Guide to Arc Re-Entry

version 1.3 – February 2022

Arc Re-Entry Guide

Summary

Arc Re-Entry is a set of tools to support a safe, confident return to work, school, and play. Re-Entry builds on Arc's long-standing performance categories with new capabilities to assess facility management, evaluate occupant experience, and measure indoor quality. With Arc Re-Entry:

1) Any project can collect, manage, and score infectious disease-related information about facility management, occupant experience, and indoor air quality.

2) Arc Essential subscribers can analyze performance and create customized reports for projects and portfolios.

Consistent with Arc's broader mission, these tools can be used to create feedback loops between management intent and real world outcomes. As always, Arc will use this information to recognize leadership and celebrate people and organizations delivering superior real world performance.

Arc Re-Entry:

- Supports the iterative assessment of facility management and occupant experience -- *not the health of individual occupants or infection risk.*
- Aggregates and interprets information reported by facility managers and occupants -- *the information provided is only as useful as the quality of the incoming data and the underlying scientific literature used to interpret it*.
- Data are subject to automated quality tests -- *not document review.*

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Quick Start

Getting started with Arc Re-Entry is easy:

1. Login to Arc, access an existing project or create a new one. Users must have a LEED Online or USGBC.org site user account. New users can create one for free.
2. After logging in, select a project and find the Leadership tab on the left side. Select the Re-Entry category. The tab provides three options:
    - Send Facility Manager survey
    - Send Occupant Observation survey
    - Add IAQ data
3. After sending surveys or adding data, you can review information about each category in the Meters & Survey section. Each component has a Data, Details, and Documentation tab. The Details tabs provide a summary of responses, and charts to view performance over time.

If you need support, please reach out to the Arc team for help.

Introduction

The COVID-19 pandemic has had a sweeping impact on the global property industry. Many authorities and academic researchers predicted a global pandemic and described its potential consequences. However, it remains difficult to fully envision the scope of its impact on our everyday lives with emerging variants of concern. It has changed so many aspects of how we live, work, and play. After months of lockdowns and quarantine, many communities are seeking to establish a new normal. This means returning to workplaces, schools, and places of recreation, public assembly, and worship.

In the last couple years, we have learned a lot about how to keep ourselves safe during this re-entry, enough to know that it will require a thoughtful, coordinated, and sustained effort. Along with vaccines and personal protective equipment (PPE), we must create a layered "defense in depth" to break the chain of infection. This means keeping people separated, cleaning and sanitizing surfaces and spaces, circulating and filtering air, and much more.

The good news is that we only need one break in the chain of infection to stop the spread of disease. The bad news is that we need to create those breaks all the time, everywhere. This is a challenge of professionals who design, build, and operate our built environment. We are very good at creating exceptional projects that, at times, deliver exceptional performance. However, we are not so good at delivering consistent performance everywhere, all the time. This reflects the reality of managing buildings and places. These are complex engineered systems, often unique in design, and subject to all manner of operating conditions and occupant behavior.

While we cannot expect to be perfect, we can create systems to provide situational awareness, offer transparency for stakeholders, and use information to improve performance over time. This is our aspiration for Arc Re-Entry: a set of tools that help facility and portfolio managers organize and communicate their infection control plans and learn from occupant observations and measured indoor air quality. We envision that these tools will be used repeatedly to improve performance over time as we learn more about what works to control the spread of infectious disease.

Arc Re-Entry provides tools for a marathon, not a sprint. With the possibility of more variants, there is no telling how long the pandemic will last or what forms it may take in the future. To that end, we have worked to get started quickly with simple, practical features that we believe can provide value over time. We are also committed to improving these tools in the months ahead

to meet this important moment and help us safely and confidently re-enter the places where we live, work, and play.

From Performance to Re-Entry

Arc measures and scores the operational performance of spaces, buildings and places. Arc scores distinguish leaders and help make real world performance measurement a ubiquitous part of green building practice.

