

A New Environmental Assessment Tool for Roofing Systems

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Abstract

Few elements of modern construction have as great an impact on long-term sustainability as the roofs over our heads. In addition to shielding building occupants from the elements, roofs provide a wide variety of functions critical to the long-term sustainability of the built environment. In an effort to support the sustainable design and management of the billions of square feet of new roofing assets installed each year in North America, the Center for Environmental Innovation in Roofing (CEIR) has developed the RoofPoint™ Environmentally Innovative Guideline for Roofing Systems. Organized around five primary categories of energy, materials, water, life-cycle and innovation, RoofPoint provides a comprehensive roadmap for the design, installation

and operation of environmentally optimal roofing systems. Starting with a brief overview of the history and mission of RoofPoint, this paper discusses how RoofPoint may serve as an ongoing decision model, asset management tool, educational framework and research agenda for the roofing industry. In addition, this paper discusses critical issues going forward as development of the RoofPoint program continues.

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Introducing RoofPoint™

Developed by the Center for Environmental Innovation in Roofing (CEIR), RoofPoint is a roofing-specific version of green building rating systems that have emerged to promote an environmentally responsible built environment. Similar to its whole-building counterparts, RoofPoint embraces a mission to elevate the professional practice of everyone involved in the roofing process to a higher level of accomplishment and recognition. In order to accomplish this mission, RoofPoint embraces several important functions. First, RoofPoint is a guideline for the selection of environmentally innovative roofing systems, roofing systems that maximize energy efficiency and longevity while minimizing environmental impact. In addition, RoofPoint may be viewed as a checklist to identify the many ways roofing systems provide economic and environmental benefit. RoofPoint also serves as an assessment system to compare different roofing alternatives for a particular environmental application. Finally, RoofPoint provides a platform for a comprehensive certification program to recognize and reward environmentally responsible roofing practice.

Why RoofPoint is Needed

Overlooked Strategic Resource. RoofPoint helps to showcase the roofing industry's strategic role in supporting energy and environmental security. Non-residential rooftops cover over 50 billion square feet of developed space in North America, and if effectively

utilized, this vast roof surface area could deliver enormous benefits, through both energy efficiency and clean energy production. A 2010 recent study prepared for CEIR estimates this total energy potential to exceed the combined output of twenty-five Grand Coulee Dams¹.

Because of this untapped energy and environmental potential, roofs are gaining expanded public interest. Increasingly, the rooftops of buildings are becoming a focal point for the benefits of green construction, bringing opportunities for enhanced occupant satisfaction, increased rents and stable property values. By directly targeting this new public awareness, RoofPoint further enlarges the visibility of roofing while helping building designers and owners put this growing interest into daily practice.

Lack of Effective Tools. Although the energy and environmental potential of roofing is significant, many green building rating systems fail to capture this potential. Rating systems for new buildings fail to address re-roofing activity, which accounts for over two-thirds of the total roofing market and billions of square feet of annual opportunity. At the same time, rating systems for existing buildings tend to only address roofing when it is part of large renovation projects. As a result, few standardized tools are available to building owners and designers to evaluate the environmental performance of roofing assets alone.

Many building and roofing professionals also recognize potential conflicts between the environmental ideals of green building rating systems and the practical realities of building construction and maintenance². The application of new technologies and the use of new materials can only be productive if these technologies and materials do not

adversely impact the longevity and serviceability of roofing systems. Aging roofs leaking beneath new rooftop solar arrays, unanticipated moisture movement in new and retrofit roofing designs, and the serviceability of new, untested roofing products are just a few examples of the concerns raised within the roofing industry. And as these concerns are raised, many roofing professionals agree that comprehensive guidelines are needed to address these issues.

Increased Industry Value. With RoofPoint, the roofing industry will be recognized and rewarded for adding value to both the environment and society. Using the guidelines established by RoofPoint, roofing becomes a *value-added product* as building owners trade up to more efficient and longer lasting roofing systems. And in the process, roofing itself becomes a *value-added profession* with enhanced public image, expanded career opportunities and higher-paying job skills. Finally, the principles embodied in RoofPoint help to increase the industry's role as a *value-added influence* on public policy as well as individual design and purchase decisions. In a nutshell, RoofPoint allows building owners and designers to make better decisions; and our industry benefits by transforming these decisions into as-built realities.

