ACCELERATING DEEP ENERGY RETROFIT IN HOUSING THROUGH MODULAR AND CIRCULAR SOLUTIONS

REPORT FROM DRIVE 0 CONFERENCE IN ATHLONE
11 MAY 2023

HOUSING EUROPE

OLLSCOIL TEICNEOLAÍOCHTA BHAILE ÁTHA CLIATH
TU DUBLIN
TECHNOLOGICAL UNIVERSITY DUBLIN

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This project has received funding from the European Union's Horizon 2020 research and innovation programme.

Introduction

Technological University Dublin and the Irish **Drive 0 project** partners, in association with **Housing Europe**, organised the conference 'Accelerating Deep Energy Retrofit in Housing through Modular and Circular Solutions' on the 11th May at the Radisson Blu Hotel, Athlone.

This conference provided an opportunity to examine **modular circular renovation and construction solutions in the Irish housing sector** and share experiences and lessons learnt from completed Irish and EU pilot projects, which should be of interest to everyone involved in sustainable housing and buildings, notably professionals in building design, construction, manufacture and those involved in housing stock management and policy.

Drive 0 is an EU research and innovation project, funded under Horizon2020, which seeks to demonstrate the application of circular solutions in the deep energy retrofit of housing (and buildings) across Europe via several pilots, one of them located in Athlone, Ireland. The project partners were TU Dublin (Research), Coady Architects and Vision Built (Industry), in association with SISK and building owners Westmeath County Council.

The Irish pilot comprised the deep energy retrofit of two 1970's masonry constructed three-bedroom semi-detached houses demonstrating use of modularised construction panels in the fabric upgrade and extension of the dwellings, achieving a 65% reduction in energy use.

The **morning session** covered the Irish deep energy retrofit case study with a focus on the design, development, testing, and realisation of the circular modular construction solution and the performance impacts of the Irish Drive retrofit.

The **afternoon session** widened out to focus on applications and lessons learnt, from the Irish and other social housing practices in Europe, on how to achieve circularity in renovation through industrialised methods, procurement, planning, regulation, management and financial instruments. An interactive exercise led by Housing Europe explored how to design your own circular renovation concept for social housing.

Site visits to the demonstration project in Athlone town were also arranged for participants to see the finalised pilot project for themselves.

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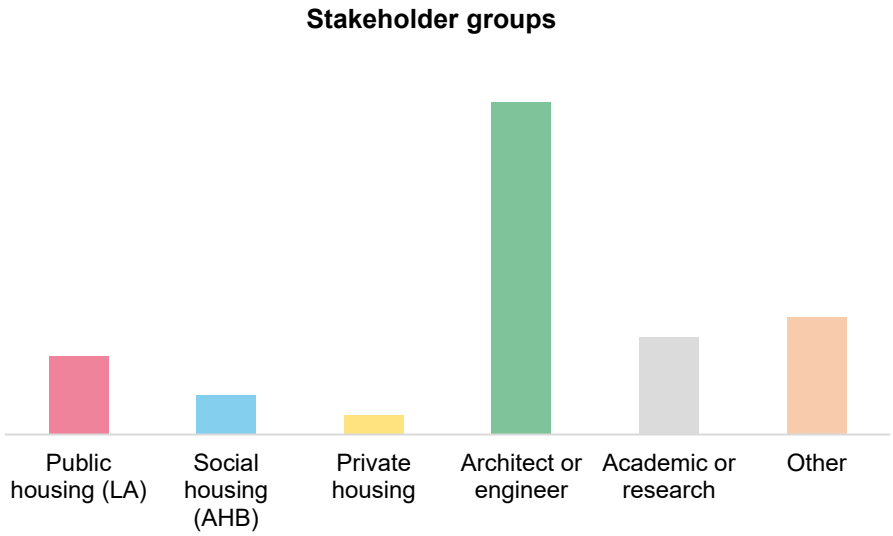
Participants

A total of 80 participants joined the conference in Athlone, mostly representing architects or engineers, academics and local authorities (LA).



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Circular modular solutions: a detailed focus on the research, development and realisation of the Irish case study.

Drive 0 and Irish case study overview

Patrick Daly (TUDublin)

Patrick Daly, principal investigator at **TUDublin** on Drive 0 project Irish Demostrator, delivered an introduction of the Drive 0 project, which is based on building circular deep renovation solutions and supporting consumer-centred business models for seven particular research and demonstration scenarios as real environments.

As a subdivision of project stages, Drive 0 is split into seven work packages.

Patrick was addressing the difficulties to commence the project, setting up a proper team and finding a demonstrator building.

Finally, a team was established including TUDublin as an Academic Partner, Coady Architects as a design partner, and Vision Built as a manufacturer partner.

The main stakeholders were Westmeath County Council as the building owner, Sisk as the contractor, and the National Advisory Board; however, many contractor suppliers and installers were also involved, including ProAir, Aereco Solar PV Ireland, Next Gen Heat Distribution, and Munster Joinery.

Following the selection of the demonstrator building, the first stage was to develop a survey in terms of physical and energy current status, thermal imagining, thermal transfer, air pressure test, and panel testing (Mock Up).

The Irish Demonstrator consists of a two-and-three-bedroom semidetached house built in 1975 with masonry cavity walls, a pitched roof constructed with a cut roof method, and an attic ventilated.

In terms of heating, one semidetached is served by a heat pump and the other by a range.

The variations between both houses are related to Westmeath County Council's ranged levels of improvement.

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Physical and energy survey study for Irish Demostrator Case

Next to the completion of the entire home study, a list of actions was taken.

Tenant Engagement, in which the renter was an active participant in the entire retrofit process.

A brainstorming session was organised at Vision Built Factory in order to build a circular modular construction system.

The entire design of 2D and 3D panels began developing the circularity evaluation technique, with a focus on design for disassembly. After the entire system of 2D and 3D panels was built, a mock up was tested to identify weaknesses and improve before the site work commenced.

The next stage was to begin retrofit site work with enabling works, followed by exterior wall insulation built at the rear and side elevations, and upgrading windows, as well as the installation of a modular system, 2D in the wall panel, and 3D in the porch lobby.

To complete the retrofitting, a new pellets system and demand-controlled ventilation was built in one of the homes, while the other retained the original heating system (heat pump) and a full heat recovery ventilation system was set up.

Solar panels were installed on the pitched roofs of both homes to help generate extra electricity and contribute to hot water production.

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Design and development of the modularised solutions

COADY Architects are the industry and architects for the **Irish demonstration project** which involved retrofitting two existing semi-detached houses owned by Westmeath County Council. As a practice they cover all aspects of project typologies;

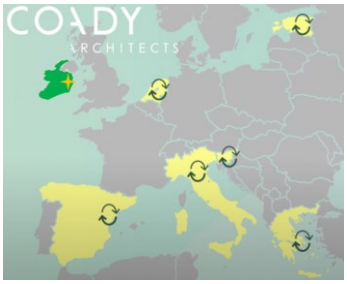
- Healthcare
- Residential
- Educational
- Office

COADY had identified a significant opportunity for Modern Methods of Construction (MMC), which directly tie in with opportunities for Circularity;

- Reduction in construction time on site
- Reduction in on site wet trades

For the Drive Zero project they designed 2D panels assembled off site and fixed to the front elevation of the houses along with 3D porches.

- **Research Project 2019-2023:**
  - Owner / Local Authority – Westmeath CoCo
  - Involved - COADY, TU Dublin, SISK, Vision-Built
- **Brief:**
  - Circular, deep renovation solutions achieving
  - Offsite 2D façade & 3D porch additions
  - Use of bio-based materials
  - Design for disassembly (DfD)
  - Renewable Energy Sources
  - Deep retrofit with 65% energy uplift
- **Innovations & Research:**
  - Ground screw foundations
  - Point cloud survey to facilitate 2D & 3D solutions
  - Monitoring air quality, in-situ heat losses, energy production, and energy bills



- Timeline of the demonstrator case in the image here.

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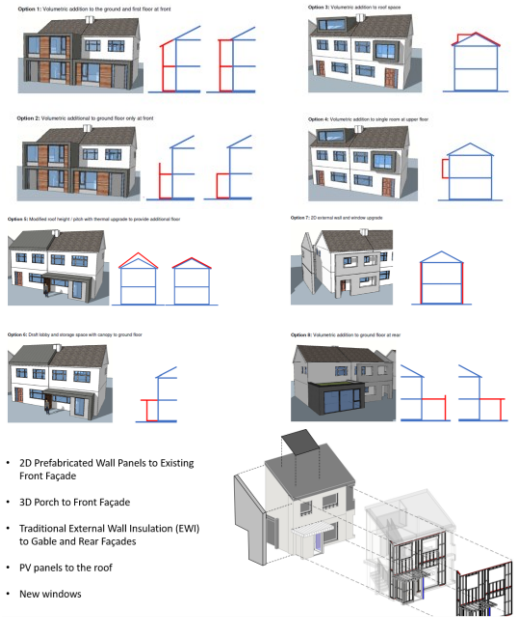
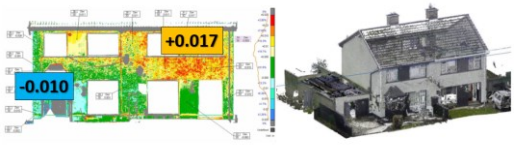
- Options for volumetric options were explored, applied to a typical Irish dwelling.



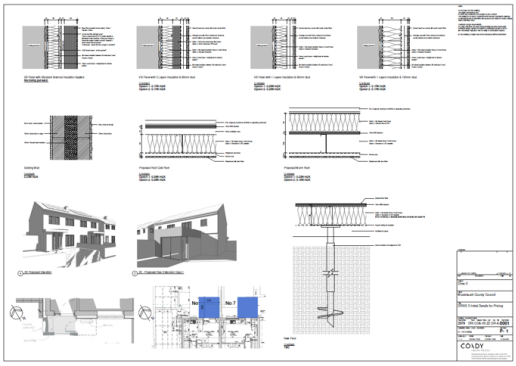
- Irish Approach to Drive 0 demonstrator case was established.