The **Arc Performance Score** provides a weighted combination of information in five categories, including:

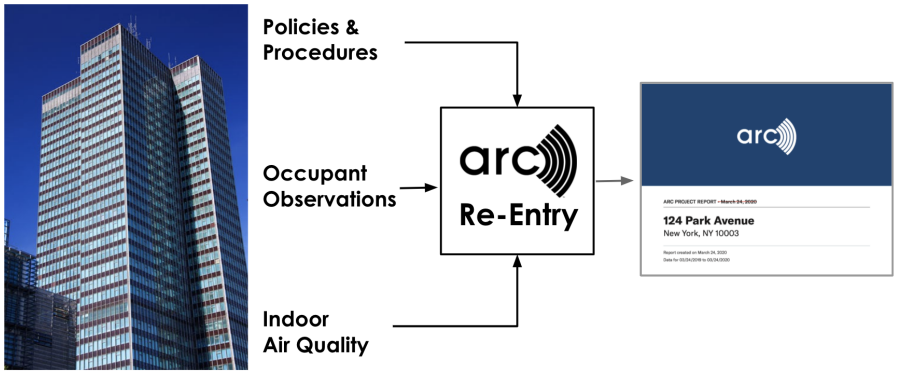
- Energy and Emissions
- Water
- Waste
- Transportation
- Human Experience

The Arc Performance Score powers LEED for Operations and Maintenance v4.1 and LEED Recertification.

The **Arc Human Experience** category collects and scores information on two equally weighted sub-categories:

- Perceived occupant satisfaction
- Measured indoor air quality, including CO_2 and TVOC

Arc Re-Entry expands and adapts tools and metrics in Arc to support the management of infectious disease transmission[1].



[1]Arc Re-Entry is focused on the management of infectious disease, specifically COVID-19. Management recommendation would be significantly different for other aspects of health and well-being. Relevant resources for other issues include the International WELL Building Institute, the Green Health Partnership, and peer reviewed literature (e.g., Worden et al. 2020).

Arc Re-Entry can complement existing building rating systems or be used as a stand-alone tool.

Figure 1. *Illustration of Arc Re-Entry support components, including data collection for facility management policies and procedures, occupant observations, and measured indoor air quality.*

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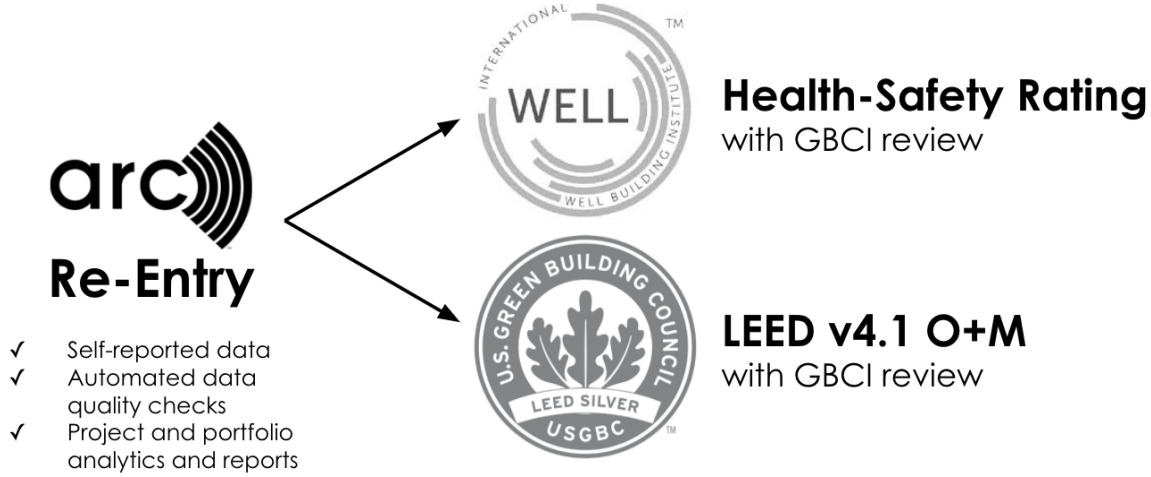
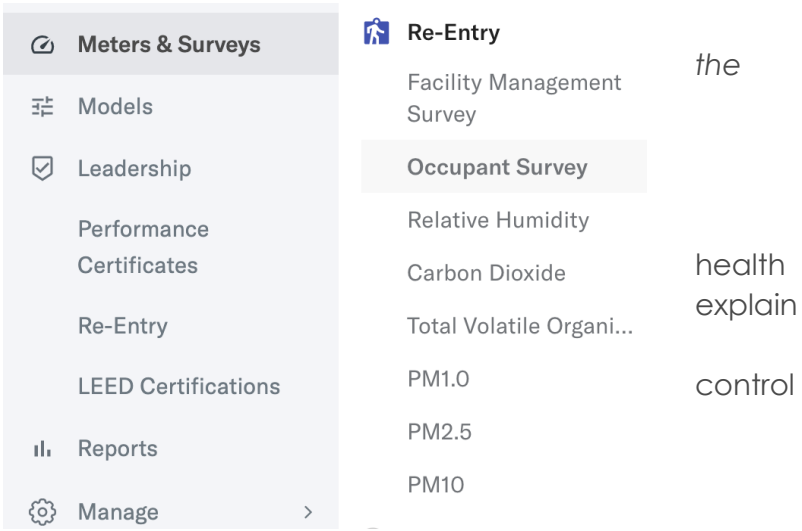
Figure 2. *Arc Re-Entry can provide a starting point for health and green building rating systems, including the WELL Health-Safety Rating and LEED v4.1 O+M.*



