

# Another Brick in the Wall: Energy Efficiency and Mobile Quality of Service Issues

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# Agenda

- 1 Background & Research Overview
- 2 Data Sources
- 3 Descriptives
- 4 Empirical Results and Implications
- 5 Questions

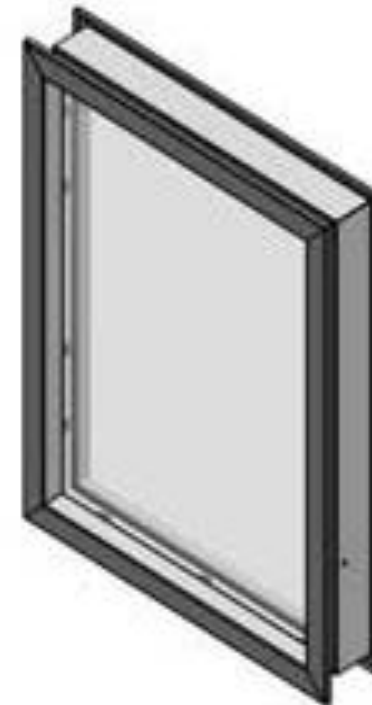
# Research Question

## Research Motivation

- Engineering literature in laboratory conditions has shown that building materials can attenuate mobile phone signal
- E.G. ComReg, 2018; Rodriguez et.al, 2014; Lu et al., 2023; Haneada et al., 2016;
- Likely to worsen over time (5G rollout, more energy efficient homes, growth in mobile data usage)

## Research Question

Are consumers who live in highly energy efficient buildings more likely to experience an in-home mobile signal quality of service issue?



# Data Sources

A row of modern, two-story townhouses with light-colored siding and dark roofs, set against a clear blue sky. The houses are arranged in a line, and the image is slightly blurred, giving it a soft, artistic feel. The text 'Data Sources' is centered over the image in a bold, black font.