- BER analysed data stated that both houses had received cavity fill insulation prior to Drive 0 project commencement.
- Borescope analysis carried out.
- Identified that the cavity fill insulation was sporadic, with voids.
- Confirmed that in-situ heat transfer analysis was required.

- Point cloud surveys and verticality surveys carried out to establish tolerances for 2D and 3D solution application.



- Bio-based materials reviewed and details established to incorporate DfD.



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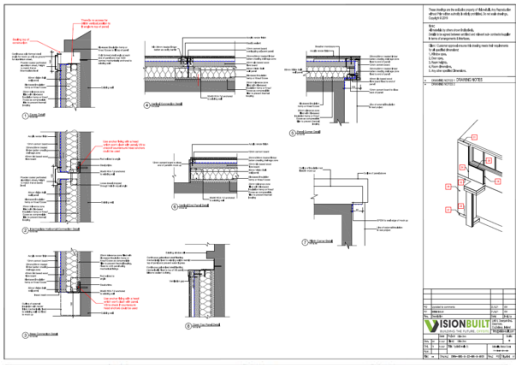


	A	B	C
Basic Module	Prefabricated, horizontal orientation modules	Prefabricated, vertical orientation modules	Semi-prefabricated, combination of prefab modules and on-site finishing
External Finish	Render	Brick / brick slip	HDF (high density fibreboard)
Insulation continuous	Wood fibre board	Stone mineral wool	Hemp Batt
Cavity Layer	Timber	Metal helping hand	
Insulation broken	Hemp batt / roll	Cellulose blown	Glass mineral wool slab
Window	PVC	Aluminium	Aluclad
Airtight membrane			
Thermal bridging at Window / plinth	AlmaTherm 100 % Recycled Polymer	Phonotherm 100 % Recycled PUR	Compacfoam Structural insulation

- Panelised system details developed to establishing key fixing points.

- Panels were manufactured in the VB factory and test fitted before transportation. This took place twice, enhancing the details each time prior to final detailing.

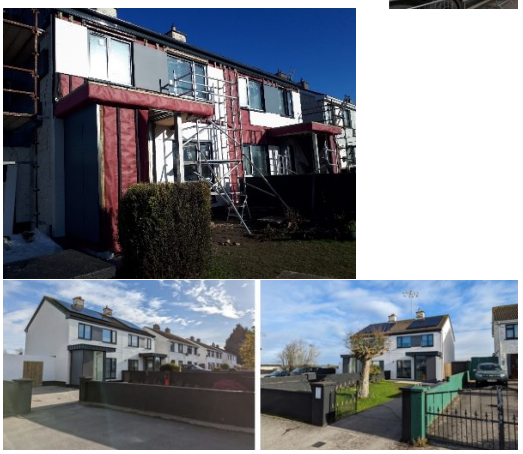
- Planning Restrictions reviewed with regard to the new panels being applied. This was overcome through discussion with the Local Authority and using a Part 8 exclusion.

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

- Team collaboration was used to finalise mock-up and final details along with colours and textures of the finishes – enabling DfD.

- The installation took place using innovative ground screws for the front 3D porch foundations and lifting frames developed by VB to apply the 2D panels.

- Some cladding sheets were omitted at junctions to allow for site tolerance. The porch was installed as panel elements and ground screws provided the foundation.



- External works complete.

Constructed off site using BIM processes, this project designed, tested, and demonstrated a demountable retrofit system. It has low maintenance requirements and was installed without the need for the occupants to leave the houses showing the low impact on building users.

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

Manufacture, testing and installation of the modularised solutions

Gavin Waller (Vision Built)

Gavin Waller, technical design coordinator at **Vision Built,** the manufacturing partner for the Irish demonstration project, which involved retrofitting two existing semi-detached houses owned by Westmeath County Council.

Gavin introduced VB as a Modern Methods of Construction (MMC) company providing building supply services from pre-design through to installation.

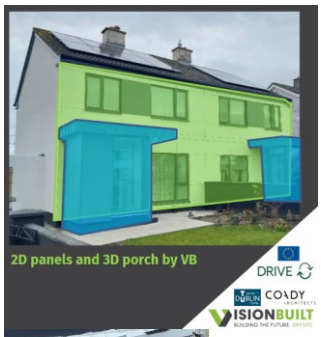
Their main offering is Category 1 buildings in the commercial and education sectors. These modular buildings embody concepts of circular economy being designed to be relocatable and demountable. As an example, one school was relocated entirely within a three-week period.

For the Drive 0 project they provided 2D panels assembled off site and fixed to the front elevation of the houses along with two 3D porches.

Retrofitting process for the Irish Demostrator Case

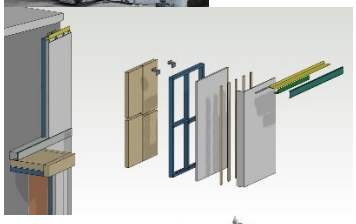
This project has received funding from the European Union's Horizon 2020 research and innovation programme.

- The extent of VB works for demonstration project. Comprising wall panels shown green bolted to the front elevation of two semi-detached houses and 3D porches highlighted in blue.



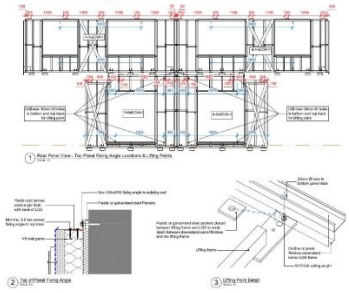
- At our factory in Tubercurry Co. Sligo, VB constructed a mock up consisting of 3no wall panels mounted on brackets fixed to the existing wall and a porch made up of 2no wall panels and roof.

- Mock up panels tested the manufacture process and demonstrated the junctions and element types.

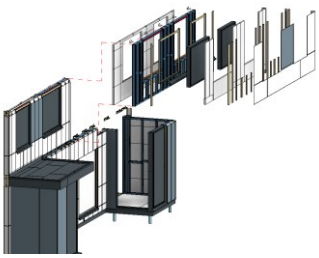


- Design for Manufacture (DfM) process included coordination with project partners TU Dublin and COADY Architects and employed a cloud point survey of exterior.

- The DfM process incorporated lessons learnt from the mock up and used the mock up to show final product to production staff. Output of this stage included drawings and schedules for procurement and assembly.



- DfM BIM model drawn up. This allowed automatically generated: drawings, cutting files, cutting lists and schedules. It also held data for procurement and manufacture, along with visualisations for assembly.



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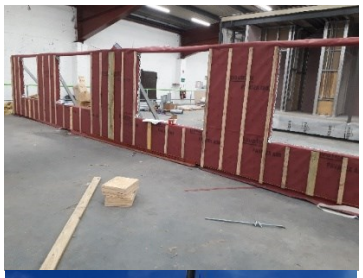
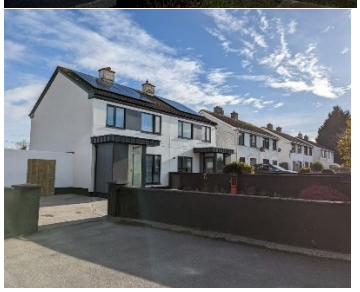
- Panels were manufactured in the VB factory and test fitted before transportation.



- All material was transported on a single truck load from factory to site. 2D elevation panels were lifted directly from the lorry bed on to support brackets bolted to the house.

- Some cladding sheets were omitted at junctions to allow for site tolerance. The porch was installed as panel elements and ground screws provided the foundation.

- External works complete.



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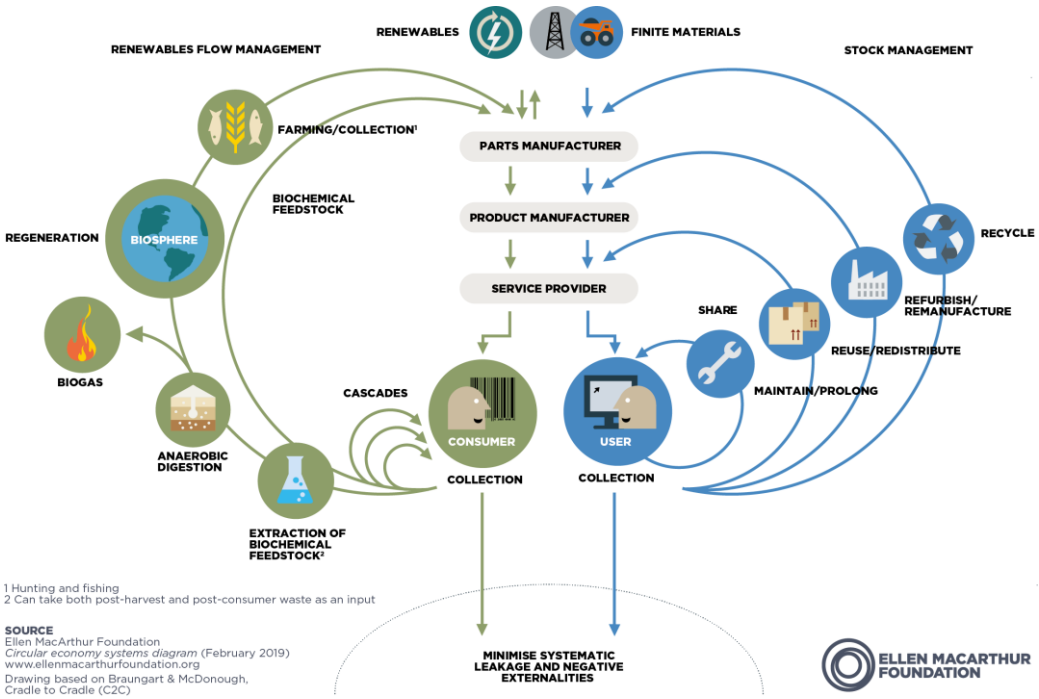
Implementing and assessing circularity

Patrick Daly (TUDublin)

Patrick Daly, principal investigator at **TUDublin** on the Drive 0 project Irish Demonstrator, presented an overview and critique of implementing and assessing circularity of the modularised façade upgrade solution and lessons learned.