Arc Re-Entry leverages existing capabilities, including Arc's long-standing occupant satisfaction survey and requirements for indoor air quality measurement. These are supplemented by two new surveys and an expanded set of indoor air quality metrics.

Figure 3. *Arc Re-Entry data are entered in a new category under Meters & Surveys tab.*



Additionally, Arc Re-Entry allows managers to document and share connections with relevant public authorities. This makes it easier to explain why facility managers have selected a given set of infection control strategies. In turn, Arc Re-Entry helps managers evaluate how occupants experience their health the

management strategies and how they may be reflected in measured indoor air quality. This provides the basis for repeatable feedback loops between management intent and measured outcomes.

New components introduced with Arc Re-Entry include:

- **New facility management survey:** The new facility manager survey requests information about infection control policies and procedures and alignment with relevant authorities (e.g., the World Health Organization, etc.).
- **New surveys for occupant observations:** The new occupant observation surveys include long-standing questions about occupant satisfaction, as well as new opportunities to share experiences with disease control-related features, such as signage or access to disinfecting products.
- **New indoor air quality metrics:** The new indoor air quality metrics expand on Arc's existing set of measurements and change interpretations to align with disease control objectives. This means that CO_2 and TVOC are found in both the long-standing Human Experience category, as well as Re-Entry. However, the metrics have changed from concentrations of pollutants to the fraction of time above a threshold. Additionally, the new section requests information about relative humidity and particulate matter; aspects of air quality linked to disease transmission or susceptibility. All of these IAQ factors can be measured with either portable instruments or sensor networks (e.g., Arc partners arbnco and QLEAR).

All together, the new Re-Entry elements include 120 variables, including simple binary responses, measurements, and supporting documentation. Information about each variable is available through Arc Re-Entry Meters spreadsheet.

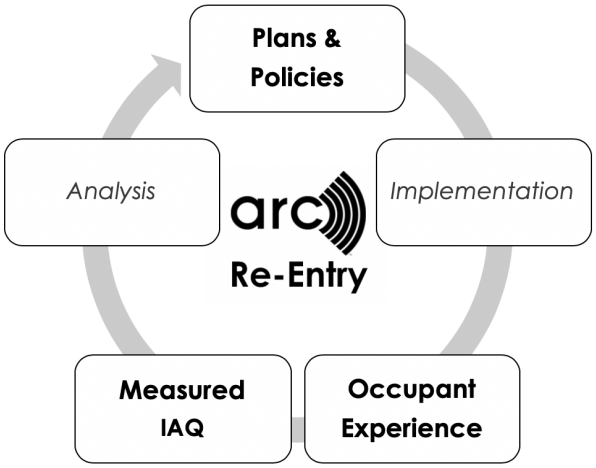


Figure 4. *Arc Re-Entry supports the repeated evaluation of infection control strategies. The bold elements are explicitly addressed in the tool. The gray elements, Implementation and Analysis, are taken outside of the tool.*

