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OVERVIEW OF CONSTRUCTION SUSTAINABILITY RESEARCH PRODUCTS

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Abstract: Much research has been conducted on capital project sustainability in the last two decades, but most of the findings only provide guidelines for its implementation during facility planning or design. This nearly exclusive focus on early project phases has left the industry with the need for more detailed guidance on implementing construction sustainability practices during jobsite execution. With this need in mind, the Construction Industry Institute (CII) chartered Research Team (RT) 304, "Sustainability Practices and Metrics for the Construction Phase of Capital Projects", to develop this missing practical guidance. This paper overviews the findings and products of the research team. The team developed a catalog of 54 Construction Phase Sustainability Actions (CPSAs) for onsite implementation during the construction phase to increase overall project sustainability. Each CPSA is characterized in terms of corresponding construction functions, potential sustainability impact, influence on project performance (i.e., cost, schedule, quality, and safety), ease of implementation, barriers to implementation, conditions that leverage benefits, and output metrics. The research team also developed two spreadsheet-based tools—the CPSA Screening Tool and the CPSA Implementation Index—to facilitate CPSA implementation during construction. The screening tool enables users to prioritize the 54 CPSAs according to project characteristics, while the index tool assesses CPSA implementation levels. Through its validation efforts, the team determined that the current level of CPSA implementation across the industry is at approximately 60 percent, and that this rate should increase with the regular use of the CPSA catalog, screening tool, and implementation index.

INTRODUCTION

As project teams seek to lessen the environmental impacts of their construction activities—water and electricity consumption, earth work, and wastes generated during demolition and construction, among others—they increasingly recognize the importance of construction sustainability techniques. More and more, owners, contractors, and other capital project stakeholders are looking for guidance and resources for conducting sustainable construction activities to improve their sustainability performance (CII 2014a and CII 2014b).

In recent decades, researchers have developed much practical sustainability-related guidance for construction activities. One of the globally recognized sources of guidance is the Leadership in Energy and Environmental Design (LEED) certification program developed by the United States Green Building Council (USGBC). While this program has been widely implemented, it only offers sustainability objectives and recommendations in the planning and design phases of projects (USGBC 2009). Similar programs were developed by the City of New York Department of Design and Construction and the

Chicago Department of Aviation (City of NY DDC 1999 and CDA 2013). These examples also focused on early project phases.

To provide the industry with practical sustainability guidance for the construction phase, the Construction Industry Institute (CII) organized Research Team (RT) 304, "Sustainability Practices and Metrics for the Construction Phase of Capital Projects." This paper introduces the research products developed by CII RT 304, the Construction Phase Sustainability Action (CPSA) Catalog, the CPSA Screening Tool, and the CPSA Implementation Index. Examples of the construction phase sustainability activities presented in these products are temporary facility design and construction, and construction means and methods.

1 RESEARCH OBJECTIVES

The objectives of the research were (1) to provide practical sustainability guidance for construction field operations, (2) to develop a spreadsheet-based tool to support sustainability implementation during the construction, and (3) to provide sustainability metrics for benchmarking. Since these objectives addressed sustainability implementation during the construction-phase, the scope of the research extended from the contractor's initial set-up to the final commissioning report of a capital project, and sustainability activities during the planning or design phase were excluded.

2 RESEARCH METHODOLOGY

Before proceeding to develop the objectives, the research team defined three key terms, i.e., construction sustainability, construction phase, and conventional project performance criteria. Construction sustainability was defined as "the processes, decisions, and actions during the construction phase of capital projects that enhance current and future environmental, social, and economic needs while considering project safety, quality, cost, and schedule." Construction phase was defined as "all fabrication/jobsite/field activities and decisions starting with construction/fabrication contracting and planning for site mobilization through to initial operations, final performance testing, and handover of the completed facility." Lastly, conventional project performance criteria were defined as "typical criteria for assessing a project’s success: safety, quality, cost, and schedule" (CII 2014a and CII 2014b).

As illustrated in Figure 1, the research team reached alignment on the objectives and terms before conducting its literature review. After that the team developed the Construction Phase Sustainability Actions (CPSAs) Catalog and two spreadsheet-based tools—the CPSA Screening Tool and the CPSA Implementation Index. Finally, the team engaged a panel of external sustainability experts to validate these research products (CII 2014a). The following section provides detailed descriptions of each phase of the research.

2.1 Literature Review

The research team examined the relevant literature in the following areas: sustainable development and sustainable construction; common sustainability models; sustainability drivers and barriers; corporate-level and project-level sustainability; advances in project-level sustainability practices; construction and demolition waste management; materials management and selection; construction site energy management and emission reduction; indoor air quality during construction; water consumption/quality during construction; and community and social aspects of sustainability. Due to the page limitations of this article, all detailed findings of the literature review can be found in Implementation Resource 304-2, "A Framework for Sustainability during Construction" (CII 2014a).

