Technical Evaluation Report

TO ASSIST WITH CODE COMPLIANCE

Wind Pressure Performance of Kingspan GreenGuard® Insulation Board Used in Exterior Wall Covering Assemblies

TER No. 1011-01

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DIVISION: 06 00 00 – WOOD AND PLASTICS
Section: 06 16 00 – Sheathing

DIVISION: 07 00 00 – THERMAL AND MOISTURE PROTECTION
Section: 07 21 00 – Thermal Insulation

1. Product Evaluated:

1.1. Kingspan Insulation LLC – GreenGuard® Insulation Board

1.2. For the most recent version of this report, visit drjengineering.org. For more detailed state professional engineering and code compliance legal requirements and references, visit drjengineering.org/statelaw. DrJ is fully compliant with all state professional engineering and code compliance laws.

2. Applicable Codes and Standards:[1]

2.1. *2009, 2012* and *2015 International Building Code* (*IBC*)

2.2. *2009, 2012* and *2015 International Residential Code* (*IRC*)

2.3. *ANSI/AWC NDS – National Design Specification for Wood Construction*

[1] Unless otherwise noted, all references in this code compliant research report (TER) are from the 2012 version of the codes and the standards referenced therein, including, but not limited to, *ASCE 7*, *SDPWS* and *WFCM*. This product also complies with the 2000-2009 and 2015 versions of the *IBC* and *IRC* and the standards referenced therein. As required by law, where this research report is not approved, the building official shall respond in writing, stating the reasons this research report was not approved. For variations in state and local codes, if any, see Section 8.

2.4. *ANSI/SBCA FS100 – Standard Requirements for Wind Pressure Resistance of Foam Plastic Insulating Sheathing Used in Exterior Wall Covering Assemblies*

2.5. *ASCE 7 – Minimum Design Loads for Buildings and Other Structures*

2.6. *ASTM C578 – Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation*

2.7. *ASTM E330 – Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference*

2.8. *ASTM E331 – Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors and Curtain Walls by Uniform Static Air Pressure Difference*

2.9. *ASTM E2178 – Standard Test Method for Air Permeance of Building Materials*

3. Performance Evaluation:

3.1. The wind pressure resistance performance of GreenGuard® Insulation Board was evaluated for use as part of an exterior wall covering assembly in accordance with the following code sections:

3.1.1. *IBC* Section 104.11 and 1404.8

3.1.2. *IRC* Section R104.11, R703.1.2 and R703.4[2], and Table R703.4[3]

3.2. This Technical Evaluation Report (TER) evaluates the wind pressure resistance performance of GreenGuard® Insulation Board for use as exterior wall sheathing in compliance with the building codes listed in Section 2.

3.2.1. When used as over-sheathing[4] on light-frame, masonry, or concrete exterior walls, GreenGuard® Insulation Board is not required to meet the wind pressure requirements of this TER.

3.2.2. This TER does not address wind pressure resistance requirements for GreenGuard® Insulation Board used as part of an Exterior Insulation Finish System (EIFS). Refer to the EIFS manufacturer's installation instructions for building code compliance.

3.3. GreenGuard® Insulation Board shall comply with the material standard listed in Section 4 and shall be applied to exterior wall construction in accordance with the general requirements of Section 5.1, as well as the prescriptive wind pressure resistance requirements of Section 5.2.

3.4. GreenGuard® Insulation Board used in accordance with this TER that is required to resist wind pressure in exterior wall covering assemblies shall also comply with the product marking requirements of Section 10 and the conditions of use listed in Section 9.

3.5. GreenGuard® Insulation Board was also evaluated for the following:

3.5.1. Use as an air barrier material in accordance with *IRC* Section N1102.4.1.1 and *IECC* Section C402.4.1.1[5] and R402.4.1.1.

3.5.2. Use as a water-resistant barrier (WRB) in accordance with *IRC* Section R703.2[6] and *IBC* Section 1404.2.

3.6. Only products in this TER with thicknesses ranging from 1" to 3" are certified for wind pressure resistance. Results of testing for other thicknesses are provided for informational purposes only.