Given the significance of the transition from linear to circular economies, a comprehensive description of circular deep renovation was provided. *"A circular deep renovation, which contributes to a circular built environment, is based on 100% life cycle renewable energy, and all materials used within the system boundaries are part of infinite technical or biological cycles with lowest quality loss as possible".*



Patrick was using the butterfly diagram to describe the circular economy system, which has two basic cycles, the technical and the biological.

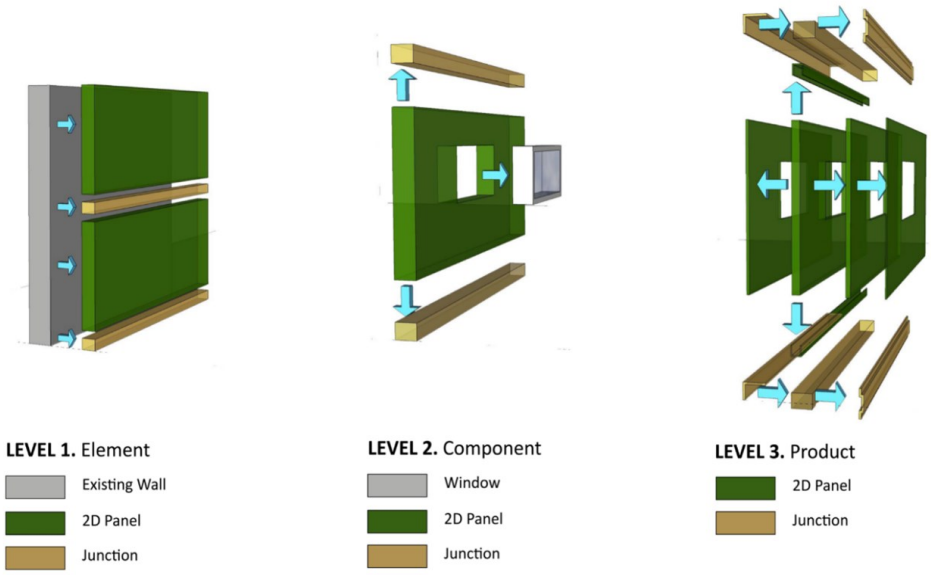
It was emphasised the importance of biobased solutions, good design for disassembly, and advanced DfD at all levels of hierarchy, element, component, and product/material.

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

Detailed critical review of the Drive 0 assessment methods was undertaken due to narrow and simplified approach, adaptations and changes in scope and indicators during life of project, meaning and use of terms, diversity of data sources, emphasis and weighting, as well as limitations pertaining to non-consideration of building hierarchy.

Under the acronym STaMPD, a more comprehensive Design for Disassembly technique was presented, with five categories: System, Technical, Material, Process, and Data.

Patrick described the steps required for developing a new methodology, beginning with a literature study, mapping DfD papers, compiling indicators, suggested categories, and creating a new framework. The incorporation of hierarchical levels, element, component, and product was relevant.



Once the desk-based technique was developed, it was used to a 2D panel and exterior wall insulation system to study different construction methodologies and their impact on circularity.

At the end of the presentation, a discussion regarding the STaMPD method took place, mainly highlighted the subjectivity of indicator scoring, future research in weighting approaches, and a possible simplified method reducing indicators.

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Energy and environment benefits

Philippe Lemarchand (TUDublin)

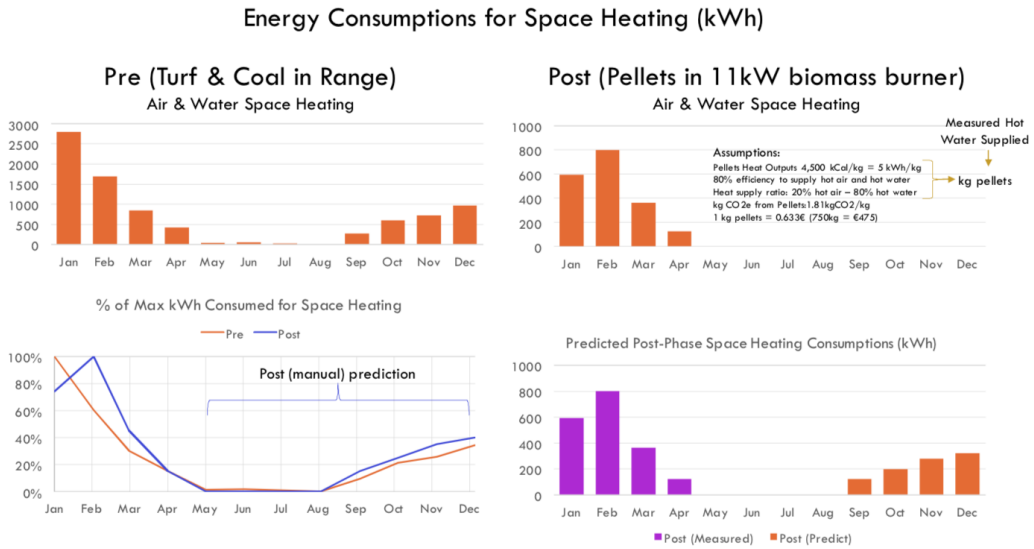
Dr. Philippe Lemarchand, research at TUDublin on Drive 0 project Irish Demonstrator, presents principal deals with energy, CO2, and cost monitoring.

As part of the energy and environmental study, a number of pre works assessments were undertaken and some of the post works assessments are still in progress as final BER and air pressure test.

Beginning with a thermal imaging inspection and in situ wall U value assessment. Followed up with a pre-phase thermal transmittance research, for which many sensors were installed in external walls and windows.

Over three analysis periods of 5 days the average of wall thermal transmittance (U-Value) for the cavity wall pumped with eco beads, monitored was 0.99 W/m2k, meanwhile calculated represents 0.37 W/m2k and DEAP default by age band 0.6 W/m2k.

The modular system installed at the front elevations was calculated as 0.15 W/m2k. After being monitoring 0.23 W/m2k UValue was the result obtained.



Assessment of Energy Consumption for Space Heating

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

A sophisticated energy and air quality monitoring assessment was undertaken and is ongoing and included detailed disaggregation of the energy by use type and location, as well as air quality indicators.

Regarding energy consumption for space heating (KWh) some assumptions have been made in order to predict the post phase values.

Post works monitoring is ongoing but preliminary results based on four months indicate that energy savings are being made but based on predictions may not be as extensive as assessments.

HOUSE		Monitored * kWh/yr	Notes kWh/m2/yr	
7 (Heat Pump)	Pre works	10,502	132	*Exc Room Stove *Only 4 months monitored
	Post works	6,378	80	*Excl room stove

		Monitored * kWh/yr	Notes kWh/m2/yr	
8 (Attic Conv)	Pre works	11,93	132	*Exc from bills, heat monitored and calculations *Only 4 months monitored
	Post works	4,8	53	*Electric and Heat monitored

After analysing the electrical energy consumptions (including solid fuel but excluding PV panels), annual savings will be about 50%, from 132 to 53 KWh/m2/yr were predicted.

When these consumptions are converted into KgCO2 emissions a reduction from 45.1 to 18.7 kgCO2/m2/yr, is expected.

In terms of cost, a 290€ yearly savings from 13.48 to 10.12 €/m2 is achievable

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Post occupancy evaluation

Paula Gallego Barril (TUDublin)

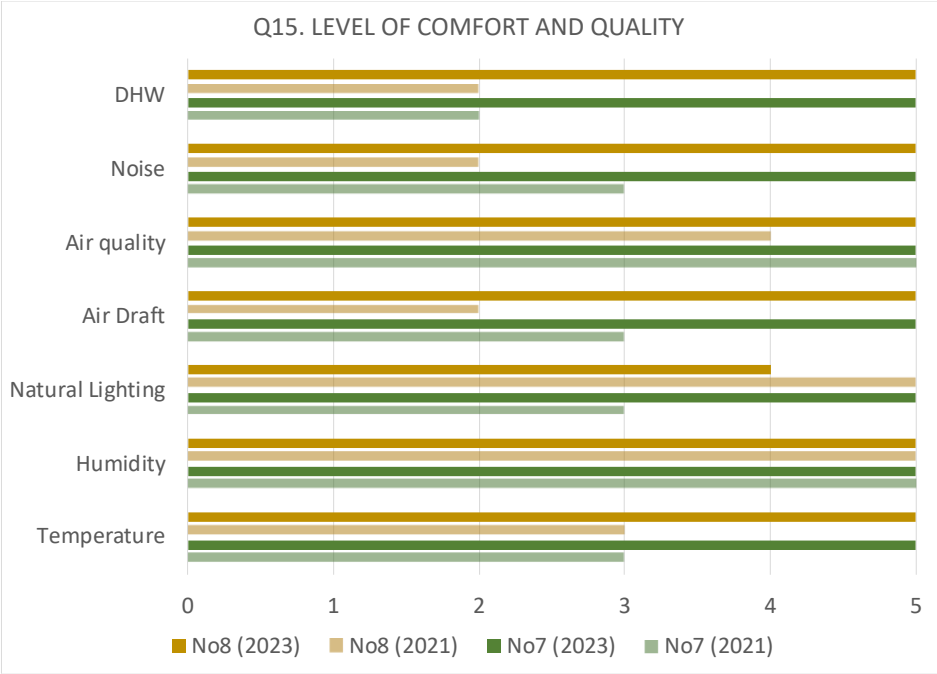
Paula Gallego Barril, research assistant at **TUDublin** on Drive 0 project Irish Demonstrator, presented an overview of a post occupancy evaluation survey conducted after site works were completed at Irish demonstrator case.