Iterative Analysis

Arc Re-Entry is not a "once-and-done" assessment. Arc Re-Entry is designed to be an iterative evaluation of the comprehensiveness of infection control practices. It is designed to provide transparency about management intent and support a comparison between intentions and occupant experiences and measured outcomes. Fundamentally, the power of the tool is in its repeated use. This means that it does not have a clearly defined stopping or end-point. Rather, it should be used as long as it is needed to improve management and build confidence for re-entry and on-going operations.

Re-Entry Comprehensiveness Score

Arc uses scores to interpret and integrate performance measurements. Arc scores for energy, water, and waste are benchmarked using a Reference Set. Arc scores for transportation and human experience are based on mathematical functions. Neither of these approaches is appropriate to interpret re-entry-related information. Benchmarks do not exist, and research to establish quantitative guidelines is still preliminary and, in some cases, conflicting. However, there is still a need to aggregate and interpret information for facility managers and stakeholders. Consequently, Arc calculates a Re-Entry Comprehensiveness Score ("Comp Score").

The Comp Score is a 0 to 100% measure of the fraction of positive responses compared to the total number of potential positive responses. The Comp Score is average of three components: facility management, occupant observations, and indoor air quality. The Comp Score should be interpreted as a simple indicator of the number of self-reported actions implemented by the facility and scope of occupant or measured indoor quality data describing conditions in a facility:

- *Comp Score = 0:* The facility reports no disease control practices and procedures, occupants uniformly observe no disease control features, and no indoor air quality data are collected.
- *Comp Score = 100:* The facility reports on all requested disease control practices and procedures. The facility managers provide supporting documentation for each element. Occupants uniformly observe disease control features. Indoor air quality information is consistently collected throughout the facility.

Comp Scores between 0 and 100 indicate a simple proportion of potential affirmative responses. There is no weighting beyond the equal proportions assigned to facility management, occupant observations, and indoor air quality.

In some cases, a response may not be applicable to a given facility. When a user selects "not applicable", the question is removed from both the numerator and the denominator of the Comp Score equation. For example, a question about increasing outdoor air supply might be not applicable for an open air venue. The absence of this response does not "count against" the Comp Score.

Note: There is no way for Arc to independently verify the applicability of responses at this time, and users should consider this when evaluating Comp Scores. Third-parties, including the International WELL Building Institute and RESET may provide third-party verification, such as on-site or data audits.

It is also important to note that Comp Scores are *not* a direct indicator of health or the risk of disease transmission. They are exactly what the name implies, an indicator of the relative comprehensiveness of management practices, occupant observations, and indoor air quality measurements.

Over time, it may be possible to use Comp Scores to evaluate the effectiveness of different combinations of facility management to disease transmission. However, this will necessarily be a retrospective analysis, possible only after re-entry has taken place (e.g., does a higher Comp Score result in a lower risk of infection). It is not possible to conduct this type of analysis until people have returned to different types of spaces, and we have a distribution of responses (i.e., some have or have not gotten sick). Until then, we can attempt to consistently implement Best Practices and measure results.

Facility Management

Facility managers cannot stop the spread of infectious disease on their own. They do play an important role in creating conditions that may reduce the rate or likelihood of disease transmission. They can use management interventions to break the chain of infection. This means limiting the introduction of virus-carrying occupants, reducing the likelihood of spread through the air and on surfaces, and facilitating the use of barriers and personal protective equipment to prevent exposure.

Arc Re-Entry uses a survey to ask facility managers about:

1. Infection control policies and procedures.
2. Authorities used to inform or align the facility's policies and procedures.
3. Specific elements included in the facility's policies and procedures.

Each element includes a yes or no question and the opportunity to provide supporting information as a hyperlink or file. The facility managers survey asks facility managers to identify a number of specific strategies recommended by some authorities, including:

- **Infection control policy or procedure:** This is a written plan applicable to the facility guiding effort to reduce the spread of infectious disease (e.g., the Hines Return to Occupancy Plan or the BXP Health Security Plan).