RoofPoint Mission and Goals

As identified by the CEIR Research Committee, the mission of RoofPoint is to provide a means of roof system selection across membrane types and system designs so that the roofing industry as a whole is recognized for the diversity of environmentally responsive options it offers to meet the needs of concerned building owners. As a starting point in fulfilling this mission, RoofPoint is designed to achieve the following goals:

- It must be easy to understand and use so it can gain rapid public visibility and recognition.
- It must reflect current green building thinking by incorporating established criteria and measurements from existing green building standards.
- It must be designed for tangible value: a reliable guide to help building owners make effective decisions, a useful template for designing education and certification programs, and a valuable tool for design and construction professionals.
- It must be designed to evolve into a recognized consensus standard so it may be formally integrated into public construction specifications and requirements.

Overall, the mission of RoofPoint is very similar to the original mission established in 1998 by the U.S. Green Building Council for its LEED (Leadership in Energy and Environmental Design) Green Building System. As shown in Figure 1, RoofPoint seeks to advance the same primary goals as LEED:

LEED Goal³	RoofPoint Goal
Define “green building” by establishing a common standard of measurement	Define “environmentally innovative roofing” by establishing a common method of evaluation
Promote integrated, whole-building design practices	Promote integrated, total roof system design, installation and management practices
Recognize environmental leadership in the building industry	Recognize environmental leadership in the roofing industry and among roofing professionals
Stimulate green competition	Stimulate innovation in roofing
Raise consumer awareness of green building benefits	Raise public awareness of roofing’s role in energy and the environment
Transform the building market	Transform the roofing industry and roofing market

TABLE 1: LEED / ROOFPOINT GOAL COMPARISON

RoofPoint Structure

The structure of RoofPoint also is very similar to the organization of many green building rating systems. Organized around five primary functional areas of environmental contribution, RoofPoint provides the end-user with a comprehensive inventory of detailed environmental goals, specific strategies to address these goals and the appropriate criteria to implement these strategies. In addition, RoofPoint incorporates an assessment system to support a formal recognition program for roof systems that meet or exceed a minimum established assessment score. Figure 1 illustrates the basic structure of RoofPoint.

