Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
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Unlicensed Use of the 6 GHz Band	)	ET Docket No. 18-295
	)	
	)	
Expanding Flexible Use in Mid-Band	)	GN Docket No. 17-183
Spectrum Between 3.7 and 24 GHz	)	
	)	

COMMENTS OF THE LEADING BUILDERS OF AMERICA

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The Leading Builders of America, ("LBA"), pursuant to 47 C.F.R. §§ 1.415, 1.419, respectfully submits these comments in response to the Commission's Notice of Proposed Rulemaking[1] in this docket. The Leading Builders of America include many of the nation's largest homebuilders.[2] In 2015, LBA members sold more than 155,000 new homes and produced more than 462,000 jobs. Our members have come together with the goal of preserving home affordability by carefully evaluating public policy at all levels of government. LBA's primary areas of advocacy include support for the economic recovery, advancing energy efficiency in residential construction, promoting adequate capital capacity for home mortgages and advocacy for the mortgage interest deduction. Our member companies provide homes, both single-and-multi-family, for the full gamut of American homebuyers. First-time and active-adult homebuyers alike enjoy our members' leading construction quality, energy efficiency and design.

I. INTRODUCTION AND SUMMARY

To best determine the degree to which indoor unlicensed use of the 6 GHz band might cause harmful interference to incumbent licensees, the Commission asks whether contemporary building codes and practices, especially with respect to modern energy efficiency standards, impact signal building entry

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[1] *Unlicensed Use of the 6 GHz Band and Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz,* Notice of Proposed Rulemaking, FCC No. 18-147, ET Docket No. 18-295 and GN Docket No. 17-183 (rel. October 24, 2018), https://ecfsapi.fcc.gov/file/1024814219781/FCC-18-147A1.pdf (last visited Dec 20, 2018) (hereafter "6 GHz NPRM").

[2] Member companies include Ashton Woods, KB Home, Shea Homes, Beazer Homes, Lennar, Taylor Morrison, Brookfield Residential, Richmond American Homes, Drees Homes, Pulte Group, Meritage Homes, Toll Brothers, David Weekley Homes, M/I Homes, TriPointe Homes, D.R. Horton, Perry Homes, Woodside Homes, and Hovnanian Enterprises.

and exit loss. They do. In fact, over time, national, state, and local building codes have become more stringent in terms of the energy and thermal efficiency, a trend that is likely to continue. The International Telecommunications Union's ("ITU") definition of a "thermally efficient" building, applies to any home built to comply with modern U.S. efficiency standards. These modern energy efficient features have been found by the ITU to significantly increase signal loss. The trend towards greater thermal efficiency is so pronounced that today, builders of new residential homes routinely use construction materials and techniques in the outer building envelope which the ITU found tend to impact signal loss. These materials include metal coated windows (including thermal coated & low emissivity ("Low E") windows); double-pane windows; window fitting (thermal panes); stone, cement, and brick siding; and metal foil barriers used in roof lining and in modern insulation of cavity walls.

Production home builders like the members of the Leading Builders of America care about unlicensed spectrum generally and this proceeding in particular because consumers demand WiFi-enabled new homes. New residential homes offer automated features that rely on increasingly more unlicensed spectrum for WiFi and IoT applications. Increased bandwidth demands for in-home functionality require more unlicensed spectrum.

Greater broadband data capacity delivered to the home by residential broadband providers, and greater bandwidth demand from devices within the home, both must traverse an unlicensed wireless connection through an access point inside the home. Increasing throughput demands on the in-home, unlicensed wireless link require additional unlicensed spectrum to optimize performance. For all of these reasons, the above-captioned proceeding impacts LBA and all home builders directly.

II. THE COMMISSION SHOULD APPLY CURRENT -- AND INCREASINGLY STRINGENT -- NATIONAL, STATE, AND LOCAL BUILDING CODES FOR NEW RESIDENTIAL CONSTRUCTION WHEN CALCULATING BUILDING ENTRY AND EXIT LOSS.

The Commission asks what assumptions should be made when calculating potential interference to outdoor incumbent licensees from indoor unlicensed devices in the 6 GHz band.[3] To answer that

[3] 6 GHz NPRM at ¶70.

question accurately, the Commission should understand home builders' use of materials and building techniques, and how such construction impacts building signal entry and exit loss ("BEL" or "entry loss").[4]

The Commission refers to ITU testing for the proposition that different building materials tend to impact entry loss. The Commission can use elements of the ITU reports to identify how building materials, construction techniques and other factors impact BEL but then should apply those factors to contemporary U.S. national, state and local building codes[5] in order to more accurately calculate potential interference from indoor unlicensed use across the entire 6 GHz band.

A. The ITU identifies physical aspects of home composition that impact building entry loss in the 5 GHz and higher bands.