While conducting the literature review, the research team was able to study a variety of construction sustainability opportunities and their impacts on construction sustainability performance, i.e., their improvement of economic, social, and environmental aspects of a project. However, most previous research was conducted in early phases of construction projects, such as planning or design. This finding showed the need for more detailed guidance and applicable strategies for construction-phase sustainability practices for owners, contractors, and other stakeholders.

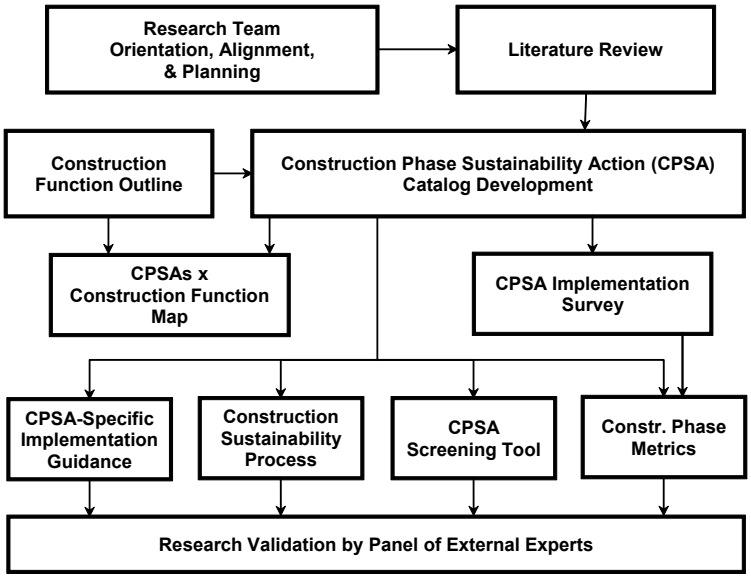


Figure 1. Research Methodology Overview (Adapted from CII 2014a and CII 2014b)

2.2 Development of Construction Phase Sustainability Actions (CPSAs) Catalog

In order to fill the research gap as lacking of guidance on construction-phase sustainability practices, the research team developed the CPSA Catalog with optional 54 actions which enhance project sustainability during the construction phase. The preliminary CPSAs with construction sustainability practices were originated from literature review. Then the research team brainstormed to assemble industry sustainability practices and collected experts opinion on construction sustainability. The team also estimated sustainability impact magnitude of each CPSA implementation with five different levels as significantly positive impact, positive impact, negative impact, significantly negative impact, and minimal/negligible impact. Before finalizing the 54 CPSAs, the draft of CPSAs had been refined with multiple reviews by the research team (CII 2014a).

Each catalog entry follows a template with the following information: CPSA title; primary construction function; secondary construction function; CPSA description; characterization of sustainability impacts; influence on conventional project performance criteria; ease of CPSA accomplishment/implementation; project conditions that leverage benefits from the CPSA; potential sustainability performance output metrics; barriers to successful implementation; and references (CII 2014a and CII 2014b). The team designed and modified the catalog throughout the course of numerous brainstorming sessions and workshops. The team was composed of 15 members, representing owners, contractors, design consultants, and equipment/material suppliers. The team's cumulative years of relevant industry experience was 316 years, with 21 years as the average amount of experience (CII 2014a).

2.3 Tools Development and Validation

RT 304 developed the CPSA Screening Tool and the CPSA Implementation Index in four different phases: (1) conceptual, (2) detailed planning, (3) tool programming, and (4) testing/modifying. During the conceptual phase, the research team identified inputs, outputs, a logic, and an algorithm for the CPSA Screening Tool. During the detailed planning phase, the team developed the content of the introduction tabs, user guide tabs, input tabs, output tabs, and database tabs for computing, for both tools. Next, the team programmed the content into the tools, using Microsoft Excel software functions. Once the tools had been developed, they were distributed to the panel of external experts to test on specific projects, and the tools were modified according to the panel's comments and suggestions (CII 2014a).

3 PRODUCT OF THE RESEARCH

This section describes the major characteristics of the research team's three research products: the CPSA Catalog, the CPSA Screening Tool, and the CPSA Implementation Index.

3.1 54 CPSAs Catalog

The research team developed 54 CPSAs for the CPSA Catalog to offer detailed guidance on construction sustainability implementation to owners, contractors, and other capital project stakeholders. Using the information provided in each CPSA, owners or project managers can decide whether to use sustainability activities to affect project performance. Figure 2 presents a sample image of CPSA No. 28. The entire CPSA Catalog can be found in CII Implementation Resource 304-2 (CII 2014a).