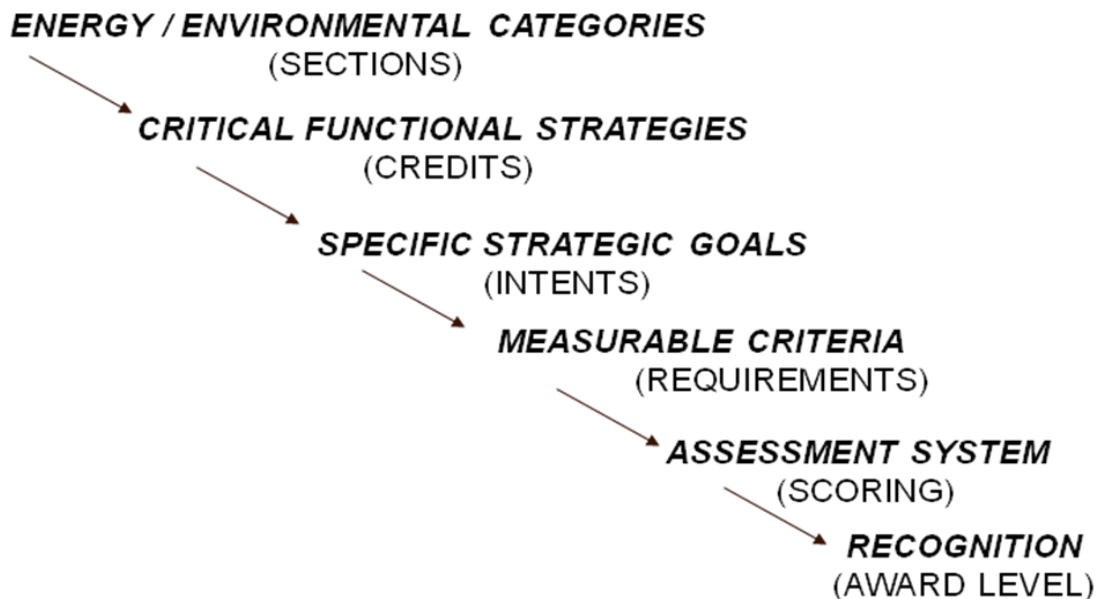


FIGURE 1: ROOFPOINT STRUCTURE

RoofPoint Pilot Draft

The *RoofPoint Guideline for Environmentally Innovative Non-Residential Roofing (Pilot Draft)* was released late in 2010⁴ and provides a comprehensive roadmap for the achievement of environmentally innovative non-residential roofing systems. In addition to addressing all key stages of roof system development from design and selection through installation and long-term maintenance, the Pilot Draft also encompasses a wide variety of roofing applications, including both new construction and re-roofing as well as low-slope and steep-slope installations. In addition, the Pilot Draft has been designed to accommodate applications involving above-deck insulations, attic spaces, structural metal roofing systems, and combinations of these applications. Table 2 provides a summary of the specific Credits included in the Pilot Draft along with a brief description of the intents and strategies for each credit.

CREDIT	TITLE	INTENT	STRATEGY
SECTION 1: ENERGY MANAGEMENT			
E1	HIGH R ROOF SYTEMS	REDUCE ENERGY USE	INCREASE ROOF R VALUE
E2	BEST THERMAL PRACTICES	REDUCE ENERGY USE	REDUCE THERMAL DISCONTINUITIES
E3	ROOF SURFACE THERMAL CONTRIBUTION	REDUCE ENERGY USE / HEAT ISLAND EFFECTS	INSTALL CLIMATE-APPROPRIATE ROOF SURFACE
E4	ROOF AIR BARRIER	REDUCE ENERGY USE	INSTALL ROOF AIR BARRIER
E5	ROOFTOP ENERGY SYSTEMS	PRODUCE CLEAN ENERGY	INSTALL ROOFTOP SOLAR / WIND SYSTEMS

E6	ROOF DAYLIGHTING	PRODUCE CLEAN ENERGY	INSTALL ROOF DAYLIGHTING
SECTION 2: MATERIALS MANAGEMENT			
M1	RECYCLED CONTENT	REDUCE SOLID WASTE	INCREASE RECYCLED PRODUCT CONTENT
M2	MATERIAL REUSE	REDUCE SOLID WASTE	INCREASE MATERIAL REUSE
M3	WASTE MANAGEMENT	REDUCE SOLID WASTE	REDUCE ROOFING WASTE & SCRAP
M4	LOW-VOC MATERIALS	REDUCE OZONE	REDUCE VOC CONTENT
SECTION 3: WATER MANAGEMENT			
W1	ROOF STORM WATER RETENTION	REDUCE STORM WATER RUNOFF / WATER POLLUTION	INSTALL VEGETATED OR WATER-RETAINING ROOF SYSTEM
W2	ROOF-RELATED WATER USE REDUCTION	REDUCE WATER USE	CAPTURE ROOF WATER FOR LANDSCAPING
SECTION 4: DURABILITY / LIFE CYCLE MANAGEMENT			
D1	DURABLE ROOF INSULATION	REDUCE INSULATION DAMAGE	INSTALL DURABLE INSULATION SYSTEM
D2	ROOF DRAINAGE DESIGN	REDUCE WATER ENTRY	ASSURE POSITIVE ROOF DRAINAGE
D3	ROOF TRAFFIC PROTECTION	REDUCE SURFACE DAMAGE	PROVIDE TRAFFIC PROTECTION
D4	INCREASED WIND RESISTANCE	REDUCE STORM DAMAGE	INCREASE WIND UPLIFT RATING
D5	HYGROTHERMAL ANALYSIS	REDUCE MOISTURE DAMAGE	CONDUCT PROJECT MOISTURE ANALYSIS
D5	CONSTRUCTION MOISTURE MANAGEMENT	REDUCE MOISTURE DAMAGE	DOCUMENT PROJECT MOISTURE MANAGEMENT