- **Alignment with public health authorities:** This question documents references or alignment with published guidance from government, academic, or non-profit sources, such as U.S. Centers for Disease Control Interim Guidance for Businesses and Employers Responding to Coronavirus Disease 2019, ASHRAE Guidance for Building Operations during the COVID-19 Pandemic, BOMA Getting Back to Work: Preparing Buildings for Re-Entry, USGBC LEED Safety First: Re-Enter Your Workspace Pilot Credit, or IWBI's WELL Health-Safety Rating. Alignment is interpreted as the intent for building management to substantially reflect material aspects of the referenced authority.

- **Communications and signage:** This question addresses signage and other communications intended to reduce disease transmission, such as advice regarding hand washing, social distancing, and personal protective equipment wearing.

- **Occupant screening:** This question addresses policies, procedures, or practices intended to prevent disease carrying people from entering the facility. This may take the form of health checks, temperature screening, or other measures, such as recommendations in the U.S. Centers for Disease Control COVID-19 Employer Information for Office Buildings.

- **Paid sick leave:** This question addresses potential incentives or disincentives for facility management staff and contractors to work while sick. Paid sick leave has been shown to reduce the likelihood of working while sick and, in turn, spreading disease (see Pitchler et al. 2020).

- **Social distancing:** This question addresses interventions to promote social distancing, including physical barriers, seating, workstation design, and other strategies. Relevant guidance varies by facility type, such as the United Kingdom Department of Digital, Culture, Media, and Sport, Guidance for providers of outdoor facilities on the phased return of sport and recreation in England (December 2021).

- **Ventilation and outdoor air supply:** Some authorities have recommended increasing ventilation rates and the supply of outdoor air. Strategies to increase outdoor air supply

vary, and they could be interpreted as increasing daily supply through 24/7 operations or increasing average air flow.

Some facilities may also increase fresh air supply by encouraging the use of operable windows. If selected, supporting documentation should explain specific strategies applied to this facility. Relevant research includes findings such as Li et al. (2020) and guidance such as ASHRAE's Position Document on Infectious Aerosols and the RESET standard (e.g., requirements for real time tracking).

- **Air filtration:** Some authorities have recommended enhancing HVAC filtration by incorporating HEPA filters or UVGI systems . Under some circumstances, this may reduce disease transmission. Guidance varies for the type and level of filtration recommended. If selected, supporting documentation should explain the type of filtration used by the facility and relative contextual information about HVAC design or operations. Relevant research includes Bolashikov and Melikov (2009) and guidance includes CIBSE Guidance on Ventilation during COVID-19 and the National Air Filtration Association. Projects may consider RESET Core & Shell or Commercial Interior guidance for the measurement and management of indoor and outdoor airborne particulates. More information on HEPA filters and UVGI can be found here.

- **Elevator operations:** Some authorities have identified elevators as a potential high risk area. Consequently, they have provided guidance for rider density, waiting, and cleaning. Relevant research includes Kandel et al (2014) and COVID-19 Precautions for Multi-unit Residential Buildings (2020) published by the Canadian National Collaborating Centre for Environmental Health.

Referencing LEED, WELL, and RESET

Facility and venue managers may elect to use elements of the LEED or WELL rating systems to inform their policies and procedures. They can reference rating systems or individual credits as authorities. This reflects that these credits are based on a specific interpretation of underlying research and guidance. This makes them practical tools to guide facility management. Examples of relevant authorities include:

- **U.S. Green Building Council:** LEED credits, including Safety First: Re-Enter Your Workspace and Safety First: Cleaning and Disinfecting Your Space
- **International WELL Building Institute:** Strategies referenced in the forthcoming WELL

Health-Safety Rating

- **RESET:** Strategies related to indoor and outdoor air quality measurement and management in the RESET Air Standard 2.0.

These and other rating systems are providing timely, best practice-based guidance for facility managers and occupants.