This study was divided into two parts.

In the first, a comparison of pre and post works survey was carried out in terms of occupancy, environmental awareness, retrofit experience, process, comfort, and quality was performed.

Second, a post-occupancy survey was established to expand knowledge of tenant satisfaction by assessing in depth thermal, humidity, natural lighting, air draught, air quality, acoustic, domestic hot water, and renewable comfort.

The results demonstrate an improvement in all elements examined, including the reduction of hours in heating system, air quality, and air draughts, which are three of the most important improvements for tenants, as well as the improvement of domestic hot water, resulting in an alternative heating system.



Post Occupancy Survey. Level of comfort and quality

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

The survey data will be used to create a Tenant Guide, a handbook that will increase environmental and circularity understanding, as well as the operation and maintenance of installed systems.

Three broad ideas were emphasised: the importance of promoting the benefits and value of using natural, recycled, and circular materials. The necessity of continuing to improve off-site construction, not just for new buildings, but also for retrofitting, since we must keep in mind that while retrofitting, families are still living in their houses, and minimising time and disruptions is critical.

Finally, for well-being improvement, a holistic retrofit procedure is required.

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

Circular modular solutions in mainstream retrofit – the Estonian story

Kalle Kuusk (Tallinn University of Technology)

Estonia has had support measures for deep renovation of apartment buildings since 2010. First pilot renovation with timber-based prefabricated elements was in 2018 when Taltech dormitory was renovated as a part of the MORE-CONNECT project.

https://www.more-connect.eu/



As part of the DRIVE0 project, next experience with prefabricated renovation was the renovation of an apartment building in Saue in 2021.



Based on success of the first prefabricated renovations and interest from woodhouse industry, Ministry of Economic Affairs and Communications and KredEx launched a new renovation measure for prefabricated renovation of apartment buildings. The grant rate was 50% and the main technical requirements included deep renovation to achieve at least EPC label C. This involved meeting the following specifications:

- Insulation of the façade with U-value of no more than 0.18 W/(m²*K)
- Insulation of the roof with U-value of no more than 0.12 W/(m²*K)
- Replacement of windows with U-value of no more than 1.1 W/(m²*K)

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- Installation of a new heating system
- Installation of a new ventilation system with heat recovery

The project required the use of prefab external wall elements for facade insulation.

The apartment association is the beneficiary of the subsidy, but KreEx played a leading role in the process. KredEx initiated a mini-competition amongst its partners for a group of apartment buildings, which consisted of 4-5 buildings of the same type. This was done to facilitate scalability. The following steps were taken by KredEx in the process:

- A call for apartment buildings was made.
- A call was made for companies that could work together as a group - comprising of a designer, manufacturer, and main contractor.
- Procurements were launched for groups of apartment buildings, based on the same type of project, in a single procurement.
- The winner of the procurement was selected based on the total cost of the group of buildings.

As for the apartment association, they were responsible for contracting with the successful group of companies. Each apartment association made a separate contract.

The initial findings have highlighted the advantages of using prefabricated renovation techniques, which include:

- A one-stop-shop approach: KredEx managed the procurement process and apartment association have one partner for the renovation (designer, manufacturer, and main contractor).
- Better quality, durability, and speed.
- Reduced disturbance due to the absence of scaffolding.
- A clean construction site.

However, some issues also emerged during the renovations, such as that existing buildings can be quite uneven, which makes it challenging to match the prefab elements to the old structure. As a result, careful planning is required to ensure that everything fits together correctly.

The renovation with prefabricated elements has been well received among apartment associations. Nineteen apartment associations are currently renovating their buildings with prefabricated elements.

This project has received funding from the European Union's Horizon 2020 research and innovation programme.



Implementing and achieving circularity in Irish construction

Patrick Daly (TUDublin)

Patrick Daly, principal investigator at **TUDublin** on the Drive 0 project Irish Demonstrator, concludes the morning session with an overview of the lessons learned from the Irish/EU Drive 0 project, as well as the challenges and prospects for implementation in the Irish construction industry.

Before beginning retrofit site work, a mock up was created to observe and improve the final model. Some considerations included altering the render finish to fibre cement to avoid the chips and marks caused during the shipment and installation process.

This material change improved the appearance of vertical joints.

Another key lesson learned was that the neoprene seal and backing insulation would not work to absorb the misaligned wall, consequently a new bracket with horizontal and vertical adjustability was designed.

Finally, the mock-up approach helped to design the exact crane used for lifting the higher panels under the eaves.

At the same time as the mock up, a parallel audit in Design for Disassembly at all levels was carried out, with some results such as a bad window connection, waste of fixings, many of which will not be able to reuse, despite the fact that the majority of the other materials were reusable and reassembly again.

On-site, in addition to technical challenges that were resolved throughout the mock-up phase, there were issues with trades availability and programme delays, which caused some tenant frustration.

In terms of modular circular systems, it was discovered that a hierarchical perspective is required, that material specification and design for disassembly are critical, and that while the overall DfD study for Mock up was favourable, there were some levels in the hierarchy which presents poor scorings.

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

In regard to modularity, after the project's technological capability was validated, a dry system with dry finishes was desirable to achieve high volume and speed. This characteristic also helped in Design for Disassembly, which is a vital aspect in circularity.

Some challenges were spotted as finding scale and replication in diverse stock, and full or partial modularity and completion.

Some lessons were also acquired from the Drive 0 experiment. Forming a stable team for the Irish Case Demonstrator was a challenge. Budget was another obstacle due to an increase in material prices due to unprecedented circumstances such as the Covid and Ukrainian Wars.

The Drive 0 team's circularity assessment process was too simplified, and a more comprehensive approach was necessary.

A follow-up study into circularity DfD should be conducted in the future, along with a larger demonstration project, such as a whole building with a residential and commercial phase, which might lead to a more holistic and advanced circularity assessment.

Circularity knowledge acquired during Drive 0 is now being applied to the MSc Building Performance Energy Retrofit, and students are carrying out examples of circularity audits.

Drive 0 Ireland demonstrated technical viability of modularity by extracting significant learning.

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

To summarise, Patrick concludes that typical design and construction are not circular at any level, whether building construction or material level.

There are numerous demonstration projects around Europe for modular circular solutions to be used in deep energy retrofit, with evidence of mainstreaming and technical potential.

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

Industrialised renovation: a training for social and cooperative housing providers on how to be more circular.

Construction is a resource intensive activity, and is a sector that is only expected to grow to meet the increasing demand for housing. In Ireland, the Housing for All Plan is expected to build 330,000 homes by 2030, says **Mr Ossian Smyth, Minister of State for Circular Economy**. And on top of that, half a million retrofits by 2030. Use of resources is therefore unavoidable. The key to a sustainable living will be on doing this the most circular way possible.

Mr Ossian Smyth, Irish Minister of State for Circular Economy

"Our history of circular economy in Ireland has not been good. If you measure Ireland on the Eurostat numbers in comparison with other EU countries, we're towards the bottom of the table" says the Minister. Indeed, according to Eurostat, Ireland ranks well below average in indicators such as 'Circular Material Use Rate' measuring the share of material recycled and fed back into the economy - thus saving extraction of primary raw materials - in overall material use[1]. This is due to the number of aggregates being removed from the ground, through quarrying and the high number of raw materials

[1] https://ec.europa.eu/eurostat/databrowser/view/CEI_SRM030/default/bar?lang=en

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

being used in construction. Backfilling and landfilling of construction waste are another major contributing factor.

The Irish government has updated this year their Whole of Government Circular Economy Strategy, which now including sectoral targets; including for construction. As part of this strategy, a circular construction roadmap will be produced in cooperation with experts from the construction sector. Overall, their Circular Economy Act requires Ireland to reach the average for European circularity by 2030.

“Bringing in more retrofit for the Irish council housing stock is not only essential to improve the lives of those who need it most, but also is a good test case” according to Minister Smyth. “We had a lot of council housing that tended to be of the same size, so if we could get it right for one configuration, we could then repeat it over an entire council estate” he continues.

The Irish National Development Plan has allocated €100 billion of spending over the next decade, including for the delivery and retrofit of public housing. This presents a unique opportunity to get investment right in a way that is circular and sustainable for the environment.

Renovation context in the Approved Housing Bodies (AHB) sector

Donal MacManus (ICSH)

Donal MacManus, CEO at the **Irish Council for Social Housing (ICSH),** represents the Approved Housing Body (AHB) sector in Ireland that, in 2022, provided 4,479 additional homes for social housing and 470 cost-rental homes. The sector collectively owns and manages more than 55,000 homes.

According to MacManus, an important part of the AHB housing stock in Ireland is relatively old, with many small developments located in rural areas that can be a challenge to renovate in a cost-effective way. Some older AHBs, like the Iveagh Trust, have a number of protected historic buildings, adding complexity to retrofitting efforts. There are at least 3,000 AHB homes from before 1990, and which have poor energy ratings. The majority of AHB tenants living in homes in need of retrofitting are low-income families, older people, those experiencing homelessness, and people with disabilities; many of whom are at risk of fuel poverty.

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Yet, “significant new social housing stock has been provided since 2016 with increased A energy ratings” says Donal MacManus. The Irish Government has also recently committed to introduce a targeted energy efficiency scheme for AHBs in the Housing for All plan, which is expected to change the trend.