			PROGRAM
D6	DURABILITY ENHANCEMENTS	INCREASE SYSTEM DURABILITY	INSTALL ROOF SYSTEM UPGRADES
L1	ROOF MAINTENANCE PROGRAM	INCREASE SERVICE LIFE	DOCUMENT ONGOING MAINTENANCE PROGRAM
L2	PROJECT INSTALLATION QUALITY	INCREASE SERVICE LIFE	DOCUMENT INSTALLATION QUALITY PROGRAM
<i>SECTION 5: INNOVATION IN ROOFING</i>			
IR1	INNOVATION IN DESIGN	RECOGNIZE DESIGN & PRODUCT INNOVATION	EXTRA CREDIT FOR FIRST-TIME INNOVATION
IR2	EXEMPLARY PERFORMANCE	RAISE INDUSTRY STANDARDS	EXTRA CREDIT FOR EXCEEDING STATE-OF-THE-ART
IR3	ROOFPOINT PROFESSIONAL	SUPPORT & CONFIRM PROJECT DESIGN	USE ROOFPOINT CERTIFIED PROFESSIONAL

TABLE 2: ROOFPOINT SECTIONS AND CREDITS (PILOT DRAFT)

Sections. As illustrated in Table 2, the RoofPoint guideline is organized into five key sections or functional areas representing the primary energy and environmental contributions of modern low-slope roofing systems:

- **Energy Management.** Reducing building and environmental energy demands through roof system thermal efficiency and production of clean energy.
- **Materials Management.** Reducing the impact of roofing materials through waste management, reuse, recycling and the used of reduced impact products.

- **Water Management.** Reducing building water demands and environmental impacts on rivers and lakes through roof storm water management and diversion.
- **Durability / Life Cycle Management.** Increasing the effective service life of roofing materials through increased durability and proactive service life management.
- **Innovation in Roofing.** Expanding the environmental contribution of roofing systems through innovation in design and product use.

While the employment of broad environmental categories provides a useful way to divide RoofPoint into manageable sections, it also offers a holistic approach to environmental innovation in which all major aspects of environmental impact may be emphasized and balanced. Although the achievement of environmental goals in any single category is important, a holistic approach to environmental innovation emphasizes the importance of all categories.

Credits. Each section of RoofPoint is further organized into a series of credits or operational strategies designed to optimize performance within each section. The potential benefit of each credit is defined both qualitatively as a broad objective (“Intent”) and quantitatively as a specific achievement criterion (“Requirement”). Similar to the structure of credits within other green building rating systems, the intent/requirement concept offers several benefits. First, the stated intent serves as a checkpoint to verify that the strategy embodied by each credit serves to advance the overall environmental agenda of the section. In addition, the stated intent for each credit also serves to test the validity of the requirement as a meaningful measure of the credit.

Intents. Intents identified in RoofPoint are focused on critical energy and environmental impacts associated with each section. Key intents within Energy Management include reduction of internal building energy use, mitigation of external energy impacts such as heat island effects, and production of clean energy or energy offsets. Key intents within Materials Management and Water Management include reduction of solid waste and mitigation of material-related environmental impacts. Key intents within Durability include reduction of roof deterioration associated with moisture infiltration, roof traffic and severe weather; while key intents within Life Cycle Management focus on critical events and processes throughout all stages of the roof life cycle.

Requirements. Requirements identified in RoofPoint provide measurable criteria to assess and confirm the achievement of the strategies available in each credit.

RoofPoint requirements embody the best available standards and practices as identified by the CEIR Research Committee and vetted through a two-stage industry review process. Primary resource references for RoofPoint requirements include ASHRAE 189.1-2009 *Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings*⁵, *LEED 2009 for New Construction and Major Renovations*⁷, as well as a variety of state and regional standards. In addition to these recognized standard references, the RoofPoint guideline also employs a number of widely recognized industry best practices to supplement formal standards. Examples of industry best practices in RoofPoint include the use of insulation coverboards and multiple insulation layers, construction moisture management and roof traffic protection.