Sample Facility Management Response

A facility management might respond to the survey with the following:

- Does the facility have an infection control **policy or procedure**?
    - Yes, file upload: 123_Main_St_Infection_Control_Plan_Section2.pdf

- Is the policy or procedure aligned with one or more **authorities**?
    - Yes, file uploads: U.S. Centers for Disease Control Guidelines, LEED Safety First: Re-Enter Your Workspace Pilot Credit

- Does the policy or procedures include **specific strategies** for:

    - Disease control **communication and signage**
        - Yes, file upload: 23_Main_St_signage_photo.jpg

    - **Clean and disinfection** to address disease transmission
        - Yes, hyperlink: LEED Safety First: Clean and Disinfect Your Space

    - **Occupant screening**
        - Yes, file upload: 123_Main_St_occupant_screening_policy.pdf

    - **Paid sick leave** for staff and contractors
        - Yes, file upload: 123_Main_St_employee_policy.pdf

    - **Social distancing (**e.g., floor markers, barriers)?
        - Yes, file upload: 123_Main_St_Infection_Control_Plan_Section1.pdf

    - **Outdoor air supply**
        - Yes, file upload: 123_Main_St_Infection_Control_Plan_Section2.pdf

- **Ventilation rates**
  - Yes, file upload: 123_Main_St_Infection_Control_Plan_Section3.pdf
- **HVAC filtration**
  - Yes, file upload: 123_Main_St_Infection_Control_Plan_Section4.pdf
- **Elevator management** (e.g., limiting occupancy, targeted cleaning)
  - Yes, file upload: 123_Main_St_Infection_Control_Plan_Section5.pdf

Examples of Relevant Public Health Authorities

Facility managers may be required or elect to align their infection control practices with any number of authorities. This may include government agencies, academic institutions, or non-governmental organizations. At this time, the specific combination of applicable authorities is likely to vary by location, type of facility, and special designations (e.g., essential vs. non-essential activities). This means that Arc cannot recommend a specific set of authorities for any given facility. It will maintain examples of authorities, and, when possible, it will share lists of authorities reported by Re-Entry users.

Examples of authorities that may be referenced by facility managers include:

- Guidance for COVID-19 (U.S. Center for Disease Control) [Link]
- 5 Ways to Optimize Buildings for COVID-19 Prevention (Center for Active Design) [Link]
- COVID-19 Disinfectant List (US Environmental Protection Agency) [Link]
- Position Paper on Airborne Infectious Disease (ASHRAE) [Link]
- Getting your workplace ready for COVID-19 (World Health Organization) [Link]
- Coronavirus Resource Center (BOMA International) [Link]
- Coronavirus Resources (BOMA Canada) [Link]
- REHVA COVID-19 guidance document, April 3, 2020 (Federal of European Heating Ventilation and Air Conditioning Associations) [Link]
- Coronavirus (COVID-19) Advice (CIBSE) [Link]

Arc can deliver these surveys and track responses within a specified time period. Users may select the interval that surveys are repeated. The default recommendation is *monthly or upon a significant change in operations*.

These new meters are available as API end-points for Arc partners. Review the Arc Integration Guide for more information.

Facility Management Comprehensiveness Score

Arc will generate a Facility Management Comprehensiveness Score ("Comp Score"). The Comp Score will reflect a 0 to 100% measure of the fraction of positive responses compared to the total number of potential positive responses.

The Facility Management component has 37 data elements, including boolean responses (i.e., yes, no) and opportunities to provide a supporting link or file.

A Facility Management Comp Score of 100% indicates that a facility manager provided a "yes" answer for each question, along with a supporting link or file. Multiple file uploads are allowed, but they do not increase the Comp Score.

By default, the Facility Management Comp Score is based on the most recent response to the Facility Management Survey. The most recent response supersedes all previous responses for the purposes of the Comp Score. Arc maintains a record of previous responses to each applicable question.

In contrast to other components, responses to the Facility Management Survey are considered valid for an indefinite period of time (i.e., no time limit or moving window is applied to these data).

Table 1. Comparison of the existing Arc survey with the Re-Entry Facility Manager Survey.