The Commission refers to ITU reports showing different signal propagation characteristics for "traditional" and "thermally efficient" building standards. The Commission notes, "the ITU model shows a median [entry loss] of approximately 18 dB for traditional construction and 30 dB for thermally

[4] Building Exit/Entry Loss, hereafter "BEL". ITU-R Study Group 3, in charge of characterizing radio wave propagation, has defined Building Entry Loss (BEL) as, "the additional loss due to a terminal being inside a building." Due to reciprocity, exit loss is the same as entry loss. This additional loss is attributed to a combination of effects including reflections, diffraction, and higher attenuation of building material compared to air. According to the ITU, building material, especially metal frames, concrete and, more recently, metal-coated glass are main contributors to propagation impairments in and around buildings. The ITU explains that due to the interaction of radio waves with the medium they travel through, the degree of impairment due to buildings is frequency-dependent. See ITU-R, Radiocommunication Sector of ITU, Recommendation ITU-R P.2040.1, Effects of building materials and structures on radiowave propagation above about 100 MHz, Annex 2, Section 3.1 1–32 (2015), https://www.itu.int/dms_pubrec/itu-r/rec/p/R-REC-P.2040-1-201507-I!!PDF-E.pdf (last visited Jan 15, 2019).

[5] The Building Codes Assistance Project describes national model codes establishing the following: "in the United States, national model energy codes were created in response to the energy and economic crises of the 1970s. In 1978, Congress passed the National Energy Conservation Policy Act, which required states that received federal financial assistance to initiate energy efficiency standards for new buildings. In 1992, Congress passed the Energy Policy Act (EP Act), which upped the ante by requiring states to certify that their energy efficiency standards meet or exceed the most efficient model energy codes (developed in response to the 1978 mandate), as determined by the U.S. Department of Energy." See Kamaria Greenfield, Codes, Standards and Rating Systems BCAPCodes.Org (2014), http://bcapcodes.org/codes-standards-rating-systems/ (last visited Feb 12, 2019). See also, U.S. Department of Energy, Building Energy Codes Program, "Residential Code Development" EnergyCodes.gov (2014), https://www.energycodes.gov/development/residential (last visited Jan 22, 2019).

efficient construction."[6] In other words, the ITU observes greater signal loss from more energy efficient buildings.

According to the ITU, building entry loss[7] depends on a combination of effects related to building type, building techniques, and construction materials.[8] The ITU reports provide experimental data on the relationship between thermal insulation and entry loss[9] and conclude that "where modern, thermally efficient building methods (such as metalised glass, foil-backed panels and cavity wall insulation) are used" building entry loss is generally significantly higher than for 'traditional' buildings without such materials."[10]

In particular, the ITU's experiments sampled buildings constructed using modern "green" materials[11] found in home insulation used in the U.S. today. The ITU provided specific analysis of the

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[6] 6 GHz NPRM at ¶70. See also, ITU-R, Radiocommunication Sector of ITU, Recommendation ITU-R P.2109-0, Prediction of building entry loss, 1–6 (2017), https://www.itu.int/rec/R-REC-P.2109/en (last visited Jan 16, 2019), Annex 1, Section 2.1, "Classification of building type," at p. 2

[7] ITU studies focused on the building entry losses (BEL) introduced by the building itself. In its examination, the ITU looked at BEL in structures similar to a modern U.S. residential building as well as in buildings constructed "with a focus on environmental factors, e.g. a lot of recycled/energy efficient material and low E glass windows." See ITU-R, Radiocommunication Sector of ITU, Recommendation ITU-R P.2346-2, Compilation of measurement data relating to building entry loss, 1–280 (March 2017), https://www.itu.int/pub/R-REP-P.2346-2-2017 (last visited Jan 15, 2019), Section 13.2.1, "Building Entry Loss from 5-32 GHz," at p. 67 (hereafter "Recommendation ITU-R P.2346-2")

[8] The ITU uses two classification types: "thermally efficient" and "traditional," categories distinguishable by the substantially higher BEL for thermally efficient buildings. The ITU also points out that for the purpose of assessing BEL, "the thermal efficiency of the complete building (or the overall thermal efficiency)" is important to consider. In light of the fact that the ITU classification refers to the thermal efficiency of whole buildings, it makes sense that BEL takes the combined effects of constituent building materials into account. See ITU-R, Radiocommunication Sector of ITU, Recommendation ITU-R P.2109-0, Prediction of building entry loss, 1–6 (2017), https://www.itu.int/rec/R-REC-P.2109/en (last visited Jan 16, 2019), Annex 1, Section 2.1, "Classification of building type," at p. 2 (hereafter "Recommendation ITU-R P.2109-0")

[9] 6 GHz NPRM ¶70.

[10] Recommendation ITU-R P.2346-2, Section 13, "Building Entry Loss from 5-32 GHz," at pp. 66-67. See 6 GHz NPRM at para. ¶70, p. 26. According to the ITU, as modern insulation was added to an uninsulated house, entry loss increased. Based on additional ITU testing conducted in the United States, buildings maximizing thermal efficiency showed significantly higher increases in entry losses. See also, Recommendation ITU-R P.2346-2, Section 24.2.1 "Building descriptions" p. 206

[11] Recommendation ITU-R P.2346-2, Section 13 "Building Entry Loss from 5-32 GHz"

components used in the construction of the building envelope including siding,[12] sheeting,[13] roofing,[14] flooring[15] and interior/exterior walls construction[16]. Buildings sampled in the ITU's testing varied in terms of the building components, with samples including composite materials like concrete,[17] brick,[18] plasterboard (metal stud)[19] and vinyl.[20]

The key findings of the ITU's experiments relate to losses attributed to the building itself which, on its own, introduces a combination of variables related to reflections[21] and diffraction properties[22] of building construction materials.[23] The ITU also discussed the impact of "insulation fitting" methods and building techniques integrating foil-backing[24] (i.e., "metallic thermal insulation fitting").[25]