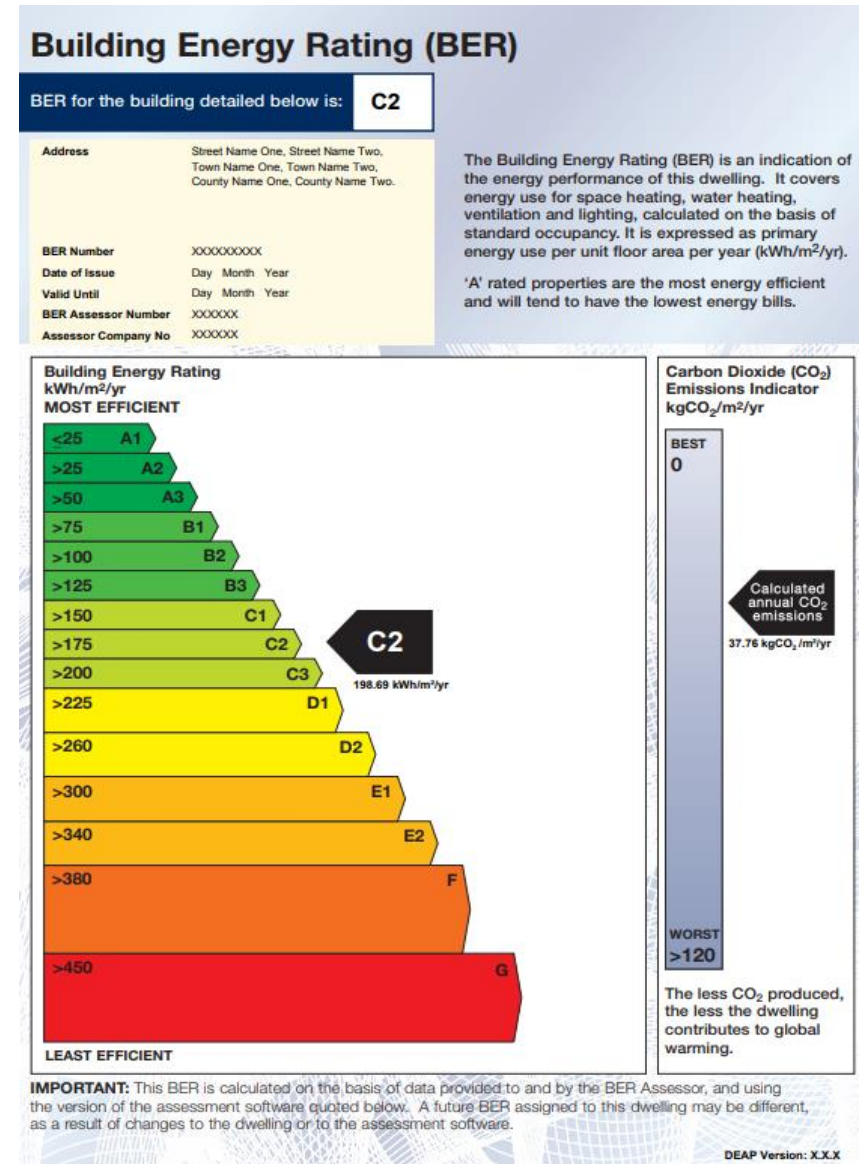
# Data Sources

1. **Building Energy Ratings (BER's):** Proxy for energy efficiency of building materials
2. **Mobile Consumer Experience Survey (MCE):** Mobile signal issues, Respondent demographics
3. **Outdoor Mobile Coverage Map:** Mobile signal quality provided at each Eircode
4. **National Broadband Plan (NBP) Map:** Proxy for availability of fixed line coverage

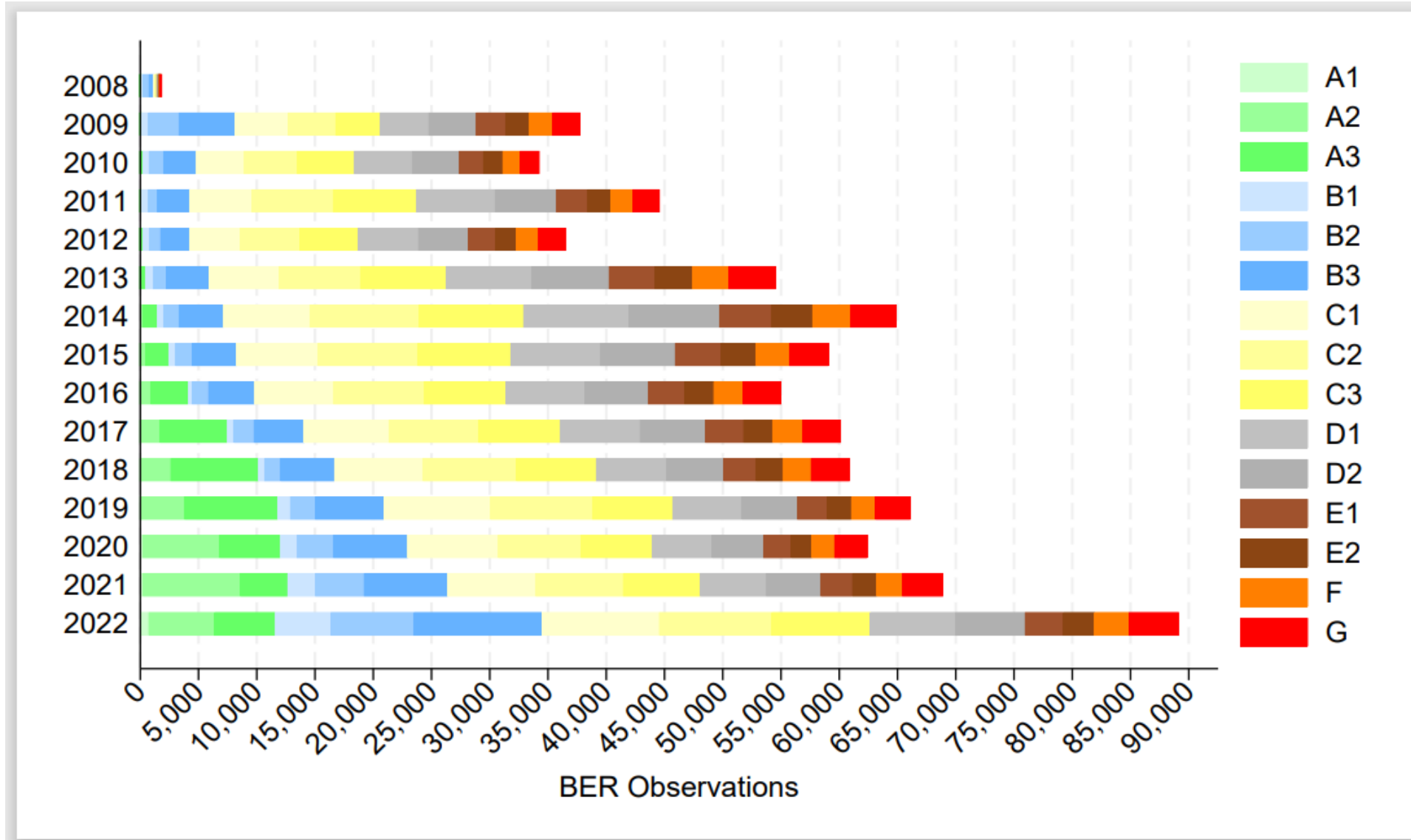
Linked together using Eircodes, and CSO Small Areas