Some of the flagship retrofitting projects delivered to date by the AHB sector are:

Retrofits From Office to Social Homes: 84 social housing units in Dublin at the (former office block) Plaza building in Park West Business Park, launched 2022. The building was vacant since circa 2000. In Cork, a retrofit of an office block at Springville House on Blackrock Road will provide 35 homes for social tenants looking to downsize. Both projects delivered by **Tuath Housing**

Family Homes – Landmark Regeneration: given the regeneration objective for a disused fire station site, the project required an innovative design solution that enhanced the streetscape. North & East Housing Association’s Tooting Meadow, Scarlet Street, located in the centre of the historic town of Drogheda, provides for a mix of accommodation needs across 15 units.

Housing for Older People – Restoration & Regeneration: Cahercalla, Ennis, Co. Clare. This project is not just a housing development. The vision was to develop a community of people who would benefit from the support of each other, and this is what Cuan an Chláir has achieved. Four new build houses and ten residential units, and a communal centre developed through the restoration and conservation of a derelict farmyard of old stone buildings in a courtyard formation.

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Housing for Formerly Homeless Households: Peter McVerry Trust's new southern regional office was opened in July 2021. The office is located in a renovated bank building and also contains five one-bed apartments.

Modular housing delivery: Castleguard in Louth by Tuath Housing, where 102 homes were constructed by MHI (Modular Homes Ireland). Approximately 80% of the build took place in the factory in Ballyjamesduff, Co Cavan

One of the main differences between council housing and AHBs lies in the funding schemes and regulatory framework for retrofitting. AHBs rely on schemes such as grants, of up to 50%, provided by the Sustainable Enenergy Authority of Ireland (SEAI). For local authorities, funding is provided by the Department for Housing. AHBs are regulated by the newly established Approved Housing Bodies Regulatory Authority (AHBRA) and the Residential Tenancies Board (which is also responsible for overseeing the private rental sector), while the activities of the housing departments of the various local authorities are directly overseen by the Department of Housing.

A major challenge for the AHB sector in retrofitting **is the existing model of income-based, or 'differential', rents paid by their tenants.** These rents are not determined by the quality or size of the homes, but simply by the income of a given social household, and they are mainly used to cover for housing management and basic maintenance. Renovations are not considered when setting the rents. "While this

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allows for sinking/reserve funds for planned maintenance, it does not allow for new retrofitting standards" says MacManus.

In 2021, the **ICSH commissioned a study** by the South East Energy Agency to undertake a financial modelling based on a sample of 500 AHB homes using current SEAI schemes (50% grant). The modelling highlighted the expenditure and income streams (capex, maintenance savings, avoided energy costs, energy credits, avoid carbon tax). **The results showed that the current 50%, and even a hypothetical 70%, grant model generated very significant net losses to the AHBs.** Costs had increased from €400 to €580 per m² in a year (2021 versus 2022).

Increased funding levels of AHB retrofitting would enhance retrofitting for at least 15,000 of the most vulnerable households, as well as ensuring longer life cycle of public housing stock for many future generations.

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

Mobilising EU funds for renovation of social housing

Dara Turnbull, Research Coordinator at **Housing Europe,** stresses the role that EU funding can play in Ireland to overcome **one of the main challenges to invest in renovation: an affordable housing system where rents are not linked to the "quality" of the housing**. In addition, he looked at ways in which current **insufficient pre-financing for renovations,** the **lack of skilled labour,** and the **higher cost of materials** are putting a strain on the renovation of social affordable housing in Ireland.

Dara Turnbull at Athlone Conference

To address these challenges, there are several sources of funding available from the EU to help Ireland meet new construction and renovation obligations:

#1 EU Structural Funds (former ESIF)-grants

The structural funds are financial tools that aim to invest in job creation and a sustainable and healthy European economy and environment. A total of €378bn will be provided in the 2021-2027 period. A "greener, low carbon transitioning towards a net zero carbon economy" is one of the financing pillars of the funds. This includes promoting "the transition to a circular economy". Any EU region can apply for Structural Funds. However, the allocation conditions vary between regions based on their level of economic prosperity. The most 'developed' regions can avail themselves of co-financing rates of 40% to 50%, while 'less developed' regions can avail themselves of rates as high as 85%.

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Table 1 Regional allocation of Structural Funds

Region Type	Definition	Co-financing rate applied
More Developed Regions	GDP per capita > 100% of EU-27 average	40% to 50%
Transition Regions	GDP per capita between 75% and 100% EU-27 average	60% to 70%
Less Developed Regions	GDP per capita < 75% EU-27 average	85%

- **European Regional Development Fund (ERDF)**

With a budget of €226.1 billion, the ERDF finances programmes in shared responsibility between the European Commission and national and regional authorities in Member States. The Member States' administrations choose which projects to finance and take responsibility for day-to-day management. The new ERDF puts a strong focus on projects related to "greener, low-carbon transitioning towards a net zero carbon economy and resilient Europe". Must make up a minimum of 30% of all ERDF funding allocated to a given region. This could be useful for developing and funding circular projects, provided national or regional authorities are convinced by the value of such initiatives.

- **European Social Fund Plus (*ESF+*)**

The ESF+ is the EU's main instrument for "investing in people". This includes programmes related to employment, social, education and skills policies; including structural reforms in these areas. With a budget of €99.3 billion, the ESF+ offers the potential to fund jobs training programmes related to developing and implementing circular or modular renovation. For example, it could help to retrain or upskill workers in the construction sector to improve their knowledge of innovative circular building and renovation practices.

- **European Territorial Cooperation (Interreg)-grants**

Interreg is one of the key instruments of the European Union supporting cooperation across borders through €9 billion project funding. Interreg projects must align with the five pillars of the Structural Funds. One of the specific aims of Interreg Europe under the current EU budget is the promotion of circular economy; specifically, the re-use of

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materials. Calls for projects can be found via the Interreg online portal: https://interreg.eu/call-for-project/.

For Ireland, check: https://interreg.eu/country/ireland/.

#2 Horizon Europe-grants

Horizon Europe is the successor to the Horizon 2020 programme, which funded projects like DRIVE 0. Currently, it is the EU's main funding programme for research and innovation, with a budget from the MFF of €95.5 billion. There have already been several calls under Horizon Europe for projects related to circularity in the built environment providing up to 100% funding directed to capital investment and research. With the EU's push toward lower emissions and greater resource efficiency, many more calls between now and the of end 2027 are expected.

#3 LIFE Programme-grants

LIFE is the funding instrument for the transition to a climate-neutral and resilient society, by supporting the implementation of the EU's climate policy. This includes the specific funding programme "Circular economy and quality of life", which aims to facilitate the transition toward a sustainable, circular, toxic-free, energy-efficient, and climate-resilient economy, as well as to protect, restore, and improve the quality of the environment. It also includes the sub-programme "Climate change mitigation and adaptation", which supports EU strategic objectives, such as "the transition to a circular economy".

#4 Innovation Fund (IF)-grants

The Innovation Fund is one of the world's largest funding programmes for the demonstration of innovative low-carbon technologies. The IF focuses on highly innovative technologies and big flagship projects with European value added that can bring significant emission reductions. Projects will be selected based on the effectiveness of greenhouse gas emissions avoidance, degree of innovation, project maturity, scalability, and cost efficiency.

#5 European Investment Bank (EIB)-Financial Instrument

The European Investment Bank is the biggest multilateral financial institution in the world and one of the largest providers of climate finance. The EIB contributes to the provision of social and affordable housing, inclusive growth, and social and economic cohesion. EIB support is eligible for a wide range of operations, including energy efficiency or circularity. The EIB is seeking to position itself as the 'Green Bank' in the EU, in order to back the European Commission's commitment to the EU Green Deal. As part of this, it is aiming for at least 50% of its investments to be 'Green' by 2025.

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#6 European Local ENergy Assistance (ELENA)-90% grant

ELENA is a joint initiative between the European Commission and the European Investment Bank. It provides grant support for the preparation (but not implementation) of investment programs and is focused on energy efficiency measures (e.g., renovation/renewables/district heating and PV). ELENA supports programs above €30 million, and can cover up to 90% of technical assistance/project development costs. Smaller projects can be supported when they are integrated into larger investment programs. In terms of payment, 40% pre-financing is possible.

#7 The Circular City Centre scheme (C3)-Financial Instrument

The C3 is a competence and resource center within the European Investment Bank, established with the support of the European Commission through the European Investment Advisory Hub. The C3 aims to support EU cities in their circular economy transition, facilitating access to advisory and financing for circular projects. These consults to cities are offered pro bono.

#8 Social Climate Fund (SCF)-new*

The EU proposes to extend its Emissions Trading System (ETS) to include transport and buildings (from 2027). This is intented to increase the costs for greenhouse gas emissions from heating and energy. To “shield” vulnerable households, the EU proposes the SCF (2026-2032). Each Member State must submit a ‘Social Climate Plan’ (before 30 June 2025) - measures and investments they intend to undertake to cushion the impacts of the new emission trading system on vulnerable households inluding: efficiency of buildings; renovation of buildings; decarbonisation of heating and cooling in buildings; and the uptake of zero-emission and low-emission mobility and transport. It will also involve measures providing direct income support in a temporary and limited manner (max 37% of the total amount used in one Member State). Ireland will receive up to €603 million (25% co-financing rate) out of a total of €65 billion.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme.

Managing circular retrofits, the experience of Westmeath County Council

Therese O'halloran
(Westmeath County Council)

Therese O'halloran**, Executive Architect at Westmeath County Council** had a first-hand experience in managing a circular deep retrofit through the Irish Drive 0 pilot. The EU-funded project has given her important lessons learnt that can help other local authorities uptake a similar retrofitting approach.

Westmeath County Council counts with a total stock of 2,463 housing units. **In one decade (2021-2023), a public programme will bring all local authority houses to a minimum of a B2 Building Energy Rating (BER)**. To achieve this target, a Pre-Works BER and Advisory Report was completed to start with. After, a package of retrofitting measures will be installed: heat pumps; photovoltaic panels; demand control ventilation; heat recovery; insulation walls; insulation of roof space; and LED lighting. **Westmeath have already completed approximately 85 houses through this programme.**

For the DRIVE 0 project, Westmeath County Council was approached by Technical University Dublin to find two houses that were suitable to meet the funding and technical requirements of the project. Two families in McCormack Park, Athlone agreed to take part in the project and their houses were deemed to be suitable.