A. CPSA NO.: 28

1. CPSA TITLE: Sustainable Temporary Facilities	4. DATE: 5/5/2014
2. PRIMARY CONSTRUCTION FUNCTION: Site Facilities & Operations	
3. SECONDARY CONSTRUCTION FUNCTION: Field Engineering	

B. CPSA DESCRIPTION:

Optimize the planning of temporary site facilities. Consider the sustainability impacts related to the scoping, sizing, location, and layout of the following: staging areas; lay down areas material storage; fabrication shops; stockpiles; borrow pits; fuel storage; refueling stations; tool storage; parking lots; field offices dining/ break facilities; toilet facilities; vertical transportation; storm drainage; temporary power generation; site lighting; and infrastructure tie-ins; among others. Consider both mobile/temporary, semi-permanent options. Consider related impacts from any separate, remote locations. Also evaluate the related special challenges and opportunities associated with projects located in dense urban areas or extremely remote rural areas (e.g. cell tower communications capacity). Consider the implications of sequencing temporary facilities and construction site aesthetics for some projects.)

C. SUSTAINABILITY IMPACTS CHARACTERIZATION:

PRIMARY IMPACTS	MOST AFFECTED AREAS/RESOURCES			IMPACT MAGNITUDE				
				--	-	N	+	++
1. ENVIRONMENTAL	Energy consumption	Greenhouse gases	Waste generation	☐	☐	☐	☐	☒
2. SOCIAL	Health & safety	Local resource depletion	Community infrastructure	☐	☐	☐	☒	☐
3. ECONOMIC	Project fiscal impacts	-	-	☐	☐	☐	☒	☐

D. THIS CPSA HAS A SIGNIFICANT POSITIVE INFLUENCE ON THE FOLLOWING CONVENTIONAL PROJECT PERFORMANCE CRITERIA:

1. Project **safety** performance: ☒	3. Project **cost** performance: ☒	5. None: ☐
2. Project **quality** performance: ☐	4. Project **schedule** performance: ☐	

E. EASE OF ACCOMPLISHMENT/IMPLEMENTATION:

1. Easy: ☐	2. Moderate: ☒	3. Challenging: ☐

F. PROJECT CONDITIONS THAT LEVERAGE BENEFITS FROM THE CPSA:

1	The project is large and complex.
2	Project involves a worker camp.
3	The project is located in an environmentally/socially-sensitive area.

G. POTENTIAL SUSTAINABILITY PERFORMANCE OUTPUT METRICS:

1	Size of carbon footprint from project.
2	Proportion of sensitive vegetation not impacted from project.

H. BARRIERS TO SUCCESSFUL CPSA IMPLEMENTATION:

1	Inadequate information to identify sustainability impacts of temporary site facilities.
2	Limited project resources –first-cost often trumps any consideration of sustainability.

I. REFERENCES

1	CDA. (2009). *Sustainable Airport Manual* (Final Report No. version 1) (pp. 1–239). Chicago: Chicago Department of Aviation.
2	CII RT 250. (2011). *Sustainable Design and Construction for Industrial Construction: A Primer* (Implementation Resource No. 250-2) (pp. 1–85). Construction Industry Institute.
3	City of New York DDC. (1999). *High Performance Building Guidelines* (pp. 1–144). New York: City of New York Department of Design and Construction.
4	Hageman, K. (2013). Let There Be Light - Light Tower Lamp Options: What Sustainable Contractors Should Know. *Sustainable Construction Magazine*, (Spring 2013), 21–23.

Figure 2. Typical CPSA Catalog Entry (Adapted from CII 2014a and CII 2014b)

3.1.1 CPSA Title and Primary Construction Function

The team identified the following eight construction sustainability-related primary functions for the CPSA Catalog: (1) project management; (2) contracting; (3) field engineering; (4) site facilities and operations; (5) craft labor management; (6) materials management; (7) construction equipment management; and (8) quality management, commissioning, and handover (CII 2014a and CII 2014b).

Table 2 categorizes the 54 CPSAs, first by primary sustainability impact, and then by the most affected project areas and resources. Around 60 percent of CPSAs are relevant to the Site Facilities & Operations, Project management, and Field Engineering. (CII 2014a)

3.1.2 Characterization of Sustainability Impacts

The most affected areas and resources of each CPSA's sustainability impact was gathered from literature and research team brainstorming. The collected areas and resources were assigned to one sustainability impact area as one aspect among economic, social, and environmental. Table 1 presents the entire list of most affected areas and resources of each sustainable area.

Table 1: Primary Sustainability Impacts of CPSA and the Most Affected Areas and Resources by CPSA (Adapted from CII 2014a)

Primary Sustainability Impact	Most Affected Areas and Resources
Environmental	Energy consumption; Greenhouse gases: Criteria air pollutants; Indoor air quality; Water consumption; Water quality; Waste generation; Land use; Noise pollution; Odors; Light pollution; or Negligible effect
Social	Health and safety; Skills development; Community relationships; Local resource depletion; Community infrastructure; Traffic; Job creation; Tax revenue generation; Community service donations; or Negligible effect
Economic	Project fiscal impacts, or Negligible effect

The tool prompts the user to indicate the most desirable sustainability impacts for a given project on a five-point scale. The research team also designed the tool to measure the positive impact of each CPSA on conventional project performance criteria, i.e., safety, quality, cost, and schedule objectives.