# Building Energy Rating (BER)

- Score between 450-0 converted to a **15-point scale**
- Collected by Sustainable Energy Authority Ireland at a Small Area level
- Non-random selection into the BER database- conducted when house sold or upgraded but average 48.6 BER observations per small area
- We use BER's to **proxy building materials** that attenuate signal
- Not a perfect proxy-140 characteristics go into a BER, only some attenuate signal
- From Engineering Literature: **Foil backed insulation and metal frame windows** are the largest concern - likely only occur in A/B homes
- Key variable: Proportion of **B2 or higher** ratings per Small Area
- **Input: Building Materials Proxy**

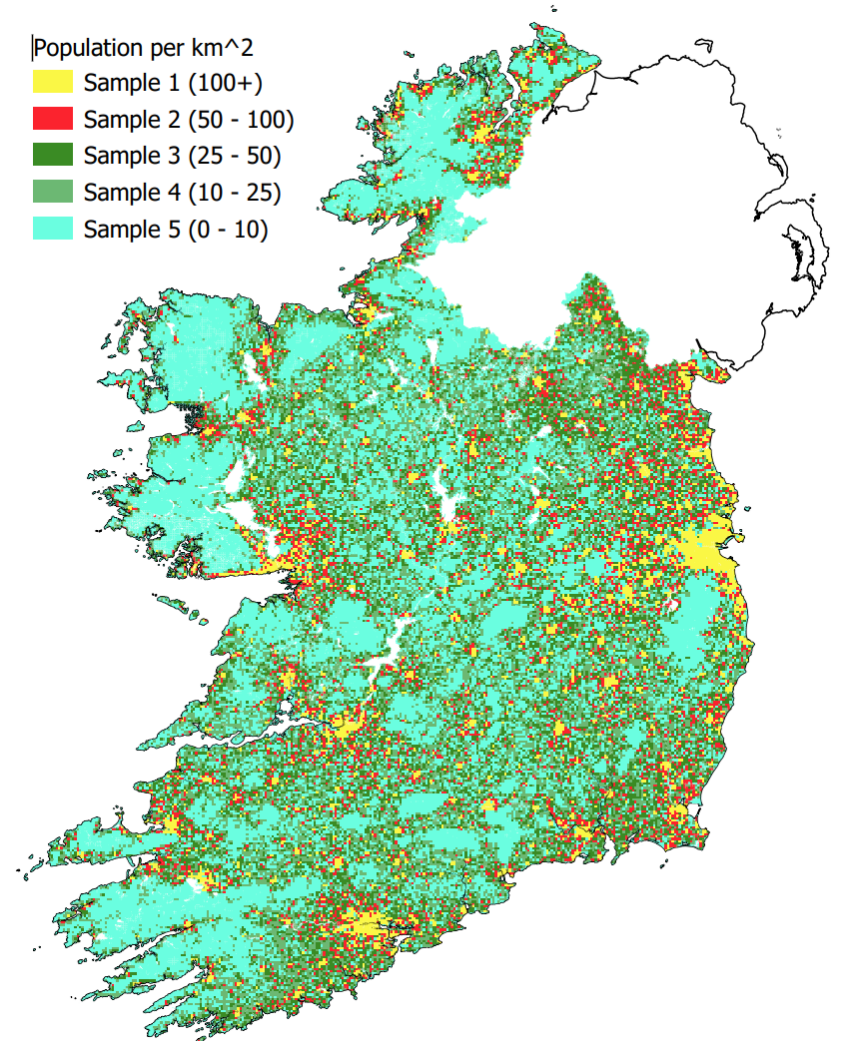


# Building Energy Rating (BER)



# Mobile Consumer Experience (MCE) 2022

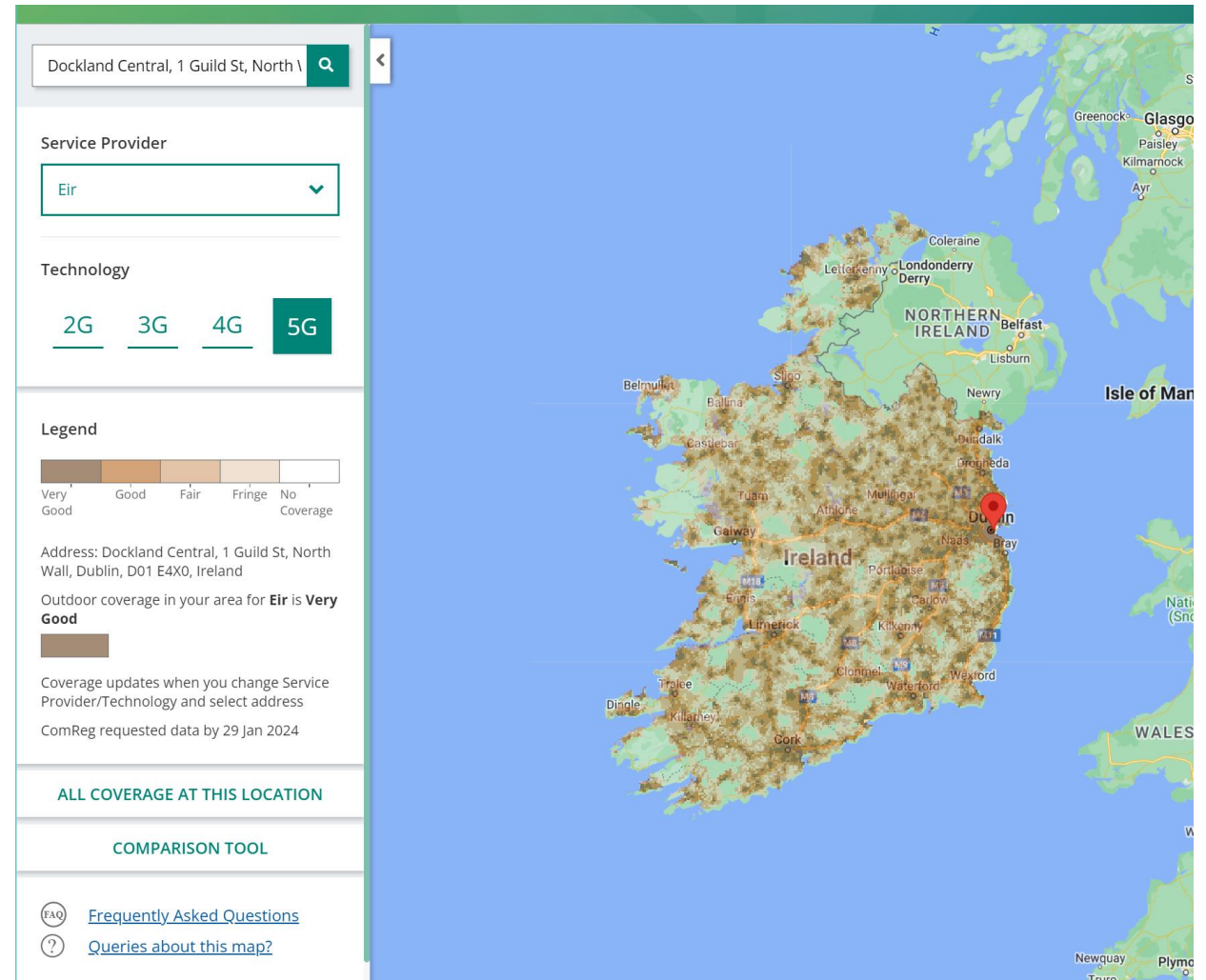
- Collected by ComReg in Q2 2022
- Sample split across 5 areas from most dense to least dense areas of the country
- Weighted towards more rural areas to focus on coverage
- Covers 2991 households, cleaned to 2728
- Collects demographics, operator, mobile model, issues
- Collects Eircodes
- **Inputs: Indoor coverage issues, Demographics**





# Outdoor Mobile Coverage Map

- The ComReg coverage map provides estimates on **outdoor** mobile coverage for each **operator and technology**
- Linked with the MCE at an Eircode level
- Covers 2G, 3G, 4G, 5G, although we exclude 3G
- From the MCE we know operator, allowing us to link **respondent's network operator coverage** to their address
- 5 scores: Very Good, Good, Fair, Fringe, No Coverage
- We assume a linear coverage relationship
- **Input: Outdoor Coverage**