Many RoofPoint requirements are *prescriptive*, especially when underlying reference standards are available and reasonably represent the stated intent of the credit.

Examples of prescriptive requirements in RoofPoint include criteria for roof system R-value, roof surface reflectivity and wind uplift resistance. When calculation and operational verification are critical to the achievement of RoofPoint goals, however, *performance-based* requirements are also employed. Examples of performance requirements include criteria for achieving daylighting levels, roof drainage design and water use reduction.

In addition to prescriptive and performance requirements, a number of RoofPoint requirements are *process-based*. The use of process-based requirements is particularly common for RoofPoint credits associated with life cycle management. Examples of process-based requirements include the use of formal procedures for moisture analysis, project installation quality, roof traffic protection and ongoing roof maintenance. Table 3 provides a summary of the prescriptive, performance and process requirements employed in the RoofPoint Pilot Draft, along with the primary industry reference used to develop each requirement.

CREDIT	TITLE	REQUIREMENT	REFERENCE
SECTION 1: ENERGY MANAGEMENT			
E1	HIGH R ROOF SYTEMS	PRESCRIPTIVE	ASHRAE 189.1-2009 ⁵ TABLES A1-A8
E2	BEST THERMAL PRACTICES	PRESCRIPTIVE	RECOGNIZED BEST PRACTICES

E3	ROOF SURFACE THERMAL CONTRIBUTION	PRESCRIPTIVE	CEC TITLE 24 (2008) ⁶ and Others
E4	ROOF AIR BARRIER	PRESCRIPTIVE	ASHRAE 189.1-2009 ⁶ APPENDIX B
E5	ROOFTOP ENERGY SYSTEMS	PRESCRIPTIVE	RATED POWER OUTPUT (VARIOUS)
E6	ROOF DAYLIGHTING	PERFORMANCE	LEED 2009 ⁷ CREDIT IE-8.1
SECTION 2: MATERIALS MANAGEMENT			
M1	RECYCLED CONTENT	PRESCRIPTIVE	LEED 2009 ⁷ CREDIT MR-4
M2	MATERIAL REUSE	PRESCRIPTIVE	LEED 2009 ⁷ CREDIT MR-3
M3	WASTE MANAGEMENT	PERFORMANCE	LEED 2009 ⁷ CREDIT MR-2
M4	LOW-VOC MATERIALS	PRESCRIPTIVE	OTC MODEL RULE (2007) ⁸
SECTION 3: WATER MANAGEMENT			
W1	ROOF STORM WATER RETENTION	PRESCRIPTIVE	VARIOUS STANDARDS
W2	ROOF-RELATED WATER USE REDUCTION	PERFORMANCE	LEED 2009 ⁷ CREDIT WE-1
SECTION 4: DURABILITY / LIFE CYCLE MANAGEMENT			
D1	DURABLE ROOF INSULATION	PRESCRIPTIVE	INDUSTRY BEST PRACTICES
D2	ROOF DRAINAGE DESIGN	PERFORMANCE	INDUSTRY BEST PRACTICES
D3	ROOF TRAFFIC PROTECTION	PRESCRIPTIVE / PROCESS	INDUSTRY BEST PRACTICES

D4	INCREASED WIND RESISTANCE	PRESCRIPTIVE	ANSI / SPRI WD-1 ⁹
D5	HYGROTHERMAL ANALYSIS	PROCESS	WUFI-ORNL/IBP ¹⁰
D5	CONSTRUCTION MOISTURE MANAGEMENT	PROCESS	INDUSTRY BEST PRACTICES
D6	DURABILITY ENHANCEMENTS	PROCESS	INDUSTRY BEST PRACTICES
L1	ROOF MAINTENANCE PROGRAM	PROCESS	INDUSTRY BEST PRACTICES
L2	PROJECT INSTALLATION QUALITY	PROCESS	ISO 9000 OR SIMILAR