3.1.3 Ease of CPSA Implementation and Leveraging Benefits of CPSA Implementation

The research team assessed the level of difficulty of each CPSA implementation as easy, moderate, or challenging, considering the required resources, expense, skill-sets, and time to implement. In addition to rating the ease of CPSA implementation, the team identified project conditions that leverage benefits from CPSA implementation, grouping them into seventeen categories. These leveraging conditions can be found in CII Implementation Resource 304-2 (CII 2014a).

3.1.4 Sustainability Performance Output Metrics and Barriers to Successful Implementation

The research team identified output metrics for measuring the sustainability performance of each CPSA during its implementation, putting these metrics into nine categories. Moreover, the team examined barriers to each CPSA implementation to prepare project teams for potential challenges. The team grouped these barriers into the following five categories: lack of information; limited project resources; outside owner/contractor control; lack of infrastructure; and unfavorable site or project conditions. The full lists of output metrics and barriers can be found in CII Implementation Resource 304-2 (CII 2014a).

Table 2: Typical CPSAs according to Primary Construction Functions (Adapted from CII 2014a)

Primary Construction Function	CPSA Title
Project Management	1. Leadership Team Staffing for Sustainable Projects 2. Community Social Responsibility Program 3. Contractor Sustainability and Recognition Program 4. Sustainability Provisions in Construction Execution Plans 5. Sustainability Risk Management 6. Stakeholder Engagement Plan 7. Site Work Hour Schedule to Reduce Traffic Impacts 8. Work Schedule to Reduce Electricity Impacts 9. Paperless Communication and Construction Documentation 10. Construction Team Sustainability Performance Assessment
Contracting	11. Verification of Sustainability Claims and Ratings 12. Sustainability-friendly Project Delivery Method 13. Contractor Prequalification Based on Safety and Sustainability Performance 14. Promotion of Local Employment and Skills Development 15. Sustainability Change Proposal Clause
Field Engineering	16. Labor-intensive versus Equipment-intensive Approaches 17. Pre-assembly and Pre-fabrication of Construction Elements 18. Sequence and Route Planning for Project Transport 19. Minimization of Project's Footprint of Disruption 20. Sustainable Material Substitutions 21. Construction Noise/Vibration Abatement and Mitigation 22. Selective Demolition versus Conventional Demolition 23. Sustainable Large-scale Earthwork and Grading Operations 24. Reduction of Dunnage for Equipment Operations 25. Reusable Shoring, Formwork, and Scaffolding
Site Facilities & Operations	26. Protection of Cultural Artifacts and Endangered Species 27. Protection of Trees and Vegetation 28. Sustainable Temporary Facilities 29. Sustainable Temporary Worker Camps 30. Source of Onsite Power 31. Site Energy Management 32. Energy-autonomous Pre-manufactured Reusable Facilities 33. Indoor Air Quality Improvements 34. Collection, Remediation, and Reuse of Gray water and Storm water 35. Environmentally-friendly Dust and Erosion Control 36. Construction and Demolition Waste Management 37. Collection, Sorting, and Recycling of Construction Wastes
Craft Labor Management	38. Promotion of Local Workforce Preparedness 39. Expatriates versus Local Employment for Global Projects 40. Promote Community Harmony within Diverse Project Workforce
Materials Management	41. Analysis of Local Materials/Services versus Non-local/Global Alliance 42. Reduction of Packaging Waste

Primary Construction Function	CPSA Title
	43. Material- and Equipment-handling Strategy 44. Sustainable Consumable Materials Management 45. Minimization of Material Surplus 46. Management of Surplus Materials
Construction Equipment Management	47. Selection and Replacement of Construction Equipment 48. Right-sizing of Construction Equipment 49. Use of Full Transport/Equipment Capacity 50. Reduction in Idling of Construction Equipment 51. Inspection and Maintenance of Construction Equipment 52. Tire-cleaning of Roadworthy Vehicles
Quality Management, Commissioning & Handover	53. Quality Management and Facility Start-up Planning 54. Sustainability Lessons Learned

3.2 CPSA Screening Tool

The research team developed the Excel-based CPSA Screening Tool to help project managers or any capital project stakeholders select the most appropriate and relevant CPSAs. This tool utilizes user input about the project to screen for these relevant CPSAs from the total 54 CPSAs. It then ranks the selected CPSAs according to their likelihood of maximizing project sustainability performance.