3.6.1. For the scope of this TER, only products with thicknesses ranging from 1" to 3" are subject to an ongoing quality control program for performance to meet wind requirements, in accordance with *ANSI/SBCA FS100*.

3.7. Any code compliance issues not specifically addressed in this section are outside the scope of this evaluation.

4. Product Description and Materials:

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[2] *2015 IRC* Section R703.3.

[3] *2015 IRC* Table R703.3(1).

[4] Over-sheathing definition: As used in this TER, over-sheathing refers to the application of foam sheathing over and directly on the surface of wall sheathing material or solid wall construction, such as masonry or concrete, whereby the substrate is capable of resisting the full design transverse wind load required by the applicable building code or latest edition of *ASCE 7*. In addition, cladding is separately installed over foam sheathing in accordance with Section 5.2. An over-sheathing application of foam sheathing does not require that the foam sheathing resist wind pressure in accordance with this TER.

[5] *2015 IECC* Section C402.5.1.1.

[6] *2015 IRC* Section R703.2 notes WRB not required for detached accessory buildings.

4.1. GreenGuard® Insulation Board used in accordance with this TER shall comply with the following material standards:

4.1.1. Extruded polystyrene (XPS) manufactured in compliance with *ASTM C578*, Type IV.

4.2. GreenGuard® Insulation Board is produced under a proprietary manufacturing process and formed into rigid insulation panels.

4.2.1. GreenGuard® Insulation Board is manufactured with or without edge treatments and facers as follows:

4.2.1.1. CM – square edges

4.2.1.2. SL – shiplap edges

4.2.1.3. SLX – shiplap edges and clear plastic facers on both sides

4.2.1.4. PGU – $^{7}/_{16}$" XPS with a reinforcing polyolefin fabric on one side and a clear plastic facer on the other side

4.2.2. GreenGuard® Insulation Board is manufactured in 4x8 sheets in ½", ¾", 1", 1½", 2" and 3" thicknesses.

5. Applications:

5.1. General Requirements

5.1.1. The following are minimum installation requirements for GreenGuard® Insulation Board when applied to light-frame wall framing members.

5.1.1.1. Light-frame wood framing members supporting GreenGuard® Insulation Board shall have a nominal thickness of not less than 2" (1.5" actual).

5.1.1.2. Light-frame steel framing members shall have a flange width of not less than $1^{1}/_{2}$" (including bend radius at web and lip).

5.1.1.3. Framing members shall be spaced a maximum of 24" o.c.

5.1.1.3.1. GreenGuard® Insulation Board shall be attached to the wall framing in accordance with the manufacturer's installation instructions and DrJ Installation Instructions (II2014-13).

5.1.1.3.2. All sheathing edges shall be supported by wall framing or blocking.

5.2. Wind Pressure Requirements

5.2.1. General

5.2.1.1. When fastened directly to light-frame wall members (i.e., studs), GreenGuard® Insulation Board shall comply with the requirements of Section 5.2, in accordance with *IBC* Section 104.11, *IRC* Section R104.11 and *ASTM C578*, as applicable.

5.2.1.2. When installed as over-sheathing, GreenGuard® Insulation Board shall not be required to comply with this TER.

5.2.2. Specific Requirements

5.2.2.1. When using *ASCE 7-10* as referenced by the *2012* and *2015 IBC* for the conditions listed in Section 5.2.2.2, the wind pressures listed in *ASCE 7* shall be multiplied by a factor of 0.6 to convert them to ASD level loads and then compared to the values in Table 1.

5.2.2.2. The minimum thickness of GreenGuard® Insulation Board shall comply with Table 1, for one of the following two conditions:

5.2.2.2.1. Where the GreenGuard® Insulation Board is directly constrained by a code-compliant cladding material (i.e., no gap between the cladding and GreenGuard® Insulation Board product, as shown in Figure 1), the components and cladding design wind pressure determined in accordance with *IRC* Table R301.2(2)[7] or *IBC* Section 1609.6 shall not exceed the allowable wind pressure value of the FPIS product per Table 1.

[7] *2015 IRC* Table R301.2(2).