TABLE 3: PRESCRIPTIVE, PERFORMANCE, PROCESS REQUIREMENTS¹¹

Scoring System. In order to calibrate and validate the value of each RoofPoint credit, the initial scoring methodology for RoofPoint will be more qualitative than anticipated in future versions. During the pilot program phase of RoofPoint (to be discussed in greater detail further in this article), all credits will be assumed to be equal in importance, and each credit will be evaluated according to the following broad assessment categories:

- **No Credit.** The roofing project does not meet the credit requirement.
- **Meets Intent.** The roofing project fulfills the broad intent of the credit although specific conditions of the project do not support full compliance with the credit requirement.
- **Meets Requirement.** The roofing project meets the credit requirement.
- **Exceeds Requirement.** The roofing project substantially exceeds the credit requirement and provides a tangible benefit by exceeding the requirement.

- **Not Applicable.** The credit does not provide a suitable measure of energy or environmental benefit for the roofing project being evaluated.

To complete the evaluation of each roofing project, the number of credits assigned to each assessment category will be tallied and compared with similar evaluations for other roofs. In addition, the number of eligible credits within each key section of RoofPoint will be identified and compared. The comparison of different roofing systems during the evaluation also will be used to determine threshold levels for project certification, establish different performance levels within credits, and evaluate the overall suitability of each credit.

RoofPoint in 2011

Starting in the first quarter of 2011, CEIR members are working to identify and qualify roofing projects for an initial pilot program. The objectives of the pilot program include the refinement of RoofPoint as an effective decision tool, developing professional expertise in the use of the RoofPoint system, and building public awareness of the value of RoofPoint. In support of this effort, members of the CEIR Research Committee are working designers, owners and managers with the application of RoofPoint. The pilot program is scheduled to continue throughout 2011, culminating with the public recognition of the first RoofPoint Certified Roofing Systems evaluated and qualified under the Pilot Draft.

After the conclusion of the pilot program, CEIR intends to formalize the roof system certification process and make the program available to the general public. In addition,

using the experience gained by the initial subject experts, CEIR will develop a certification program for “RoofPoint Registered Professionals” to support the roofing project certification process. In order to assure that the RoofPoint guideline will evolve into an established industry standard, CEIR also will begin work on developing a formal development model for the ongoing support of the RoofPoint system, using an ANSI or similar consensus process. Finally, additional versions of RoofPoint may be published, starting with a residential version targeted toward residential roofing contractors, homebuilders and homeowners.

The RoofPoint Opportunity for the Roofing Industry

Roofing Decision Model. Because RoofPoint addresses a broad array of roof conditions and design issues, it offers an unmatched opportunity for detailed comparison among many different design and product alternatives. At the same time, it must be recognized that RoofPoint is complex in scope and indefinite in output. As a consequence, the effective use of RoofPoint as a decision model likely will require the oversight of a professional roofing practitioner with specialized knowledge and experience. However, when managed by an experienced roofing professional, RoofPoint may provide an ideal format to guide end-users through the options and trade-offs required for effective roof system selection and management.

Life Cycle Management Tool. Because it combines principles of inherent material durability with design and management processes to assure and optimize roof system service life, RoofPoint also may serve as a template for effective life cycle management of roofing systems. And because RoofPoint relies not only on formal material and

system standards but also the best in recognized industry practice, roof management strategies may be identified that otherwise might be overlooked by a more empirical approach to service life management.

Training Curriculum. The same features that allow RoofPoint to serve as a compelling decision model and life cycle management tool also make it an attractive basis to develop an industry curriculum for training roofing designers and practitioners. CEIR's intention to develop a formal certification program for RoofPoint practitioners will also stimulate the development of a new training agenda within the roofing industry.

Research Agenda. The broad scope of RoofPoint also may help to identify critical gaps in roofing knowledge that need to be addressed by additional research. It is interesting to note how closely the primary categories and key credits of RoofPoint coincide with key research issues identified by the Roofing Industry Research Summit¹² convened by the RCI Foundation in 2009. Hopefully, after the conclusion of the International Roofing Symposium, interested industry stakeholders, including CEIR and the RCI Foundation can work together to develop and promote a common research agenda for the roofing industry.