Composite construction materials, particularly concrete, insulation and metal-coated glass were shown by the ITU to significantly impact building entry loss.[26] Construction techniques related to the design and the insulation characteristics of windows in a home were also shown to significantly impact

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12 Recommendation ITU-R P.2346-2, Section 13.2.1, "Building descriptions," at p. 67

13 Ibid.

14 Recommendation ITU-R P.2346-2, Section 13.4, "Tables of Building Parameters," Table 30 "Measurement parameters for Building 1," at p. 82. See also, Section 13 "Building Entry Loss from 5-32 GHz," at p. 66

15 Recommendation ITU-R P.2346-2, Section 13.4, "Tables of Building Parameters," Table 31 "Measurement parameters for Building 3," at p. 84

16 Recommendation ITU-R P.2346-2, Section 23.4.2, "Modern Construction Houses" at p. 201

17 Recommendation ITU-R P.2346-2, Section 13.4, "Tables of Building Parameters," Table 31 "Measurement parameters for Building 3," at p. 84

18 Ibid.

19 Recommendation ITU-R P.2346-2, Section 13.4, "Tables of Building Parameters," Tables 30, 31 & 32 at pp. 82 - 84

20 Recommendation ITU-R P.2346-2, Section 13.2.1, "Building descriptions," at p. 67

21 Recommendation ITU-R P.2346-2 at pp. 24-25

22 Ibid.

23 Recommendation ITU-R P.2346-2 at pp. 64-65

24 Experimental results from the ITU's small house testing case show that building methods incorporating a, "combination of foil-backed insulation and metalised double glazed windows (representative of a well-insulated property), added 5-10 dB to the building entry loss" and that an additional 5 dB of screening was obtained, "when, in addition, all windows and door apertures were covered by foil" approximating a whole building figure for building entry loss. See Recommendation ITU-R P.2346-2, Section 6.5 "Impact of insulating materials on loss" at p. 28, see *also* Section 6 "Impact of thermally insulating materials (88 MHz – 5.8 GHz)" at 25

25 Recommendation ITU-R P.2346-2, Section 13.4, "Tables of Building Parameters," Tables 30, 31 & 32 at pp. 82 - 84

26 Recommendation ITU-R P.2346-2, Section 12, "Measurements at 5.2 GHz" at p. 65

BEL.[27] Fenestration elements tested in the ITU's studies included factors like window coating (inclusive of double, triple glazing and thermal coating),[28] the effect of double and single pane windows,[29] and window-fitting methods (thermal insulation fitting, thermal panes).[30] Here, the findings reflect the fact that window characteristics necessarily influence the quality of insulation in the whole home.[31] Other related factors included the thickness of interior/exterior walls and flooring.[32]

Thus, the building materials and techniques identified by the ITU to most significantly impact building entry loss, particularly with respect to thermal insulation,[33] are as follows:

- Metalised double-glazing on windows (reflective thermal coating, & triple glazing techniques)
- Low E glass windows, (windows covered by thin metal coating)
- Double-paned Low-E glass windows
- Thermal insulation window fitting (thermal panes)
- Modern-insulation techniques, using recycled/energy efficient materials
- Stone, cement and brick
- Construction focused on environmental factors, use of "green materials"

[27] The ITU describes specific measurements produced and the impact of metallic coating, here they say, "the median excess loss increases more than 5 dB with frequency. This increase may partly be explained by shielding due to metallic window coating which attenuates the received signal substantially more at 5.1 GHz than at the other frequencies. See Recommendation ITU-R P.2346-2 at Section 8.2 "Measurements in Stockholm at 0.5 to 5 GHz - General Results" at p. 31.

[28] Recommendation ITU-R P.2346-2, Section 6.5, "Impact of insulating materials on loss" at p. 28

[29] Recommendation ITU-R P.2346-2, Section 13.4, "Tables of Building Parameters," Tables 30, 31 & 32 at pp. 82 - 84

[30] Recommendation ITU-R P.2346-2, Section 6.5 "Impact of insulating materials on loss" at p. 28. See also, Section 6 "Impact of thermally insulating materials (88 MHz – 5.8 GHz)" at p. 25. With regard to metal coating and multiple layers of thermal coating, the ITU says, "There also is a reflective thermal coating on the windows to help keep the building cool in the summer and warm in the winter. This coating as well as the low E glass seems to have a large effect on the transmission of signals into/out of the building…" See Recommendation ITU-R P.2346-2, Section 24.2.1 "Building descriptions" at p. 206.

[31] Measurements taken by the ITU in a UK office at 5.2 GHz show high significance for "the kind of window" used in a structure. The ITU specifically highlights "coated glass" saying, "if all windows in the office had been of the coated glass kind, then at least 20 dB higher excess loss would be expected and the coverage would be significantly more limited. Thus, the deployment opportunities strongly depend on the specific location and the kind of windows that are present." See Recommendation ITU-R P. 2346-2, Section 12 "Measurements at 5.2 GHz" at p. 65

[32] Ibid.