The first user inputs for the CPSA Screening Tool are project-specific sustainability objectives; the user determines the relative importance of environmental stewardship, social progress, and direct project economics. Next, the tool prompts the user to provide information about project characteristics. The output is the prioritized list of CPSAs. Figures 3 and 4 show the screenshot of the tool's Input tab. Figure 5 presents the screenshot of the Output tab. (CII 2014a)

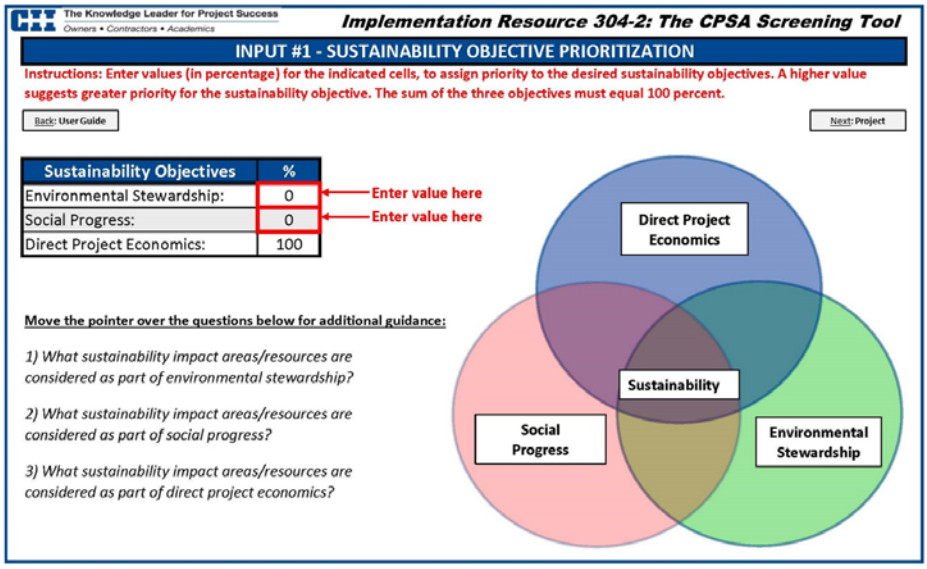
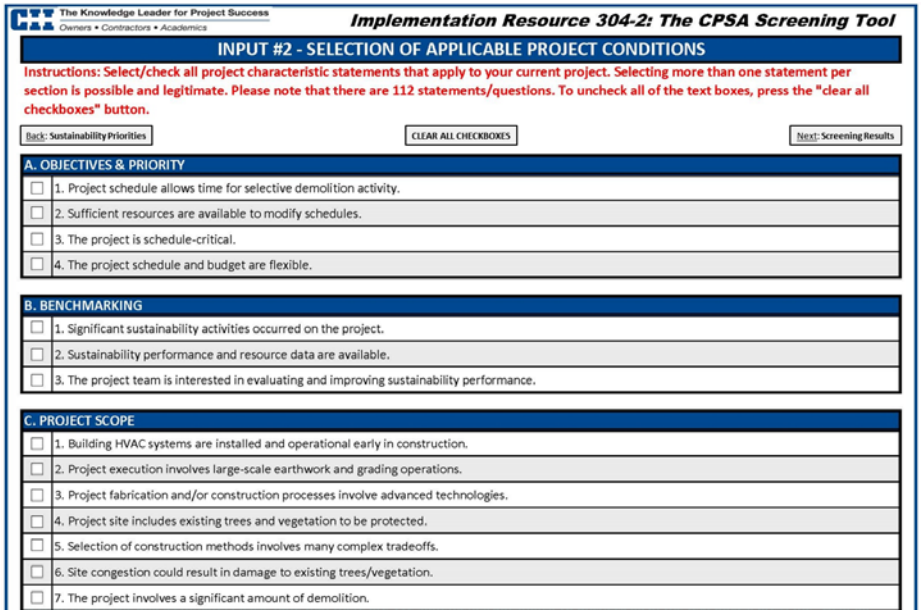


Figure 3. CPSA Screening Tool - Sustainability Priorities Tab (Adapted from CII 2014)



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Implementation Resource 304-2: The CPSA Screening Tool

INPUT #2 - SELECTION OF APPLICABLE PROJECT CONDITIONS

Instructions: Select/check all project characteristic statements that apply to your current project. Selecting more than one statement per section is possible and legitimate. Please note that there are 112 statements/questions. To uncheck all of the text boxes, press the "clear all checkboxes" button.