When **engaging with the tenants**, Westmeath County Council focused on **highlighting the benefits the intervention**. Keeping a continuous flow of information and updating tenants on the progress of the retrofit was key. Above all**, minimising disruption** was of outmost importance to keep tenants' interest in the project.

On a project management level, the retrofit extended beyond the initial programme and exceeded anticipated costs.

Regarding the prefabricated panel installation, O'halloran shares how the building process proved arduous for the tenants. Additional works that were not anticipated arose, such as rewiring the prosperities to take new electrical installation which had a knock-on effect on the budget and the programme. Lastly, lighter panels modification could benefit larger scale projects.

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

Including circularity in procurement processes

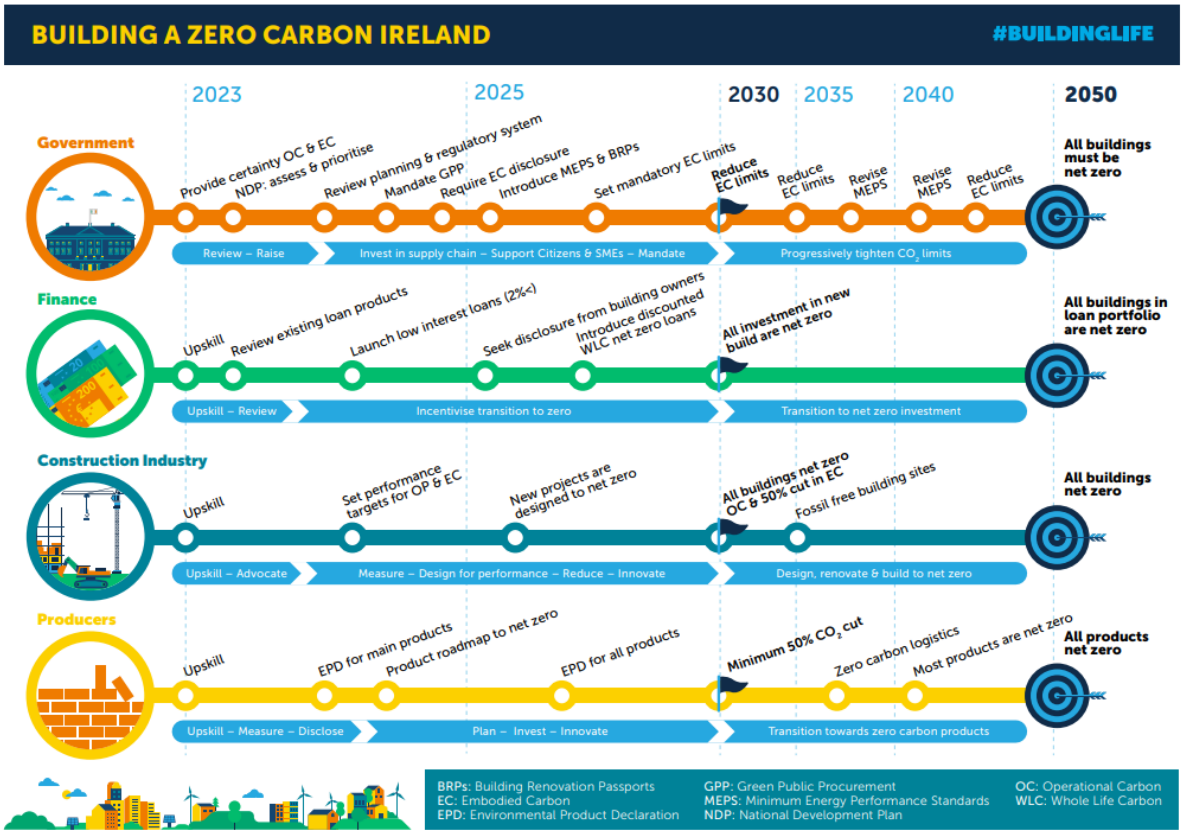
Patrick Barry (IGBC)

Patrick Barry, CEO at the **Irish Green Building Council (IGB)** defends the integration of circularity in housing projects over the whole life cycle of buildings.

The "Building a Zero Carbon Ireland: A Roadmap to decarbonise Ireland's Built Environment across its Whole Life Cycle" report by IGBC presents a set of recommendations to halve our sector emissions by 2030, and to decarbonise Ireland's built environment by 2050.

The roadmap puts a global number on the impact of the built environment through a peer reviewed academic study.

Individual roadmaps are also provided for each stakeholder in the built environment value chain tasked with delivering these actions on the ground, including educators, finance, investment, developers, manufacturers and all professionals operating in the construction industry.



Sectoral roadmaps to zero carbon in Ireland Source: IGBC

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

Patrick also introduces the EU Level(s) framework, setting common language for assessing and reporting on the sustainability performance of buildings. It also offers a simple entry point for applying circular economy principles in the built environment. Tested by the European Commission Joint Research Centre, Level(s) identifies 6 macro-objectives for sustainable building design:

- GHG Emissions
- Resources and Circularity
- Water use
- Occupant Health and well being
- Adaptation and Resilience as our climates change
- Life Cycle Costs and value opportunities

The structure of Level(s) means that each set of indicators follows a similar pattern. Guidance on each indicator details how to approach it depending on the level of involvement or relevance it has with a concrete project.

Level(s) structure

The three levels now also reflect stages in the execution of a project:

- **Level 1 is a QUALITITATIVE** assessment at the conceptual design stage. It provides an accessible entry point into each indicator and introduces the concepts to be considered and the reasons for the indicator's inclusion.
- **Level 2 is a QUANTITATIVE** assessment that takes place at the detailed design stage. It builds on the knowledge acquired at Level 1 by providing a methodology and a unit of measurement.
- **Level 3 is MONITORING** or actual feedback, and happens at the completion stage: It can be used to compare with the Level 2 modelled result.

Macro-Objective 2: Resources and Circularity of Level(s) addresses how buildings are designed with the future in mind considering factors such as: waste; adaptability and deconstruction. This indicator highlights the importance of considering at design

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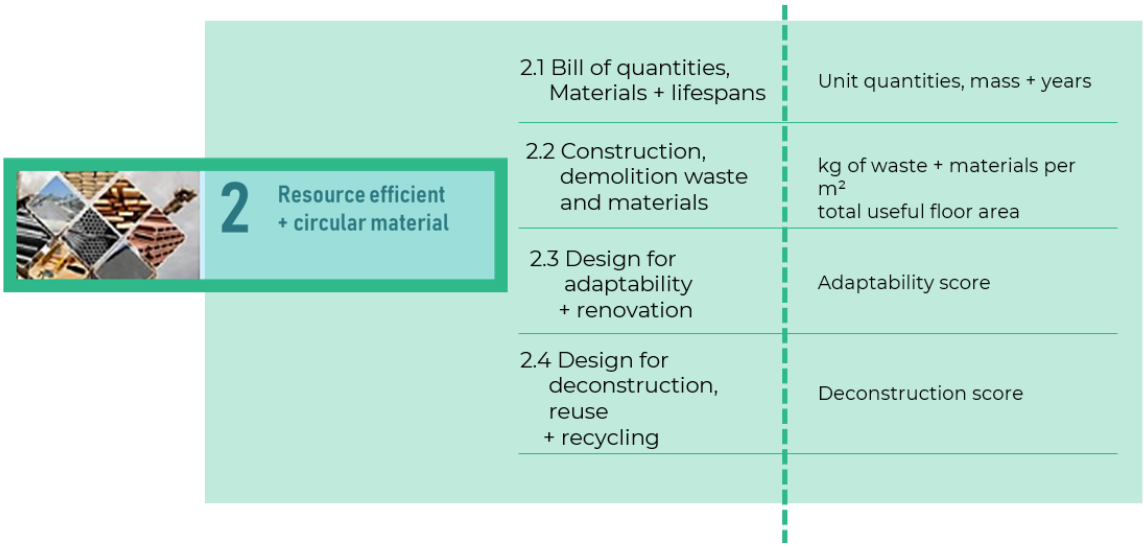
stage how future flexibility and adaptability to changing needs can be factored into the design process.

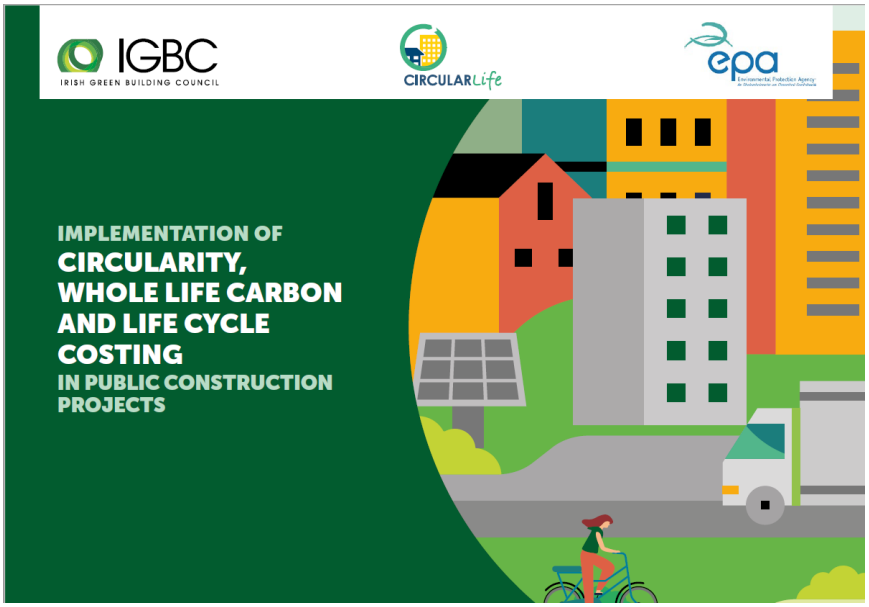


Level(s) macro-objective 2 indicators Source:IGBC

Renovation and repurposing of existing buildings almost always has a lower carbon cost than building new, so it makes sense that when building new, it is done in a way that takes account of future renewal, modification or repurposing.