[33] Recommendation ITU-R P.2346-2, Section 6, "Impact of thermally-insulating materials (88 MHz - 5.8 GHz)" at p. 25. See also, Ibid at Section 12 "Measurements at 5.2 GHz" at p. 65 & Section 13.2.1, "Building descriptions" at p. 67 & Section 24, "BEL from 5-39 GHz in the United States" at p. 207

B. The Commission should use the ITU reports only as a starting point and should apply contemporary U.S. national, state, and local building codes to more accurately reflect domestic thermally efficient building standards

The Commission acknowledges that the ITU classifications of "thermally efficient" and "traditional" refer "purely to the thermal efficiency of construction materials and makes no assumption regarding the year of construction, type (single or multi-floors), heritage or building method.[34] ITU models are based on broad testing conducted in a number of countries including Australia, China, France, Japan, Sweden, the U.S. and the UK. Moreover, the ITU tested broad spectrum ranges, reporting results for frequencies from 5 to 39 GHz, for example. Studies conducted in the United States offered more data but excluded the 6 GHz band specifically. The research design for U.S. based experiments reported BEL for the 5, 12, 20, 25 and 30 GHz bands only.[35] The Notice cites ITU estimates from a report testing building entry loss at frequencies in an even broader range, "between about 80 MHz and 100 GHz."[36]

Thus, the ITU reports cover too broad a range of countries and spectrum frequencies to adequately inform the Commission about building entry loss in modern U.S. construction. To do that, the Commission must look at contemporary national, state, and local building codes in the U.S. for guidance regarding the use of relevant building materials.

III. CONTEMPORARY U.S. NATIONAL, STATE, AND LOCAL BUILDING CODES COMPEL WIDESPREAD USE OF BUILDING MATERIALS AND CONSTRUCTION TECHNIQUES THE ITU FOUND TO INCREASE BUILDING ENTRY LOSS.

A. Building codes in the U.S. increasingly require greater thermal efficiency in home construction.

Builders and developers incorporate materials that improve upon the thermal insulation of the whole home envelope in order to meet state and municipal-level building code requirements designed to reduce home energy consumption.[37] An important factor affecting home energy consumption in building

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[34] NPRM at fn. 151 <u>citing</u> ITU Recommendation P.2109

[35] Recommendation ITU-R P.2346-2, Section 24.1, "BEL from 5-39 GHz in the United States" at p. 206

[36] Recommendation P.2109-0 at p. 1

[37] The DOE says of energy efficient material usage, "buildings that comply with an energy code will have higher levels of efficient materials and systems…." <u>See</u> U.S. Department of Energy, Building Energy Codes 101: An

construction is the thermal performance of the building envelope.[38] Building code requirements are specific about thermal insulation levels in the home envelope, which includes the floor, foundation, ceiling and walls. Builders make determinations about material selection and techniques to improve insulation depending on the local climate and construction costs.[39] This varies to some degree among U.S. climate regions from the upper Midwest and Northeast, to the West and Southwest, to the Southeast and southern Florida.[40]

Introduction, Report 1–33 (2010), http://www.energycodes.gov/sites/default/files/documents/BECP_Building%20Energy%20Codes%20101_February 2010_v00.pdf (last visited Jan 22, 2019), "What do codes mean for the builder?" at p.15. See also, Martha VanGeem & Ryan Colker, Whole Building Design Guide, Energy Codes and Standards, Resources > Energy Codes and Standards WBDG.Org, National Institute of Building Sciences (2016), https://www.wbdg.org/resources/energy-codes-and-standards (last visited Jan 22, 2019).

[38] Simona Paraschiv, Spiru Paraschiv & Ion Ion V., *Increasing the energy efficiency of buildings by thermal insulation: International Scientific Conference "Environmental and Climate Technologies," CONECT 2017,10–12 May 2017, Riga, Latvia*, 128 Energy Procedia 393–399 (2017), https://www.sciencedirect.com/science/article/pii/S1876610217338882 (last visited Jan 21, 2019).

[39] "The builder must select products and materials that best fit the design of the building and satisfy the requirements of the energy code. For example, the builder may use 2" X 6" studs (instead of 2" X 4") for walls in a home so that higher levels of insulation can be installed to meet the code." See U.S. Department of Energy, Building Energy Codes 101: An Introduction, Report 1–33 (2010), http://www.energycodes.gov/sites/default/files/documents/BECP_Building%20Energy%20Codes%20101_February 2010_v00.pdf (last visited Jan 22, 2019), at Slide 19.

[40] See Figure 2. Florida attic insulation moved from R-30 to R-38. R-38 (24 inches thick versus R-30 which is 23 inches thick). There are regional differences in state level adoption of the national model energy codes. The Model Energy Code (MEC), maintained by the International Code Council as the IECC (the International Energy Conservation Code) is certified by the D.O.E. and is voluntary for residential and commercial buildings but almost every major municipality adopts a recent version of the model code. For Federal and State buildings receiving federal funds adherence to the model energy codes is mandatory.