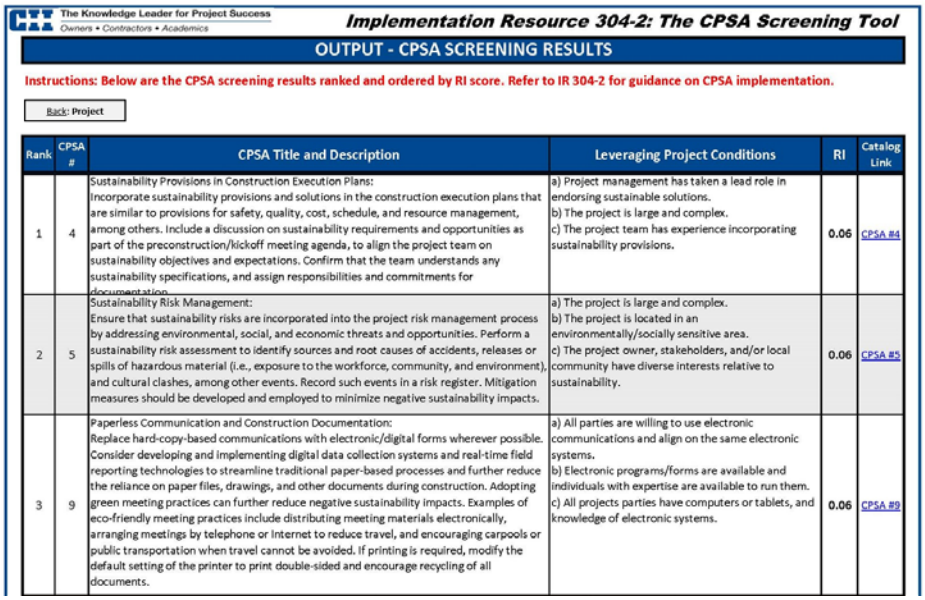
Back: Sustainability Priorities | CLEAR ALL CHECKBOXES | Next: Screening Results

A. OBJECTIVES & PRIORITY	
☐	1. Project schedule allows time for selective demolition activity.
☐	2. Sufficient resources are available to modify schedules.
☐	3. The project is schedule-critical.
☐	4. The project schedule and budget are flexible.

B. BENCHMARKING	
☐	1. Significant sustainability activities occurred on the project.
☐	2. Sustainability performance and resource data are available.
☐	3. The project team is interested in evaluating and improving sustainability performance.

C. PROJECT SCOPE	
☐	1. Building HVAC systems are installed and operational early in construction.
☐	2. Project execution involves large-scale earthwork and grading operations.
☐	3. Project fabrication and/or construction processes involve advanced technologies.
☐	4. Project site includes existing trees and vegetation to be protected.
☐	5. Selection of construction methods involves many complex tradeoffs.
☐	6. Site congestion could result in damage to existing trees/vegetation.
☐	7. The project involves a significant amount of demolition.

Figure 4. CPSA Screening Tool - Input Tab (Adapted from CII 2014a)



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Implementation Resource 304-2: The CPSA Screening Tool

OUTPUT - CPSA SCREENING RESULTS

Instructions: Below are the CPSA screening results ranked and ordered by RI score. Refer to IR 304-2 for guidance on CPSA implementation.

Back: Project

Rank	CPSA #	CPSA Title and Description	Leveraging Project Conditions	RI	Catalog Link
1	4	Sustainability Provisions in Construction Execution Plans: Incorporate sustainability provisions and solutions in the construction execution plans that are similar to provisions for safety, quality, cost, schedule, and resource management, among others. Include a discussion on sustainability requirements and opportunities as part of the preconstruction/kickoff meeting agenda, to align the project team on sustainability objectives and expectations. Confirm that the team understands any sustainability specifications, and assign responsibilities and commitments for documentation.	a) Project management has taken a lead role in endorsing sustainable solutions. b) The project is large and complex. c) The project team has experience incorporating sustainability provisions.	0.06	CPSA #4
2	5	Sustainability Risk Management: Ensure that sustainability risks are incorporated into the project risk management process by addressing environmental, social, and economic threats and opportunities. Perform a sustainability risk assessment to identify sources and root causes of accidents, releases or spills of hazardous material (i.e., exposure to the workforce, community, and environment), and cultural clashes, among other events. Record such events in a risk register. Mitigation measures should be developed and employed to minimize negative sustainability impacts.	a) The project is large and complex. b) The project is located in an environmentally/socially sensitive area. c) The project owner, stakeholders, and/or local community have diverse interests relative to sustainability.	0.06	CPSA #5
3	9	Paperless Communication and Construction Documentation: Replace hard-copy-based communications with electronic/digital forms wherever possible. Consider developing and implementing digital data collection systems and real-time field reporting technologies to streamline traditional paper-based processes and further reduce the reliance on paper files, drawings, and other documents during construction. Adopting green meeting practices can further reduce negative sustainability impacts. Examples of eco-friendly meeting practices include distributing meeting materials electronically, arranging meetings by telephone or Internet to reduce travel, and encouraging carpools or public transportation when travel cannot be avoided. If printing is required, modify the default setting of the printer to print double-sided and encourage recycling of all documents.	a) All parties are willing to use electronic communications and align on the same electronic systems. b) Electronic programs/forms are available and individuals with expertise are available to run them. c) All projects parties have computers or tablets, and knowledge of electronic systems.	0.06	CPSA #9