# Fixed Line Coverage



- Fixed Line Coverage (ie. Wifi) can be a substituted for mobile coverage
- Note this **excludes** mobile broadband (MBB) which makes up 18.8% of broadband subscriptions which will still be impacted
- NBP intervention zones split the country into areas where high-speed broadband is commercially viable, or not
- We use NBP maps (Q2 2022) to proxy high-speed broadband availability captured as the percentage of addresses per Small Area which are in Excluded Area regions

# Descriptive Statistics

# Outcome: Issues

**“Thinking about your mobile phone experience over the past month, have you experienced a loss of signal (or no/poor coverage) when using the following services?”**

If yes then we asked:

**“How often did you experience a loss of signal in each of these locations?”**

- This allows us to get at specific in-home signal issues, rather than general signal issues
- We know from previous research consumers have trouble recalling specific details related to telecoms, so we coded any frequency of issue as having an issue
- Coded as a binary dummy (0 if no in-home issue, 1 if issue in-home)
- Only asking if they have an issue-not if they’ve done anything about it!

**30.7% of our sample (weighted) report experiencing an in-home QoS issue**

# Independent Variables: BER and Coverage

## BER Ratings

- Low number of A ratings
- 10.18% of ratings over a B2 (level required for retrofit grants)

## Outdoor Mobile Coverage

- Coverage based on **own network operator** split by 2G, 4G, and 5G
- Everyone has some level of 2G coverage, just 0.27% with no 4G
- 5G coverage is almost dichotomous

	2G	4G	5G
Very Good	67.16%	26.95%	48.69%
Good	27.37%	44.41%	20.24%
Fair	5.23%	23.9%	7.5%
Fringe	0.22%	4.48%	2.13%
No Coverage	0%	0.27%	21.44%







# Empirical Results

## Model

- Dependent Variable: Dummy variable for in-home mobile quality of service issue (*MCE*)
- Main independent variable: Proportion of B2 or higher rated BER's per small area (*BER*)
- Outdoor Mobile Coverage: 2G, 4G, 5G coverage levels for **own** operator (*Outdoor Coverage Map*)
- Demographic Variables: Urban/Rural Status, Age, Employment Status, Education (*MCE*)
- Fixed Coverage: Proportion of homes in intervention zone per small area (*NBP map*)

$$\begin{aligned} issue_{i,SA} = & \alpha + \beta BER_{SA} + \psi Rural_i \\ & + \lambda MobileCoverage_i + \tau FixedCoverage_{SA} \\ & + \phi Ind_i + \theta MobileDevice_i + \epsilon_{i,SA} \end{aligned}$$

# Empirical Results-Detailed Model

Variable		Final Model	QoS Issues
BER Rating	BER B2	<b>0.3331***</b>	
Coverage	2G	-0.0447*	
	4G	-0.0508**	
	5G	-0.0113	
Urban/Rural		0.0385	
Fixed Coverage		-0.0022***	
Over 65		-0.1343***	
Education	3 <sup>rd</sup> Level	Base	
	2 <sup>nd</sup> Level	-0.0112	
	Primary/No Formal	0.0862	
Employment Status	Employed	Base	
	Student	0.0304	
	Retired/Unemployed	0.0858**	

Being in a small area with all B2 or higher ratings is associated with an increase of 33.31% in reported issues, compared to an area with no B2 or higher ratings

Both 2G and 4G both associated with reduced reported issues

Being over 65 is associated with reduced reported issues

Being retired/unemployed is associated with increased reported issues. No other education or employment category is significant.





## Main Finding

Living in Small Areas characterised by higher proportions of energy efficient homes, significantly increases the probability of individuals reporting that they had experience an in-home quality of signal issue.

## Limitations

Imperfect measure of building materials:

1. BER's are only a proxy for signal attenuating building materials
2. BER is measured at a small area, not individual level
3. The BER system is not a random sample within small areas

There could be unobserved variables which jointly determine both reports of mobile signal issues and living in areas characterised by highly energy efficient homes.

Unobserved 'masking' such as mobile repeaters

# What does this mean?

## Building Materials and their effect on indoor mobile performance

Just ten years ago, we used our mobile phones mainly to make and receive calls and text messages.

These days, they have many more uses such as...

- online banking
- social media
- streaming music
- watching video

But at the same time, we have been building more energy efficient houses, or converting our homes to make them more energy efficient.

Improved building materials are great at keeping out the cold. But they can also block mobile phone signals from entering the home.

ComReg, has conducted tests on different construction materials to determine their effect on mobile phone signals.

The results showed that energy efficient insulation materials can have a significant effect on making or receiving calls within your home.