The U.S. Department of Energy's ("D.O.E.") Building Energy Codes program certifies minimum efficiency standards which often are more stringent[41] with each new version of the IECC code.[42] The D.O.E. is required by law to publish a final determination stating that the latest version of the IECC[43] building code for low-rise residential buildings improves energy efficiency over the previous edition.[44] According to the D.O.E., homes built to the 2009 standard used 15 to 20 percent less energy than homes

[41] The Code of Federal Regulations (CFR) requires the Department of Energy to make determinations regarding residential codes. According to the underlying statute, "whenever CABO Model Energy Code, 1992, (or any successor of such code) is revised, the Secretary shall, not later than 12 months after such revision, determine whether such revision would improve energy efficiency in residential buildings. The Secretary shall publish notice of such determination in the Federal Register." See 42 U.S.C. § 6833. See also, Rosemarie Bartlett & Bob Schultz, Energy Codes 101/ "What's New in Codes?," PowerPoint Slides, National Energy Codes Pre-conference, July 15, 2018, Austin, TX, https://www.energycodes.gov/sites/default/files/documents/NECC2018_Codes_101_Whats_New.pptx (last visited Jan 23, 2019). The Consortium for Energy Efficiency, among others, support the notion that, "energy efficiency building codes across the United States and Canada are becoming increasingly stringent." See Alice Rosenberg, Residential New Construction Initiative 1–41 (2018), https://library.cee1.org/system/files/library/13436/CEE_ResNewConstruction_Initiative_16Jan2018.pdf (last visited Jan 25, 2019) at p. 17.

[42] Herein, "IECC" refers to the International Energy Conservation Code, a national model energy code certified by the D.O.E.

[43] Department of Energy, DOE Position on Energy Efficiency and Renewable Energy in Residential Building Energy Codes During the 2018 IECC Code Development Cycle (2018), https://www.energycodes.gov/sites/default/files/DOE%20Position%20Brief%20for%20the%202018%20IECC_10062016.pdf (last visited Jan 21, 2019). See Energy Department & Federal Register, Energy Efficiency Standards for the Design and Construction of New Federal Low-Rise Residential Buildings' Baseline Standards Update FederalRegister.Gov (2017), https://www.federalregister.gov/documents/2017/01/10/2017-00025/energy-efficiency-standards-for-the-design-and-construction-of-new-federal-low-rise-residential (last visited Jan 19, 2019). See also, Energy Department & Federal Register, Energy Efficiency Standards: Design and Construction of New Federal Low-Rise Residential Buildings' Baseline Standards Update FederalRegister.Gov (2017), https://www.federalregister.gov/documents/2019/01/29/2017-00242/energy-efficiency-standards-design-and-construction-of-new-federal-low-rise-residential-buildings (last visited Jan 21, 2018).

[44] Pursuant to federal law, "Not later than 2 years after October 24, 1992, each State shall certify to the Secretary that it has reviewed the provisions of its residential building code regarding energy efficiency and made a determination as to whether it is appropriate for such State to revise such residential building code provisions to meet or exceed CABO Model Energy Code, 1992." See 42 US Code, Section 6883(a)(1). In addition, federal law requires any revision to the code "improve energy efficiency in. The Secretary shall publish notice of such determination in the Federal Register." See 42 U.S.C. § 6883(a)(1). See also, Legal Information Institute, 42 U.S. Code § 6833. Updating State building energy efficiency codes Law.Cornell.Edu (2019), https://www.law.cornell.edu/uscode/text/42/6833#fn003406 (last visited Jan 20, 2019). See also, U.S. Department of Energy, Building Energy Codes Program, "Residential Code Development" EnergyCodes.gov (2014), https://www.energycodes.gov/development/residential (last visited Jan 22, 2019).

following the 2006 standard[45] and the building codes published in 2012 decreased home energy consumption by 30 percent.[46]

The U.S. utilizes national building codes and updates them every three years, often increasing energy efficiency standards.[47] States and municipalities have adopted various editions of the IECC model energy code. Of the states implementing the national model code, only two states are operating at energy efficiency levels less than the 2009 national model energy code.[48] A number of states, including California,[49] Oregon, Washington and Massachusetts, are more energy efficient than the 2012/2015 IECC

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[45] RESNET, Energy Rating Index Performance Path: HERS Index Scores and Versions of the IECC (2018), http://www.resnet.us/uploads/documents/EnergyRatings_FactSheet6_Final.pdf (last visited Jan 21, 2019). See also, Department of Energy, DOE Position on Energy Efficiency and Renewable Energy in Residential Building Energy Codes During the 2018 IECC Code Development Cycle (2018), https://www.energycodes.gov/sites/default/files/DOE%20Position%20Brief%20for%20the%202018%20IECC_10062016.pdf (last visited Jan 21, 2019).

[46] U.S. Department of Energy, Building Energy Codes 101: An Introduction, Report 1–33 (2010), http://www.energycodes.gov/sites/default/files/documents/BECP_Building%20Energy%20Codes%20101_February

[47] "The U.S. Department of Energy's (DOE's) Building Energy Codes Program (BECP) was created in response to congressional direction in ECPA to promote energy efficiency in buildings through energy codes. Since then, BECP has supported the development and adoption of model energy codes, and encouraged compliance with those codes through various educational and tool-development activities. […] The most recent three editions of the IECC and ASHRAE Standard 90.1 have the potential to generate almost a 30% reduction in energy use compared to codes a decade ago" See RA Athalye et al., Impacts of Model Building Energy Codes 1–58 (2016), https://www.energycodes.gov/sites/default/files/documents/Impacts_Of_Model_Energy_Codes.pdf (last visited Jan 21, 2019).

