoted by the SEAI in presenting the value of energy efficiency upgrades?	**Dr Paul Moran:** I agree, weightings could be applied to results when presenting values of EE upgrades. These weightings would of course need to be based on robust data collected from a significant sample size. I am unaware if such a database exists with theoretical and corresponding actual energy demand of buildings
All	We're consumers who have recently purchased an F rated 60s build in Dublin – what advice can the panel give for our renovation and retrofit?	**Dr Jamie Goggins:** Employ a properly qualified and experienced architect or engineer to assist you with the project.

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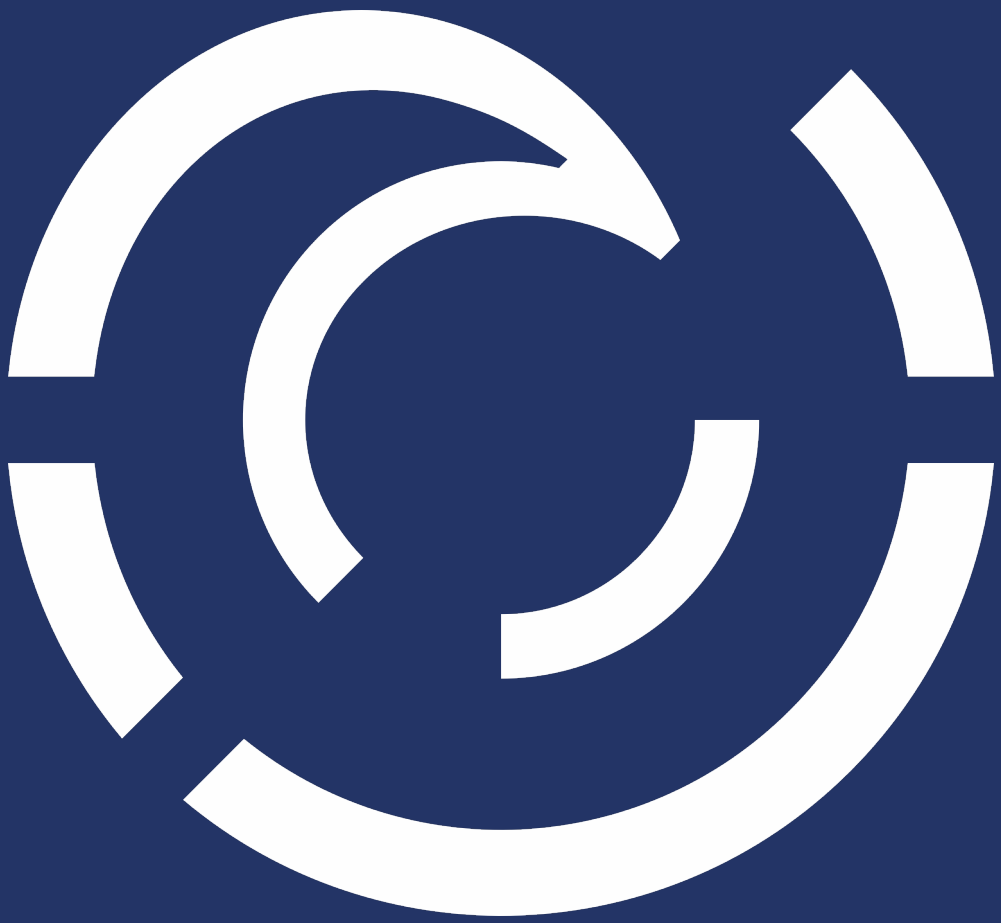

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