5.2.2.2.2. Where a code-compliant cladding system is installed over but not directly on the surface of the GreenGuard® Insulation Board such that there is a space between the sheathing and the cladding (e.g., furring is used over GreenGuard® Insulation Board product, as shown in Figure 2), the components and cladding design wind pressure determined in accordance with *IRC* Section R301.2 or *IBC* Section 1609.6 shall not exceed the allowable wind pressure value of GreenGuard® Insulation Board, per Table 1.

5.2.2.3. The basic wind speed for GreenGuard® Insulation Board shall not exceed the values in Table 2 or Table 3.

5.2.2.4. Except as noted in Table 1, footnote 4, GreenGuard® Insulation Board can be oriented with the length dimension parallel or perpendicular to the wall framing members. When perpendicular to framing members, horizontal joints shall be supported by blocking, unless use of unblocked joints qualifies in accordance with *IBC* Section 104.11, *IRC* Section R104.11 and *ASTM C578*, as applicable.

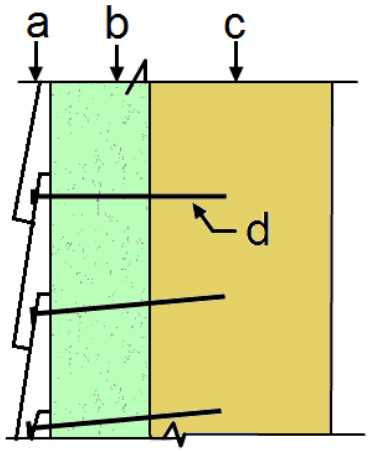

Figure 1: Exterior Wall Covering Assembly with Cladding Installed Directly Over GreenGuard® Insulation Board

a. Cladding material and fasteners
b. GreenGuard® Insulation Board
c. Wall framing per code (i.e., wood or steel studs)
d. Cladding fastener per code and of minimum size to support cladding weight

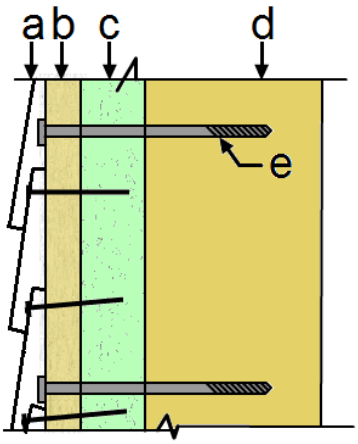

Figure 2: Exterior Wall Covering Assembly with Cladding & Furring Installed Over GreenGuard® Insulation Board

a. Cladding material and fasteners
b. Wood or steel furring (which battens the foam sheathing to the wall framing and creates an airspace between the foam sheathing and the cladding)
c. GreenGuard® Insulation Board
d. Wall framing per code (i.e., wood or steel studs)
e. Furring fastener by design and with minimum size to support cladding weight

Kingspan XPS Products [2]	Sheathing Thickness (in.)	Allowable (ASD) Components & Cladding Design Wind Pressure (psf)	
		16" o.c. Framing	24" o.c. Framing
GreenGuard® Insulation Board	½"	19.5	NP
	¾"	25.9	20.5
	1"	38.4[3]	30.6
	1½"	72.8	41.3
	2"	122	53.7[3]
	3"	260	139.4
GreenGuard® PLYGOOD® Ultra (PGU)	7/16"	78.6	61.4

For SI: 1" = 25.4 mm, 1 pound per square foot (psf) = 0.0479 kPa., NP = not permitted
1. Linear interpolation shall not be permitted.
2. Table 1 shall be used in accordance with requirements of Section 6.1. Allowable design wind pressure ratings are based on *ASTM E330* testing in accordance with *IBC* Section 1609 and *IRC* Section 301.2. These values were determined in accordance with *ANSI/SBCA FS100* for a fully-blocked condition (i.e., all horizontal and vertical sheathing joints supported on blocking or framing members) using a PEF of 1.0.
3. Based on yield load in accordance with *ANSI/SBCA FS100*.
4. Table values for the 3" GreenGuard® Insulation Board are limited to sheathing panels installed with the length dimension parallel to the framing.
5. Design values are applicable to the bending strength of the product only. Fastening to resist wind loads must be achieved by separate specification for attachment of the foam and/or the cladding system over the foam sheathing in addition to the manufacturer's minimum attachment requirements.