[48] Of the states implementing the national codes, two states, Arizona and Tennessee are operating at energy efficiency levels less than the 2009 national model code, see Figure 2. The Home Energy Rating System (HERS) index, a nationally recognized energy ratings index provides a performance-based pathway for builders to meet IECC standards. Comparing the HERS index ratings over time illustrates the trend toward greater energy efficiency in residential home construction. According to RESNET Executive Director Steve Baden, over 206,000 homes were HERS rated in 2016 and "homebuilders are increasingly seeing energy efficiency as a major selling point for buying a new home. To take advantage of this opportunity, builders across the nation are presenting their homes' energy performance in a way that every home buyer can understand, the home's HERS Index Score. *I expect that this trend will continue.* It is particularly encouraging that the average HERS Index Score was 61. This is 39% more efficient than homes built as recently as 2006 and 69% more efficient than a typical home built in 1970. I congratulate the energy smart builders, HERS Raters and program sponsors that are leading the trend to mainstreaming high performance homes in the marketplace." See Laurel Elam, Record Number Of Homes HERS Rated In 2016 Over 206,000: Residential Energy Services Network Resnet.Us.Blog (2017), [emphasis added] http://www.resnet.us/blog/record-number-of-homes-hers-rated-in-2016-over-206000/ (last visited Jan 21, 2019).

[49] Patrick Sisson, How California builders are adapting to state's super-strict energy mandates Curbed.Com (2018), https://www.curbed.com/2018/3/23/17157208/california-construction-building-code-solar-home (last visited Feb 4, 2019).

baseline.[50] Comparing various editions of the national model code over time illustrates a trend toward greater energy efficiency and less energy use.[51]

D.O.E. is implementing its 2020 goal[52] to reduce residential home energy consumption by pushing energy efficiency standards to the states through the national model energy code. Over the past five years, there has been an increase in the number of states adopting building codes more tightly aligned with the national model codes. Each year, a greater number of states are catching up with the national efficiency standards. The number of states adopting IECC standards released after the 2009 IECC has also increased in the past five years.

California, one of the country's biggest home construction markets, has adopted efficiency standards more stringent than the national codes, as have Washington, Oregon and Massachusetts.[53] In the last five years, states in the Midwest region, including Michigan, Illinois, and Indiana, have adopted tighter state building codes, aligning themselves more closely with the national standard. In general, state-level codes are not far behind the national standard. Thus, the states, including localities, are adopting ever more stringent energy efficiency codes.

B. To meet the increasingly stringent energy efficiency building codes, home builders have deployed more of the building materials and construction techniques the ITU found to impact building entry loss.

As stated above,[54] the ITU studies provide a starting point for the Commission to determine how building materials impact building entry loss and therefore impact whether indoor use of unlicensed 6 GHz spectrum would cause harmful interference to incumbent licensees. These items include modern insulation integrating metal foil layers, the use of "green materials," stone (including concrete and brick), metal-coated (Low E) and double-paned (thermal pane) windows, and window fitting methods. To meet

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[50] See Figure 2.
[51] See Figure 1.
[52] Office of Energy Efficiency and Renewable Energy & Department of Energy, Home>>About the Office of Energy Efficiency and Renewable Energy Energy.Gov (2018), https://www.energy.gov/eere/about-office-energy-efficiency-and-renewable-energy (last visited Feb 1, 2019).
[53] See Figure 2.
[54] See supra § II.A.

national, state, and local building code requirements in the U.S., home builders over the last five years have used more of all the aforementioned items.

Insulation materials and thickness

Across the U.S., the home building industry is focused on the insulation quality of materials used in home construction in order to meet energy efficiency building codes, particularly in light of D.O.E.'s 2020 benchmark. Five years ago, home builders around the country built 2x4" exterior walls. Today, the depth of the wall cavity has increased by at least 50%, especially in colder climates. The contemporary standard is 2x6" -- 2" thicker -- to allow for better insulation. The home building industry has introduced better, more sophisticated methods of thermal insulation in U.S. homes, which incorporate modern insulation materials. Over the last 5 years, there has been a significant increase in the use of high-performing insulating materials, which maximize the thermal efficiency of the whole-home building envelope. This contrasts with building construction a decade ago when materials like plywood and vinyl were more prevalent in U.S. homes, and this trend of using thermally efficient materials will continue in future years.

Metal Foil

To improve the energy efficiency of the home envelope, builders use so-called radiant barrier layers. Compared to five years ago, radiant barrier layers are more frequently integrated into building components[55] and the most common material used is metal foil.

Over the last ten years, materials like oriented strand boards (OSB),[56] a common insulating material, have been enhanced by adding a thin-metal foil backing. The addition of the foil-layer in OSB maximizes the thermal efficiency of the building envelope. Today, homes are being framed with foil,

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[55] "In building applications, this surface is typically a very thin, mirror-like aluminum foil. The foil may be coated for resistance to the elements or for abrasion resistance. The radiant barrier may be one or two sided. One sided radiant barrier may be attached to insulating materials, such as polyisocyanate, rigid foam, bubble insulation, or OSB." Elizabeth Spencer, Home>>Weatherize>>Insulation>>Radiant Barriers Energy.Gov (2018), https://www.energy.gov/energysaver/weatherize/insulation/radiant-barriers) (last visited Feb 1, 2018).