Figure 5. CPSA Screening Tool - Output Tab (Adapted from CII 2014a)

Equation 1 presents the Relevance Index (RI), the tool's prioritizing algorithm. The RI is the Impact Score (IS) times the Conditions Score (CS). The IS is the sum of the Project-specific Sustainability Priorities (PSP) times the Sustainability Impact Rating (SIR); these are shown in Section C of each CPSA sheet. (See the sample sheet in Figure 2.) The percentage of each sustainability priority entered in the Input tab of the tool is its PSP value, and the SIR value is defined as 0 when the SIR is "N," 0.60 when the SIR is "+," -0.60 when the SIR is "-," 1.00 when the SIR is "++,", and, lastly, -1.00 when the SIR is "--." (CII 2014a)

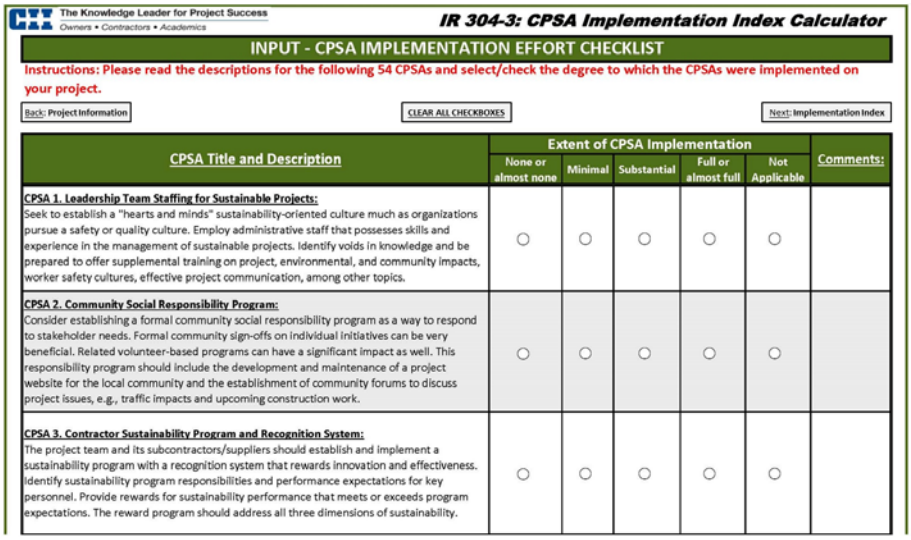
[1] Relevance Index (RI) = Impact Score (IS) X Conditions Score (CS),

where IS = Σ {(Project-specific Sustainability Priorities) X (Sustainability Impact Rating)}

The CS is determined by the number of leveraging conditions applicable to the project; it is 0.10 when there are zero CPSA leveraging condition, 0.33 when there is one leveraging condition, 0.67 when there are two leveraging conditions, 1.00 when there are three leveraging conditions. (CII 2014a)

3.3 CPSA Implementation Index

To help project teams assess the sustainability performance of their projects, the research team developed CPSA Implementation Index. This tool's numerical index score (out of 100 possible points) represents the project's level of CPSA implementation. This score also allows project teams to compare projects for sustainability performance. As discussed above, the input for the CPSA Implementation Index is a rating of the extent of implementation of all 54 CPSAs. Figures 6 and 7 show screenshots of the tool's Input and Output tabs, respectively. (CII 2014a)



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IR 304-3: CPSA Implementation Index Calculator

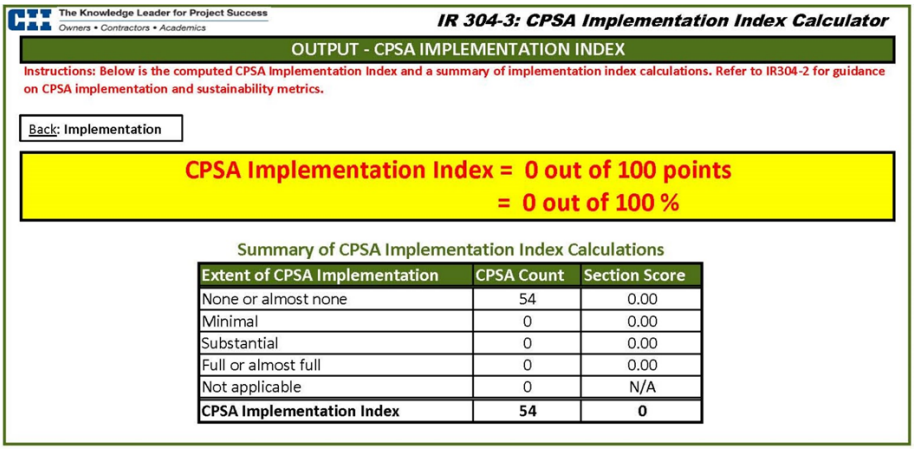
INPUT - CPSA IMPLEMENTATION EFFORT CHECKLIST

Instructions: Please read the descriptions for the following 54 CPSAs and select/check the degree to which the CPSAs were implemented on your project.