A buildings service life may end earlier than its potential design life if it can't adapt to changes in market demand or the needs of its occupier. As it is the structure and façades that usually come at the highest environmental cost, if the useful life of these elements can be extended, there can be significant environmental benefits as we avoid the need for new-build.

Finally, Patrick recommends the IGBC '**Handbook for public procurers**' providing detailed guidance on how to consider key green indicators that should be applied within the procurement of public construction projects.



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Circular and cost-neutral social housing renovation in the Netherlands

Robin Van Leijen (AEDES)

Robin Van Leijen, Senior European Public Affairs **at The Dutch Association of Housing Corporations (AEDES)** explains the way social housing providers in his country manage building renovations, while trying to balance affordability, sustainability and availability.

Dutch housing associations own and manage about 2.4 million dwellings, accommodating around 4 million tenants. The Dutch sector is the largest in Europe, **representing about one third of the Dutch housing stock**. Aedes' members are independent, non-profit and non-governmental, and are usually organised either as an association or as a foundation. Also important, they are not directly subsidised. There is, however, a government guarantee for the loans taken by social housing providers, though it has never been used. Because the loans are guaranteed, **Dutch social housing companies have access to capital at low interest rates.**

The Dutch social housing sector has a strong will to become more sustainable. In 2015, AEDES members committed to reaching an average label B by the year of 2021. In the end, this target was met one year later in 2022. "We are considered as one of the frontrunners in the energy transition" says Robin.

The way to cost-neutrality: the Dutch social rent agreement

AEDES and their member recognise the social dimension of the energy transition and the need to support tenants along the way. That is why they operate on the principle of cost neutrality, in other words, rent increases after building renovation may never be higher than the decrease of the energy bill. This is entrenched into the social rent agreement, signed between AEDES and the Dutch Union of Tenants.

The agreement was backed by a model in which for every energy label of building an average energy saving was estimated. For example, a building label A+ renovated into an A++, the average energy saving would be €4 and consequently, the social housing provider may increase the rent by €4. This is a way to ensure cost neutrality for the tenants, but does not guarantee cost neutrality for the social housing provider. 'What we see in reality is that investments in building renovation are often not paid back by future savings on the energy bill. So, the energy savings do not pay for the renovation costs assumed by social housing providers, eventually creating a financial gap' says

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Robin. This financial gap could have an impact on the investment capacity of social housing companies in new construction

Reasonable rent increase based on improvement in EPC label (based on the Sociaal Huurakkoord)

From / To	A++	A+	A	B	C	D	E	F
A+	€4							
A	€13	€9						
B	€15	€11	€2					
C	€22	€18	€9	€7				
D	€28	€24	€15	€13	€6			
E	€31	€27	€18	€16	€9	€3		
F	€32	€28	€19	€17	€10	€4	€1	
G	€34	€30	€21	€19	€12	€6	€3	€2

Source: Aedes
Notes: Based on a typical home of 70sqm

The social rent agreement was recently updated in the context of the lifting of landlord levy, a tax to social housing companies accounting for € 2 billion a year. With that heavy fiscal burden removed for the sector at the start of 2023, the government and AEDES agreed to give these additional financial resources back to tenants to mitigate the cost-of-living crisis.

Now the agreement excludes building insulation from rent increases. So, if a building is insulated the principle of cost neutrality does not apply anymore, but the housing provider pays for the entire renovation, ensuring housing affordability for the tenant. ‘From the principle of cost neutrality, we move to the principle of free building insulation’ Robin concluded.

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The Northern Ireland experience with retrofitting homes

Northern Ireland Housing Executive (NIHE) is Northern Ireland's strategic housing authority, the arm's length body of Northern Ireland's Government and its largest social landlord with 84,000 homes. Like Ireland, the social and affordable housing sector is generally self-funded from rental income.

The NIHE has put forward a **Corporate Sustainable Development Strategy and Action Plan (2022-2027)** aiming at achieving Net Zero in all their operations by 2050. The strategy is coupled with a major programme of work and investment in in a set of areas from improving energy and water efficiency in buildings and switching to low-carbon forms of heat to enhancing nature and carbon removal in the estate.

Adrian Blythe, Quality Improvement Manager at the NIHE highlights how S-IMPLER, an Innovate UK Research Funded project, has informed the retrofit strategy for taking no fines retrofit to scale.

Adrian Blythe at the Athlone conference

The S-IMPLER project aimed at developing retrofit solutions for seven NIHE solid walled homes. After completion, key results were achieved:

- External wall insulation solutions made significant energy and carbon savings for tenants, made their homes more comfortable at lower running costs as well supporting the regeneration of the street overall.
- Involving the tenants in the process through the 'voice of the customer' process and regular communication during the retrofit resulted in high levels of customer satisfaction that will support the ongoing performance improvement when going to scale.

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- The waste and non-value-added time in the construction process ranged. between 40% and 85% demonstrating the enormous potential for reduced cost and provision of much improved value to the public.
- If digital tools/technology such as ‘Refurbify’ are used accurate and rapid surveying, labour saving observations and effective site management can be achieved to support the continuous improvement process.
- Once a highly collaborative culture is achieved performance improvement can be supported utilising digital tools/technology such the BIM Protocol and process measurement tools
- Allow knowledge to be shared across the supply chain encouraging collaboration for continuous improvement.

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Interactive exercise | DIY: design your own circular renovation concept for social housing

Moderated by Housing Europe and TU Dublin

The interactive exercise aimed at exploring how social housing providers can plan and successfully execute circular building renovations in a resource and cost-efficient way. Knowledge and tools necessary to support informed decisions to roll-out circular renovation in social housing buildings were disseminated.

The workshop was divided into two main exercises:

i. Need finding

Participants were asked to map the Irish circular renovation context, with a focus on the social housing sector. Post-its were used to write and stick ideas into the canvas. The dimensions assessed were:

- Local construction materials
- Main energy sources
- Financial support available
- Common renovation methods
- Features of the building stock
- Climate needs
- Knowledge, skills and awareness

This first exercise paved the ground for the second one, as it allowed participants to create an overall picture of the available resources, needs and readiness toward circular housing renovation in their region. With this in mind, it became much easier to think of the most appropriate circular measures to be used for their own social housing renovation project.

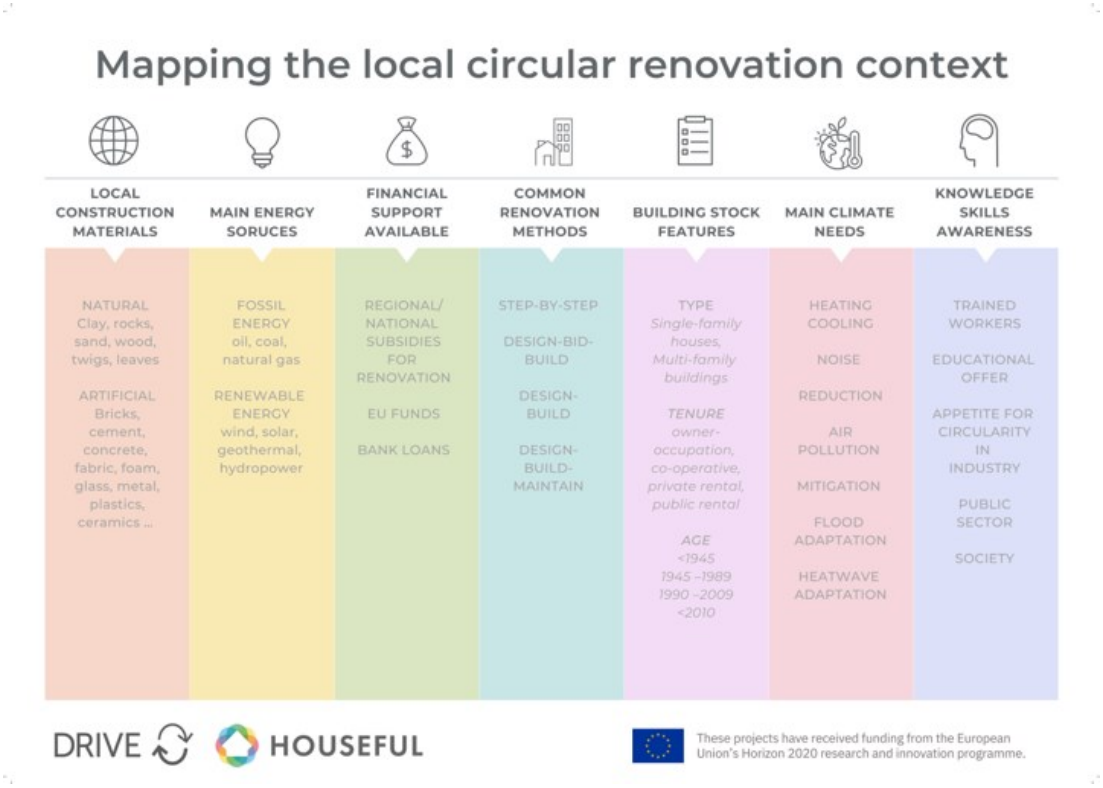
ii. DIY: design your own circular renovation concept for social housing

For the second exercise, a set of poker-size cards was prepared presenting all circular measures that developed to date by the technical suppliers of the HOUSEFUL and DRIVE 0 projects. While some of these have already been installed and tested in real-life housing renovation scenarios, others continue to be work in progress. Measure cards included a short description, an illustration and were classified into four groups: materials, water, energy and comfort (see below a sample from each group).