[56] To improve wood utilization efficiency, oriented strand board (OSB) was developed; 80% of the wood removed from the forest can now be processed into marketable products. John Zerbe, Zhiyong Cai & George Harpole, An Evolutionary History of Oriented Strandboard (OSB) 1–10 (2015), https://www.fpl.fs.fed.us/documnts/fplgtr/fpl_gtr236.pdf (last visited Feb 4, 2018).

something not often seen five or ten years ago. Builders also install radiant barriers in roof sheathing, lowering the roof temperature and reducing the cost to heat or air-condition the home. Five years ago, someone looking up at the roof of a home under construction probably would see plywood. Today, she would see metalised foil. Almost all new homes built in the U.S. have metal foil lining on the inside surface of the roof.

Stone, cement, brick

Home builders in the past finished the exterior wall of a home with wood or vinyl siding. Today, they increasingly install cement siding or stone. Many new homes have brick siding. Nationwide, cement-based stone is used in siding more now than it has been at any other time.[57] In Florida, home builders over the last five years increasingly use external "block" construction, combining very thick cement block walls with radiant barriers. These building techniques are Florida-specific in that they comply with the windstorm building codes adopted by the state.

Metal coated and double-paned windows

In the span of five years, there has been a 100-fold increase in Low E windows in U.S. homes. Low E glass has a thin metal coating on the surface. This and other types of coating, including thermal coating, is used on windows and is more common today than it was five years ago. Energy efficiency standards have driven this shift to improve thermal insulation in the window envelope. Progressively stringent building codes impel builders to abandon single-window panes in favor of thermal panes, which are now the standard in home construction.

Window features are particularly important to the thermal efficiency of the whole home envelope. Double and triple coating on windows, whether with thermal coating or other insulating treatments, are more frequently used in U.S. homes because these windows insulate much more effectively than do

[57] Local ordinances require the use of certain materials like brick and stone. However, several localities require "masonry" and do not characterize cement siding as masonry. Local zoning ordinances that require a specific percentage of masonry ensure a standard of design throughout specified land uses, and these ordinances set a clear minimum requirement for all developers creating a level playing field for builders. In cases where cement siding is not considered masonry, builders use either stone, brick or stucco. This trend in local governance toward requiring builders to use specific materials is becoming more and more common. Local zoning ordinances that require a specific percentage of masonry ensure a standard of design throughout specified land uses, and these ordinances set a clear minimum requirement for all developers, creating a level playing field for builders.

windows without coating. Taking another example from southern Florida, builders have adopted thick double-paned impact glass, not only for energy efficiency purposes, but to "harden the house," and comply with the state's windstorm building codes.

Thus, as a result of ever more stringent national, state, and local building codes, requiring higher levels of thermal efficiency, home builders across the U.S. have used more and more of the materials and building techniques identified by the ITU to directly impact building entry loss. The Commission should use these contemporary, real-world facts when determining the likely impact to incumbent licensees from indoor unlicensed use across the entire 6 GHz band.

IV. CONCLUSION

The Commission should apply current – and increasingly stringent – national, state and local building codes for new homes when calculating outdoor emissions from indoor devices using all of the unlicensed 6 GHz band. The ITU reports cited by the Commission in the Notice identified building elements that impact building entry loss, including materials used in siding, roofing, flooring, walls, insulation, and window elements. Contemporary building codes result in ever-increasing use of materials the ITU found to increase building entry loss. The Commission should consider these factors when calculating building entry loss due to unlicensed spectrum use throughout the 6 GHz band.

Respectfully submitted,

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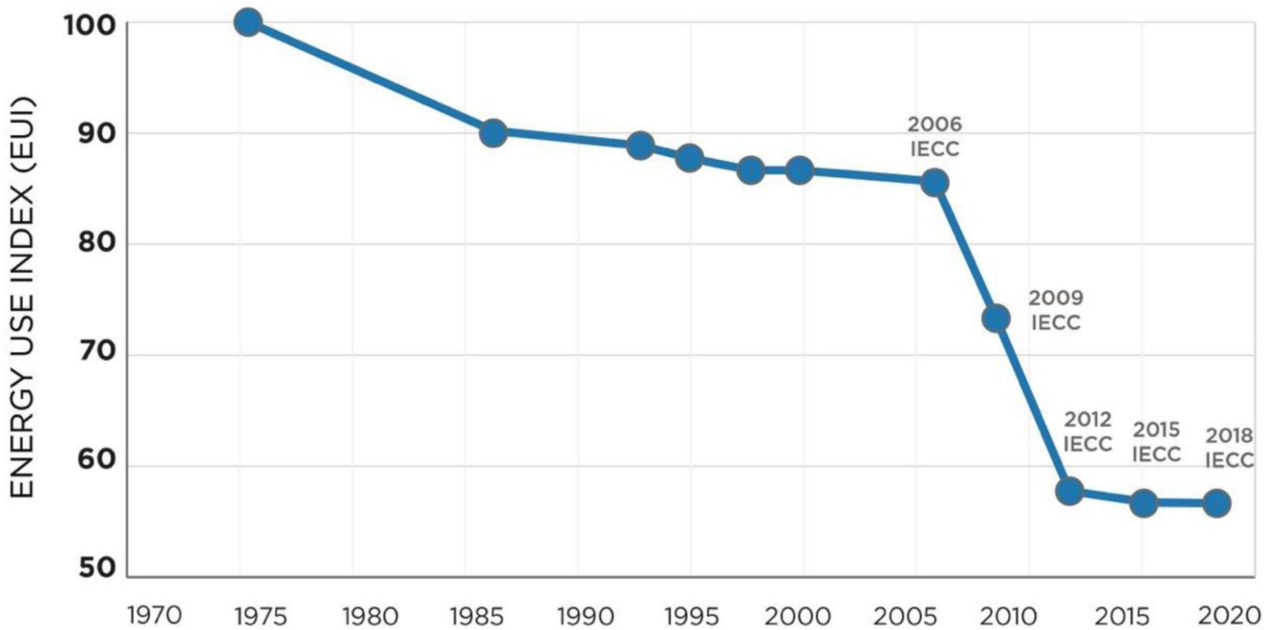
APPENDIX A