Back: Project Information | CLEAR ALL CHECKBOXES | Next: Implementation Index

CPSA Title and Description	Extent of CPSA Implementation					Comments:
	None or almost none	Minimal	Substantial	Full or almost full	Not Applicable	
CPSA 1. Leadership Team Staffing for Sustainable Projects: Seek to establish a "hearts and minds" sustainability-oriented culture much as organizations pursue a safety or quality culture. Employ administrative staff that possesses skills and experience in the management of sustainable projects. Identify voids in knowledge and be prepared to offer supplemental training on project, environmental, and community impacts, worker safety cultures, effective project communication, among other topics.	○	○	○	○	○	
CPSA 2. Community Social Responsibility Program: Consider establishing a formal community social responsibility program as a way to respond to stakeholder needs. Formal community sign-offs on individual initiatives can be very beneficial. Related volunteer-based programs can have a significant impact as well. This responsibility program should include the development and maintenance of a project website for the local community and the establishment of community forums to discuss project issues, e.g., traffic impacts and upcoming construction work.	○	○	○	○	○	
CPSA 3. Contractor Sustainability Program and Recognition System: The project team and its subcontractors/suppliers should establish and implement a sustainability program with a recognition system that rewards innovation and effectiveness. Identify sustainability program responsibilities and performance expectations for key personnel. Provide rewards for sustainability performance that meets or exceeds program expectations. The reward program should address all three dimensions of sustainability.	○	○	○	○	○	

Figure 6. CPSA Implementation Index - Input Tab (Adapted from CII 2014a)



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IR 304-3: CPSA Implementation Index Calculator

OUTPUT - CPSA IMPLEMENTATION INDEX

Instructions: Below is the computed CPSA Implementation Index and a summary of implementation index calculations. Refer to IR304-2 for guidance on CPSA implementation and sustainability metrics.

Back: Implementation

CPSA Implementation Index = 0 out of 100 points
= 0 out of 100 %

Summary of CPSA Implementation Index Calculations

Extent of CPSA Implementation	CPSA Count	Section Score
None or almost none	54	0.00
Minimal	0	0.00
Substantial	0	0.00
Full or almost full	0	0.00
Not applicable	0	N/A
CPSA Implementation Index	**54**	**0**

Figure 7. CPSA Implementation Index - Output Tab (Adapted from CII 2014a)

To compute the CPSA Index score, the tool allocates a maximum of 1.85 points for each CPSA implementation, with a total of 100 possible points. That is, the points allocated for each CPSA will be 1.85 when the extent of CPSA implementation is selected as "Full or Almost Full." Further, when the extent selected is "Substantial," the points awarded will be 1.23. When the extent selected is "Minimal," the points will be 0.62. When the extent selected is "None or Almost None," the points will be 0.00. (CII 2014a)

4 VALIDATION OF THE PRODUCT

4.1 54 CPSAs Catalog

The research team distributed a survey to the review panel, to identify any missing content, to identify any items in need of correction, and to examine their current levels of CPSA application. The 33-member review panel was composed of research team members and external industry practitioners. They had an average of 26 years of industry experience (CII 2014a).

The first section of the survey assessed background, e.g., years of industry experience, project role, primary industry sector, and company size, among other characteristics. The second section asked frequency of CPSA application to the project and likelihood of application of each CPSA to future projects. The respondents indicated that they would either sometimes or frequently apply around 41 CPSAs (75 percent) to their projects; they also said that they were either somewhat or very likely to apply 53 CPSAs (98 percent) to their future projects (CII 2014a).

4.2 CPSA Screening Tool and CPSA Implementation Index

The research team demonstrated the CPSA Screening Tool on a large mining project in Mexico, and demonstrated the CPSA Implementation Index on a large U.S. urban rail transit project. In this validation process, project managers from each project gave constructive and valuable feedback that the team used to modify the tools. The CPSA Implementation Index demonstration showed that the current level of CPSA implementation is 60 percent (CII 2014a).

5 CONCLUSIONS AND RECOMMENDATIONS

The industry's need for practical guidance on construction-phase sustainability implementation motivated the research team to develop the Construction Phase Sustainability Actions (CPSAs) Catalog, the CPSA Screening Tool to prioritize relevant CPSAs for each project, and the CPSA Implementation Index to measure the level of CPSA implementation efforts. All three outputs were validated by selected experts in construction sustainability. The tool demonstrations showed that the current level of CPSA implementation is 60 percent. (CII 2014a)

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