Table 1: Allowable Wind Pressure Resistance Values (PSF) for Kingspan GreenGuard® Insulation Products Used in Exterior Wall Covering Assemblies

Kingspan XPS Products	Sheathing Thickness (in.)	Components & Cladding Basic Wind Speed (mph)	
		16" o.c. Framing	24" o.c. Framing
GreenGuard® Insulation Board	½"	90	NP
	¾"	100	90
	1"	125	110
	1½"	170	130
	2"	170	145
	3"	170	170
	7/16" PGU	170	150
1. Allowable wind speeds are based on the following: Mean roof height – 30', Exposure B, 10 sq. ft. effective wind area.			

Table 2: Basic Wind Speed Values (mph) for Kingspan GreenGuard® Insulation Products Used in Exterior Wall Covering Assemblies Based on *ASCE 7-05* Three-Second Gust

Kingspan XPS Products	Sheathing Thickness (in.)	Components & Cladding Basic Wind Speed (mph)	
		16" o.c. Framing	24" o.c. Framing
GreenGuard® Insulation Board	½"	115	NP
	¾"	130	115
	1"	160	140
	1½"	200	160
	2"	200	180
	3"	200	200
	7/16" PGU	200	190
1. Allowable wind speeds are based on the following: Mean roof height – 30', Exposure B, 10 sq. ft. effective wind area.			

Table 3: Basic Wind Speed Values (mph) for Kingspan GreenGuard® Insulation Products Used in Exterior Wall Covering Assemblies Based on *ASCE 7-10* Three-Second Gust

5.3. Water-Resistive Barrier

5.3.1. GreenGuard® Insulation Product (Note: Applies to both Insulation Boards and PGU) may be used as a WRB as prescribed in *IRC* Section R703.2[8] and *IBC* Section 1404.2, when installed on exterior walls as described in this section.

5.3.2. GreenGuard® Insulation Products shall be installed with board joints placed directly over exterior framing spaced a maximum of 24" (610 mm) o.c. The fasteners used to attach the board shall be installed in accordance with Section 6.

5.3.3. All seams and joints between boards shall be butt jointed and sealed with an approved construction tape in accordance with Section 6. Approved construction tapes include 1 7/8" GreenGuard® Seam Tape or equivalent except:

5.3.3.1. 7/16" PGU approved construction tape shall be a minimum 3" GreenGuard® Seam Tape or equivalent.

[8] *2015 IRC* Section R703.2 notes WRB not required for detached accessory buildings.

5.3.4. A separate WRB may also be provided. If a separate WRB method is used, taping of the sheathing joints is not required.

5.3.5. Flashing must be installed at all sheathing penetrations and shall comply with the all applicable code sections.

5.4. Air Barrier

5.4.1. GreenGuard® Insulation Board may be used as an air barrier material as prescribed in *IRC* Section N1102.4.1.1 and *IECC* Section R402.4.1.1[9] and C402.4.1.

5.4.2. When used as part of a continuous air barrier, GreenGuard® Insulation Board shall be installed as follows:

5.4.2.1. All sheathing panel edges at the top and bottom of the wall assemblies and all butted joints between sheathing panels shall be sealed with an approved seam tape, self-adhering flashing or sealant.

6. Installation:

6.1. GreenGuard® Insulation Board Installation

6.1.1. Refer to the manufacturer's installation instructions, in addition to this TER, for complete details and requirements.

6.1.2. All required wall bracing shall be installed prior to insulation board installation.

6.1.3. The insulation boards should be oriented with the printed side facing the exterior side of the building.

6.1.3.1. Except as noted in Table 1, footnote 4, GreenGuard® Insulation Board can be oriented with the length dimension parallel or perpendicular to the wall framing members. When perpendicular to framing members, horizontal joints shall be supported by blocking, unless use of unblocked joints qualifies in accordance with *IBC* Section 104.11, *IRC* Section R104.11 and *ASTM C578*, as applicable.

6.1.4. Secure the sheathing to framing members with fasteners capable of resisting the imposed loads in accordance with *NDS*. Fasteners will vary, depending on the substrate and cladding materials.