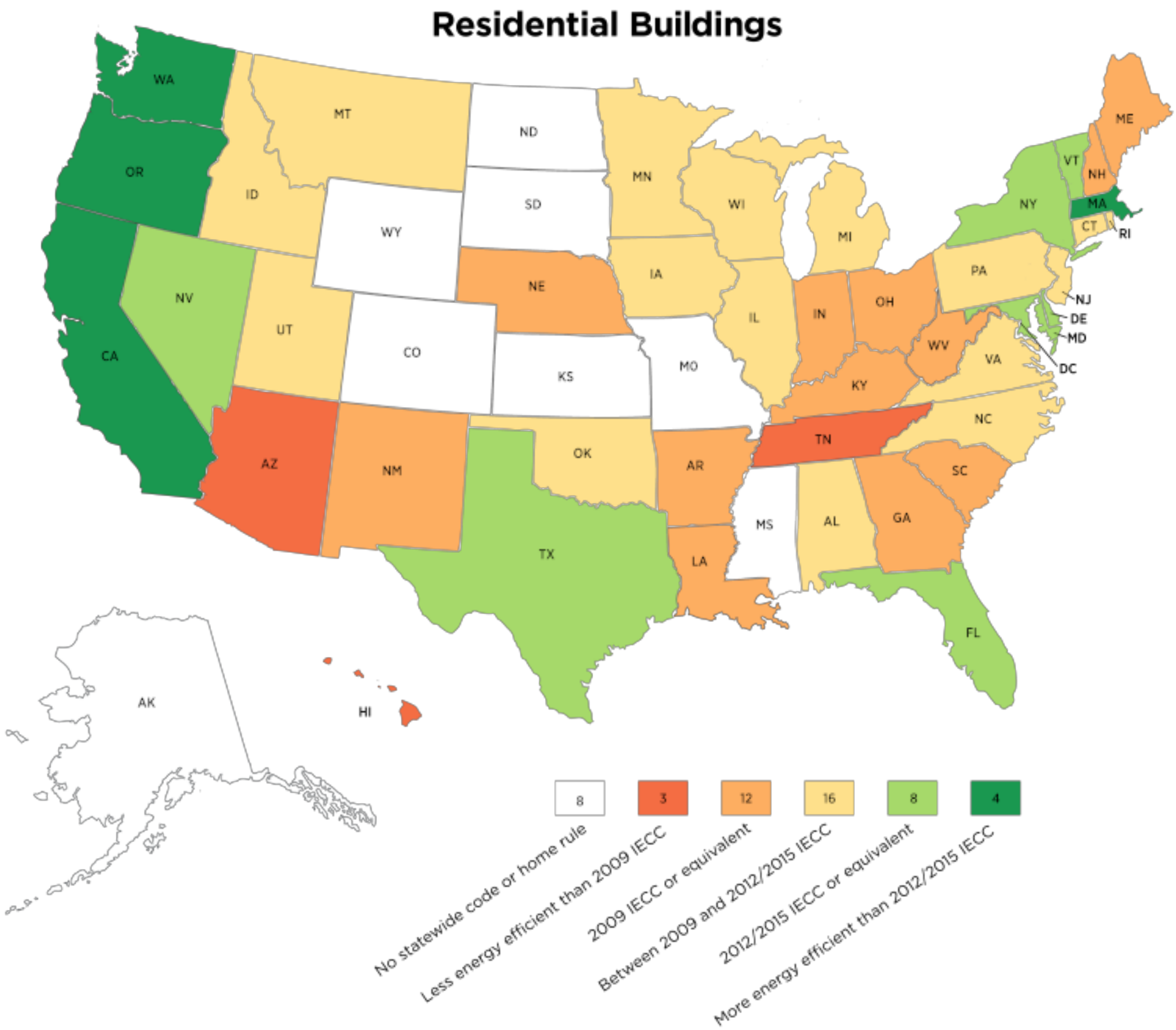
See Figure 1 and Figure 2 below

Figure 1. Residential Code Improvement, including from 2006 IECC to 2015 IECC[58]



[58] Alice Rosenberg, Residential New Construction Initiative 1–41 (2018), https://library.cee1.org/system/files/library/13436/CEE_ResNewConstruction_Initiative_16Jan2018.pdf, citing Building Codes Assistance Project, Tackling Energy Codes with Energy Modeling: Preparing Design Professionals to Face Building Performance Demands, August 9, 2016, p. 6 (adapted from US DOE), bcapcodes.org/wpcontent/uploads/2016/08/Preparing-Design-Professionals-FINAL-08092016.pdf

Figure 2. Current U.S. Residential Building Energy Code Adoption by state[59]



[59] U.S. Department of Energy, Status of State Energy Code Adoption EnergyCodes.gov (2018), https://www.energycodes.gov/status-state-energy-code-adoption (last visited Jan 26, 2019).