Based on the regional context drawn in the first exercise and the circular measures presented, groups were then asked to co-design a circular renovation concept for a social housing project.

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

All circular measure cards were placed in their matching category area by the facilitator (materials, water, waste and energy). Participants had to pick the most appropriate cards based on the regional resources, needs and readiness previously identified and placed them in the middle of the canvas (see below).



Canvas used for the Need Finding exercise

Canvas used for the DIY exercise

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

Participants were split into two groups:

First working group

Second working group

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Results for Ireland

The following circular renovation measures were chosen by the different groups during the workshop based on the needs identified in Ireland:

i. Need finding

Group participants were able to agree on a number of common points. In terms of the **climatic needs, 'heating'** was the main need in most homes over the course of the full year. 'Cooling' is progressively being needed, especially for commercial buildings as a result of increasing temperatures/ Dealing with **air pollution** and ensuring that homes offer healthy environments for residents was also important in many urban areas. With rain events becoming heavier and more extreme, homes need to be adapted to better protect households from **'flooding'**

With regard to construction materials, **most buildings rely on highly unsustainable and extraction-based materials** such as cement or clay tiles and bricks. However, Natural and bio-sourced materials are increasingly being used in the construction sector, though materials such as **hemp, timber, bark, acaya wood and forest thinning**. **Re-use of waste** as source of construction materials is also gaining more attention in Ireland through bio plastics made from agricultural waste as well as building demolition waste. The idea of 'Buildings as Materials Banks' (BAMB), meaning that the materials in a building can be viewed as a 'store' of value and can be reused, is also becoming a more popular concept amongst architects and building owners.

Financial support available for building retrofitting tend to come from governmental sources such as local authorities in the form of SEAI grant or European funding.

Common renovation methods include competitive tenders, energy performance contracts and One-Stop-Shops. Although private self-upgrades are frequent as well.

In general, **awareness of circularity is low** in the construction sector and knowledge mostly lies on engineers and contractors.

ii. Circular renovation concept

In terms of which circular products and solutions were well adapted to the Irish context, both working groups agreed on the **great potential of water saving devices and harvesting of rainwater**. Regular precipitation and the increasing frequency of heavy rains in Ireland are an opportunity to maximise the use of water for residential use.

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

Prefabricated products and **building material passports** are gaining momentum in Ireland and are gradually being adopted by the market to optimise sustainable renovation processes. **Circular waste management** and **reusing existing building products and recycled materials** recently started to get more attention in the industry.

Systems like **home and building automation**, **thermostats** and **ventilation** were also discussed as something essential to guarantee the residents' comfort. **Building airtightness** and **acoustic insulation** were also highlighted.

Energy smart meters, **energy efficient windows**, **thermal insulation** were considered well established measures to maximise energy efficiency coupled with the **installation of renewable energy systems.**

Overall, though, the result was that in Ireland has a rather 'limited' circular renovation approach that would benefit from more policy and funding support.

Overview of selected circular renovation measures for Ireland

Category	Subcategory	Table 1	Table 2
Materials	Biobased materials		
	Biogas production		
	Compost production		
	Prefabricated products	✓	✓
	Building materials passport	✓	✓
	Circular waste management	✓	
	Reusing existing building products and recycled materials	✓	
	Local and/or certified circular materials	✓	
Water	Water saving devices	✓	✓
	Harvesting rainwater	✓	✓
	Reusing greywater	✓	
	Monitor water consumption	✓	
	Reusing black water		
	Re-use of unsegregated water		
Comfort	Indoor air purification		
	Radiant heating floor		
	Ecological paints		

This project has received funding from the European Union's Horizon 2020 research and innovation programme.

	Biophilia	✓	
	Building airtightness		✓
	Home and building automation	✓	✓
	Indoor air quality	✓	
	Thermostats	✓	✓
	Ventilation	✓	✓
	Acoustic insulation	✓	
Energy	Energy smart meters	✓	✓
	Energy efficient windows	✓	✓
	Green walls and roofs		
	Hot water, heat and/or cold generation	✓	
	Renewable energies	✓	✓
	Shading		
	Thermal insulation	✓	✓

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Conclusions

- **Ireland's position in the transition to a circular economy is still below average when compared to their European peers**. In the built environment, typical design and construction are not circular yet at any level, whether applied to building construction or material selection. Most buildings rely on highly unsustainable and extraction-based materials. Awareness of circularity is low in the construction sector and knowledge mostly lies on engineers and contractors.
- **The recent 'Whole of Government Circular Economy Strategy', 'Circular Economy Act' and the 'Irish National Development Plan' can take Ireland closer to the European circularity targets for 2030**. The circular retrofitting of social and affordable housing will play a major role in the transition of the built environment.
- **An important part of the AHB housing stock in Ireland is relatively old, with many small developments located in rural areas that can be a challenge to renovate in a cost-effective way**. The majority of AHB tenants living in homes in need of retrofitting are low-income families, older people, those experiencing homelessness, and people with disabilities; many of whom are at risk of fuel poverty.
- **Insufficient financing for renovations, the lack of skilled labour, and the higher cost of materials are putting a strain on the renovation of social affordable housing in Ireland.**
- **A major challenge for the AHB sector in retrofitting is the existing model of income-based, or 'differential', rents paid by their tenants**. While the model allows for sinking/reserve funds for planned maintenance, it does not allow for new retrofitting standards.
- **Building renovation tends not to be cost neutral and often leads to a zero-sum situation between housing providers and tenants**. The 'Dutch social rent agreement' provides a good reference for application of cost-neutrality principles in social housing renovation and the management of split-incentives between housing providers and tenants.
- **The current grant model used by the AHB sector to finance renovation generates losses**. Increased funding levels of AHB retrofitting would enhance retrofitting for the most vulnerable households, as well as ensuring longer life cycle of public housing stock for many future generations.

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- To address these challenges, **there are several sources of funding available from the EU to help Ireland meet new construction and renovation obligations**. More awareness of the EU funding opportunities available to Irish social housing providers is needed. Housing Europe can assist in this matter.
- **There are numerous demonstration projects around Europe for modular circular solutions** to be used in deep energy retrofit, with evidence of mainstreaming and technical potential. **A good example is the EU-funded Drive 0 Irish demonstrator.**
- **Buildings shall be designed with the future in mind considering factors such as: waste; adaptability and deconstruction**. In terms of modular circular systems, a hierarchical perspective is required where biobased solutions and design for disassembly are considered at all levels of the building hierarchy, element, component, and product/material.
- The EU Level(s) framework, provides a common language for assessing and reporting on the sustainability performance of buildings. It also offers a simple entry point for applying circular economy principles in the built environment.
- Preparing an off-site mock up, as well as a parallel audit in Design for Disassembly at all levels is key.
- Forming a stable team for the Irish Case Demonstrator was a challenge. Budget was another obstacle due to an increase in material prices due to unprecedented circumstances such as the Covid and Ukrainian Wars.
- The results of the post occupancy evaluation showed an improvement in all elements examined, including the reduction of hours in heating system, air quality, and air draughts, which are three of the most important improvements for tenants, as well as the improvement of domestic hot water, resulting in an alternative heating system.
- When engaging with the tenants, Westmeath County Council focused on highlighting the benefits the intervention. Keeping a continuous flow of information and updating tenants on the progress of the retrofit was key. Above all, minimising disruption was of outmost importance to keep tenants' interest in the project.

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Annex

Summary of needs identified in Ireland during the workshop:

Local construction materials	• Timber • Rocks • Sand • Hemp • PIR • EPS • Insulation foam glass • Gravel • Aggregates	• Sallies. Reeds • Acaya wood • Forest thinning • Brash • Bark • Bio plastics made from waste material from agricultural+food waste	• Clay bricks (air dried) • Block masonry • Concrete/cement • Demolition of existing building providing feedstock
Main energy sources	• Waste to energy • Co-generation • PV panels • Energy park • Local ESCO (solar panels in an industrial estate) • Hydrogen • Bio • Peat • Gas urban • Wind		
Financial support available	• Energy communities • Local Authority/Government • EU Demonstrators • Large grant to old building renovations • SEAI grants for retrofitting		
Common renovation methods	• Traditional design by client/design team • Competitive tender • One Stop Shop renovation • Energy performance contracts • Man in van for single measures • Private (self-upgrades)		
Building stock features	• Single family houses • Home ownership • Terrace housing		
Main climate needs	• Ventilation • Flooding • Air pollution • Heating and cooling for commercial • Stock heating dominates		
Knowledge skills awareness	• Engineers and contractors • Low awareness of circularity		

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DRIVE

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 solutions include innovative technical products, innovative construction processes, combined with process optimisation and digitalisation (with BIM as a main carrier) and innovative business models. The selected cases are already in preparation and each them has 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.

The results of the project are expected to trigger and average of 75% of energy savings from deep renovation (a total of 0,645 GWh/year) and greenhouse gases emissions reduction (total 20868,3 tCO2-eq/year). All renovated buildings in the pilots are renovated to a level of NZE or 'zero on the meter'. However, the DRIVE 0 holistic circular renovation strategy will lead to a total high performance of the renovated buildings, including energy, indoor environmental quality and wellbeing.

DRIVE 0 will also allow to reduce the time needed on site for renovation works by 20% compared to current national standard practice. The use of prefabrication and plug & play smart connectors can lead to an important cost/output optimisation with a more than 35% improvement compared to the traditional renovation process. Prefabrication can lead to an enhanced quality control of the automated BIM controlled production process which drives a reduction of construction failure costs to less than 5% compared to the traditional 15 to 20%. The application of prefabricated components reduces the number of stakeholders involved in the deep renovation process (e.g., the replacement of the traditional contractor by direct application b by direct application by subcontractors) leading to possible cost savings of 10%.

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