6.1.4.1. Fastener heads shall be a minimum of $^3/_8$" diameter. Do not allow the fastener head to penetrate the sheathing facer. Use of washers at the fastener head is recommended.

6.1.4.2. Space fasteners 12" o.c. in both the field and perimeter.

6.1.4.3. Minimum penetration of the fasteners into the substrate is ¾".

6.2. Cladding Installation

6.2.1. Wind pressure rating adjustments for vinyl siding installed directly over GreenGuard® Insulation Board shall comply with *IRC* Section R703.11.2[10] for buildings constructed under the *IRC* or *IBC*.

6.2.2. Cladding installation and fastening through foam sheathing shall comply with the applicable building code and the cladding manufacturer's installation instructions. The minimum fastener size shall be capable of supporting the cladding weight when cantilevering through the GreenGuard® Insulation Board.

6.2.3. Wall assemblies that include GreenGuard® Insulation Board and that are intended to serve as part of the lateral force resisting system of a structure shall be braced to resist the in-plane shear force in accordance with *IRC* Section R602.10, *IBC* Section 2308.9.3[11], or a design in accordance with *IRC* Section R301 or *IBC* Section 2305, as applicable.

6.2.4. Wall assemblies with GreenGuard® Insulation Board attached to gravity load supporting members (i.e., studs) that require buckling restraint in a direction parallel to the plane of the wall shall have such restraint provided by other suitable materials. Wall assemblies shall be designed with an effective buckling length equal to the length of the member between points of lateral support provided by attachment to other building assemblies.

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[9] *2015 IECC* Section C402.5.1.1.
[10] *2015 IRC* Section R703.11.2.
[11] *2015 IBC* Section 2308.6.

7. Test and Engineering Substantiating Data:

7.1. Test reports and data supporting the following material properties:

7.1.1. Air barrier material in accordance with *ASTM E2178*.

7.1.2. Water-resistive barrier in accordance with *ASTM E331*.

7.1.3. Wind pressure resistance in accordance with *SBCA FS100*.

7.2. *Attaching Exterior Wall Coverings through Foam Sheathing to Wood or Steel Wall Framing*, *FSC Tech Matters*.

7.3. Engineering analysis of data prepared for the Foam Sheathing Committee by Jay H. Crandell, P.E, ARES Consulting, West River, MD.

7.4. The product(s) evaluated by this TER falls within the scope of one or more of the model, state or local building codes for building construction. The testing and/or substantiating data used in this TER is limited to buildings, structures, building elements, construction materials and civil engineering related specifically to buildings.

7.5. The provisions of model, state or local building codes for building construction do not intend to prevent the installation of any material or to prohibit any design or method of construction. Alternatives shall use consensus standards, performance-based design methods or other engineered alternative means of compliance. This TER assesses compliance with defined standards, generally accepted engineering analysis, performance-based design methods, etc. in the context of the pertinent building code requirements.

7.6. Some information contained herein is the result of testing and/or data analysis by other sources, which DrJ relies on to be accurate as it undertakes its engineering analysis.

7.7. DrJ has reviewed and found the data provided by other professional sources are credible. This information has been approved in accordance with DrJ's procedure for acceptance of data from approved sources.

7.8. DrJ's responsibility for data provided by approved sources is in accordance with professional engineering law.

7.9. Where appropriate, DrJ relies on the derivation of design values, which have been codified into law through codes and standards (e.g., *IRC*, *WFCM*, *IBC*, *SDPWS*, etc.). This includes review of code provisions and any related test data that helps with comparative analysis or provides support for equivalency to an intended end-use application.

8. Findings:

8.1. When installed in accordance with the manufacturer's installation instructions and this TER, GreenGuard® Insulation Board complies with, or is a suitable alternative to, the applicable sections of the codes listed in Section 2 for the following applications:

8.1.1. Performance for use as a WRB in accordance with *IRC* Section R703.2 and *IBC* Section 1404.2.

8.1.2. Performance for use as an air barrier in accordance with *IRC* Section N1102.4.1.1 and *IECC* Section R402.4.1.1.

8.1.3. Transverse load resistance due to components and cladding pressures on building surfaces as defined in Section 5.

8.2. *IBC* Section 104.11 and *IRC* Section R104.11 (*IFC* Section 104.9 is similar) state:

> **104.11 Alternative materials, design and methods of construction and equipment.** The provisions of this code are not intended to prevent the installation of any material or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been *approved*. An alternative material, design or method of construction shall be *approved* where the *building official* finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, at least the equivalent of that prescribed in this code. … Where the alternative material, design or method of construction is not *approved*, the *building official* shall respond in writing, stating the reasons the alternative was not *approved*.[12]

[12] The last sentence is adopted language in the 2015 codes.