Critical Issues Going Forward

Any program with the scope and ambition of RoofPoint will face many critical issues as it moves forward. Because the pilot phase of the program has just been launched as this paper is written, the Center will provide a more detailed report on emerging issues

during the presentation of this paper at the 2011 International Roofing Symposium.

Critical issues expected to be addressed include:

- **Developing an Effective Weighting and Scoring System.** By design, the pilot program scoring system is overly qualitative in order to assess the overall cohesiveness of RoofPoint and the general effectiveness of each credit. In future versions of RoofPoint, a more qualitative and robust weighting and scoring methodology may be added.
- **Addressing Additional Energy and Environmental Impacts.** The CEIR Research Committee already has identified a number of energy and environmental impacts that might be addressed by additional credits within future versions of RoofPoint. These impacts include:
 - Manufacture of roofing products under Responsible Care Management or similar environmental management programs.
 - Product environmental impact reporting such as Environmental Product Declarations (EPDs).
 - Total roof system environmental impact evaluation using Life Cycle Assessment (LCA).
 - The use of rapidly renewable, bio-based and regionally sourced roofing materials.
 - New technologies and strategies to extend service life through periodic renewal of critical roof system components.
 - Health and safety requirements for roofing and maintenance workers.

- **Establishing an Ongoing Development Process.** In order to serve as a widely-recognized and referenced guideline for roofing, RoofPoint should evolve into a recognized national / international standard supported by a public consensus process.

¹ CEIR (2010). *Non-Residential Roofing and National Energy Transformation*. Washington, DC: Center for Environmental Innovation in Roofing (CEIR). (www.roofingcenter.org)

² Hoff, J.L. (2009). "Sustainable Buildings: Addressing Long-Term Building Envelope Durability." *Proceedings of the 24th RCI International Trade Show and Convention*. Raleigh, NC: RCI, Inc.

³ Original LEED goals available as part of Wikipedia history of LEED. (http://en.wikipedia.org/wiki/Leadership_in_Energy_and_Environmental_Design#History)

⁴ CEIR (2010). *RoofPoint Guideline for Environmentally Innovative Non-Residential Roofing (Pilot Draft)*. Washington, DC: Center for Environmental Innovation in Roofing (CEIR). (www.roofpoint.wikispaces.com)

⁵ ASHRAE (2009). *Standard 189.1 for the Design of High-Performance, Green Buildings Except Low-Rise Residential Buildings*. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). (<http://www.ashrae.org/publications/page/927>)

⁶ CEC (2008). *Building Energy Efficiency Standards for Residential and Nonresidential Buildings*. Sacramento, CA: California Energy Commission (CEC). (<http://www.energy.ca.gov/2008publications/CEC-400-2008-001/CEC-400-2008-001-CMF.PDF>)

⁷ USGBC (2009). *LEED 2009 for New Construction and Major Renovations*. Washington, DC: U.S. Green Building Council (USGBC). (<http://www.usgbc.org/ShowFile.aspx?DocumentID=7244>)

⁸ OTC (2009). *OTC Model Rule for Adhesives and Sealants*. Washington, DC: Ozone Transport Commission (OTC). (http://www.otcair.org/projects_details.asp?FID=99&fview=stationary#)

⁹ SPRI (2008) *ANSI/SPRI WD-1 2008 Wind Design Standard Practice for Roofing Assemblies*. Waltham, MA: SPRI. (<http://www.spri.org/publications/policy.htm>)

¹⁰ ORNL (2010) *WUFI-ORNL/IBP Moisture Design Tool for Architects and Engineers v 3.0*. Oak Ridge, TN: Oak Ridge National Laboratory (ORNL). (<http://www.ornl.gov/sci/btc/apps/moisture/index.html>)

¹¹ Section 5: Innovation in Roofing has been omitted from this table because innovative materials and methods may not be addressed using existing reference standards.

¹² Hoff, J.L. (2010). "Report for the Roofing Industry Research Summit." *Proceedings of the 25th RCI International Trade Show and Convention*. Raleigh, NC: RCI, Inc.