- Materials containing metal - such as foil-backed insulation or windows with metal frames have the biggest loss of mobile phone signal entering or leaving the home (up to 3 million times reduction in signal).
- Blocks and roof tiles were found to have a minor reduction of signal power received in the home (up to 200 times).

One solution to poor indoor reception is to install a **mobile phone repeater**. These devices pick up mobile signals and amplify them indoors. While these devices work on all mobile phones and operator networks, only compliant devices are legal to use in Ireland.

A second solution is known as **Native Wi-Fi** - this works by your smart phone connecting to your mobile operator's network through your Wi-Fi connection without the need for using apps to make and receive calls and texts.

## Policy Implications

- ComReg has permitted the use of some Mobile Phone Repeaters
- Substitution towards Fixed Line (ie. WiFi), enabling WiFi calling on mobile devices
- Re-allocation of lower spectrum bands across Europe (ie. 700MHz) which are less attenuated by materials. E.G. MBSA2 in Ireland
- Building regulations with signal attenuation characteristics?
- This may apply to **all** buildings (not just residential)
- Could be an issue going forward (5G rollout, more energy efficient homes, growth in mobile data usage)
- Alignment of climate change mitigation policy and telecommunication policy will be key.

A row of modern, two-story townhouses with light-colored siding and dark roofs, set against a clear blue sky. The houses are arranged in a line, and the image is slightly blurred. The word "Questions?" is overlaid in the center in a large, bold, black font.

**Questions?**

# Appendix

	(1)	(2)	(3)	(4)
B2 Share	0.4027*** (0.1101)	0.3275*** (0.1053)	0.3331*** (0.1029)	0.3115*** (0.0997)
Region: Urban	0.0000 (.)	0.0000 (.)	0.0000 (.)	0.0000 (.)
Region: Rural	0.0840*** (0.0288)	0.0375 (0.0317)	0.0385 (0.0315)	0.0506 (0.0309)
2G Mobile Coverage	-0.0513* (0.0276)	-0.0479* (0.0272)	-0.0447* (0.0265)	-0.0446* (0.0259)
4G Mobile Coverage	-0.0520** (0.0206)	-0.0516** (0.0207)	-0.0508** (0.0201)	-0.0473** (0.0197)
5G Mobile Coverage	0.0095 (0.0082)	0.0136* (0.0080)	0.0113 (0.0079)	0.0112 (0.0078)
Fixed Coverage		-0.0021*** (0.0005)	-0.0022*** (0.0005)	-0.0022*** (0.0005)
Age: Under 65			0.0000 (.)	0.0000 (.)
Age: 65+			-0.1343*** (0.0355)	-0.1094*** (0.0354)
Employment Status: Employed			0.0000 (.)	0.0000 (.)
Employment Status: Student			0.0304 (0.0812)	0.0074 (0.0817)
Employment Status: Other			0.0858** (0.0353)	0.0879** (0.0351)
Education: High			0.0000 (.)	0.0000 (.)
Education: Medium			-0.0112 (0.0300)	0.0031 (0.0299)
Education: Low			0.0862 (0.0717)	0.1109 (0.0709)
Mobile Device: No 5G				0.0000 (.)
Mobile Device: 5G Enabled				-0.0700* (0.0400)
Mobile Device: Missing				-0.0163 (0.0310)
Wifi-Calling: Never/Don't Know				0.0000 (.)
Wifi-Calling: Less than Weekly				0.1132** (0.0556)
Wifi-Calling: More than Weekly				0.1135*** -----

	%
<b>Any Home Signal Issues</b>	
No	0.69
Yes	0.31
<b>2G Operator Coverage</b>	
None/Fringe/Fair	0.05
Good	0.27
Very Good	0.67
<b>4G Operator Coverage</b>	
None/Fringe	0.05
Fair	0.24
Good	0.45
Very Good	0.27
<b>5G Operator Coverage</b>	
None/Fringe	0.23
Fair	0.07
Good	0.20
Very Good	0.49
<b>Mobile Device</b>	
No 5G	0.47
5G Enabled	0.18
Missing	0.35
<b>Wi-Fi Calling</b>	
Never/Don't Know	0.31
Less than Weekly	0.07
More than Weekly	0.62
<b>Age</b>	
Under 65	0.81
65+	0.19
<b>Regional Classification</b>	
Urban	0.66
Rural	0.34
<b>Education Status</b>	
High	0.52
Medium	0.43
Low	0.06
<b>Labour Market Status</b>	
Employed	0.64
Student	0.05
Other	0.31