8.3. This product has been evaluated with the codes listed in Section 2, and is compliant with all known state and local building codes. Where there are known variations in state or local codes that are applicable to this evaluation, they are listed here:

8.3.1. No known variations

8.4. This TER uses professional engineering law, the building code, ANSI/ASTM consensus standards and generally accepted engineering practice as its criteria for all testing and engineering analysis. DrJ's professional engineering work falls under the jurisdiction of each state Board of Professional Engineers, when signed and sealed.

9. Conditions of Use:

9.1. Where required by the authority having jurisdiction (AHJ) in which the project is to be constructed, this report and the installation instructions shall be submitted at the time of permit application.

9.2. Any generally accepted engineering calculations needed to show compliance with this TER shall be submitted to the code official for review and approval.

9.3. Design loads shall be determined in accordance with the building code adopted by the jurisdiction in which the project is to be constructed.

9.4. GreenGuard® Insulation Board listed herein complies with, or is a suitable alternative to, the applicable sections of the *IBC* and *IRC* and is subject to the following conditions.

9.4.1. These products shall be installed in compliance with the manufacturer's instructions, the applicable building code and this TER.

9.4.2. The manufacturer shall provide the building official and purchaser with evidence of code compliance for matters beyond the wind pressure resistance scope of this TER.

9.5. Design

9.5.1. Building Designer Responsibility

9.5.1.1. Unless the AHJ allows otherwise, the Construction Documents shall be prepared by a Building Designer (e.g., Owner, Registered Design Professional, etc.) for the Building and shall be in accordance with *IRC* Section R106 and *IBC* Section 107.

9.5.1.2. The Construction Documents shall be accurate and reliable and shall provide the location, direction and magnitude of all applied loads and shall be in accordance with *IRC* Section 301 and *IBC* Section 1603.

9.5.2. Construction Documents

9.5.2.1. Construction Documents shall be submitted to the Building Official for approval and shall contain the plans, specifications and details needed for the Building Official to approve such documents.

9.6. Responsibilities

9.6.1. The information contained herein is a product, engineering or building code compliance research report performed in accordance with the referenced building codes, testing and/or analysis through the use of accepted engineering procedures, experience and good technical judgment.

9.6.2. DrJ research reports provide an assessment of only those attributes specifically addressed in the Products Evaluated or Code Compliance Process Evaluated section.

9.6.3. The engineering evaluation was performed on the dates provided in this TER, within DrJ's professional scope of work.

9.6.4. This product is manufactured under a third-party quality control program in accordance with *IRC* Section R104.4 and R109.2 and *IBC* Section 104.4 and 110.4.

9.6.5. The actual design, suitability and use of this research report for any particular building is the responsibility of the Owner or the Owner's authorized agent, and the report shall be reviewed for code compliance by the Building Official.

9.6.6. The use of this TER is dependent on the manufacturer's in-plant QC, the ISO/IEC 17020 third-party inspection process, proper installation per the manufacturer's instructions, the Building Official's

inspection and any other code requirements that may apply to assure accurate compliance with the applicable building code.

10. Identification:

10.1. GreenGuard® Insulation Board described in this TER is identified by a label on the board or packaging material bearing the manufacturer's name, product name, label of the third-party inspection agency, and other information to confirm code compliance.

10.2. Additional technical information can be found at www.kingspaninsulation.us.

11. Review Schedule:

11.1. This TER is subject to periodic review and revision. For the most recent version of this report, visit drjengineering.org.

11.2. For information on the current status of this report, contact DrJ Engineering.

- Mission and Professional Responsibilities
- Product Evaluation Policies
- Product Approval – Building Code, Administrative Law and P.E. Law