Existing Arc Facility Management Survey	Re-Entry Facility Manager Survey
None	Operating plans, policies, and procedures Alignment with public health authorities Plan or policies includes strategies for: • Occupant communication and signage • Cleaning and disinfection • Occupant screening • Social distancing • HVAC management • Elevator management

Occupant Observations

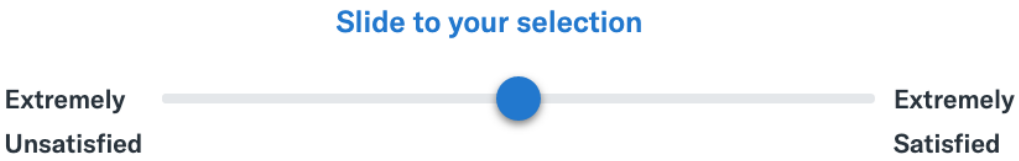
Arc has long-standing tools to understand occupant satisfaction. This includes an email-based survey asking occupants about their experience. The survey dynamically expands to ask for more information about reasons for satisfaction or dissatisfaction. This simple occupant satisfaction instrument provides the foundation for an expanded set of occupant observations to support re-entry.

The goal is to support an iterative feedback loop between the intentions of facility management and the experience of occupants. To this end, occupant observations become a source of "ground truth" to confirm expectations or identify needs for management action.

New re-entry elements include:

- Observations about the presence of disease control signage
- Observations about occupant screening, such as temperature checks
- Perception of proper PPE wearing
- Perception of social distance

Users are asked to evaluate each on a 5-point Likert scale:



Each element is associated with a free text box which provides opportunities to suggest opportunities for improvement if the response is less than "always".

Users can select one of three types of surveys to fit their situation:

- Base building only
- Tenant space only
- Whole building

This selection changes the introduction to the survey to request observations from the selected scope. Each option asks the respondent to reflect on a different area, such as only common areas (base building) or their organization's workspace (tenant space).

The selected survey can be targeted at specific groups, including:

- Facility management team or crew
- Tenants or other habitual occupants
- Visitors

Information about scope and groups is stored with responses to support follow up analysis. Individual survey responses are anonymous with no identifiable information (i.e., an Arc user can see the scope and group, but not the identity of individuals).

Arc will deliver these occupant observation surveys and track responses within a specified time period. Users may select the interval that surveys are repeated. The default recommendation is *weekly*. Arc can also provide project-specific links that can be distributed through other email or social media platforms.

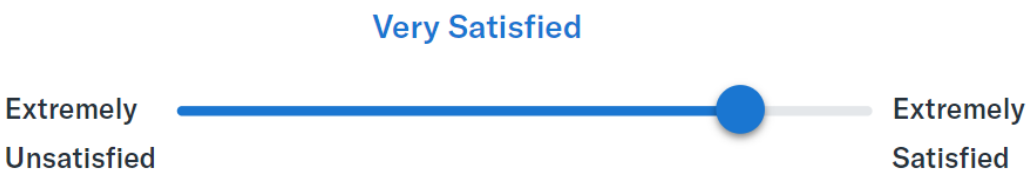
The occupant survey end-points can also be directly populated by Arc's integration partners during the Arc API.

Sample Occupant Observation Responses

The project manager makes two selections to control the framing and distribution of the occupant survey. First, the manager selects the scope of the response (base building, tenant space, or whole building). Second, the manager selects the group (facility management team/crew, tenants/vendors, or visitors).

An occupant might respond to the survey with:

1. Occupant satisfaction



a. If satisfied, select the options that significantly enhance your satisfaction:

- [x] Thermal comfort
- [ ] Cleanliness
- [ ] Views
- [ ] Sound
- [ ] Light
- [x] Daylight
- [ ] Air quality
- [x] Privacy

b. If dissatisfied, select the options that significantly reduce your satisfaction:

- [ ] Dirty
- [ ] Smelly
- [ ] Stuffy
- [ ] Acoustics
- [ ] Hot
- [ ] Cold
- [ ] Dark
- [ ] Glare
- [ ] Privacy
- [ ] Humid
- [ ] Drafty
- [ ] Bright
- [ ] Views
- [ ] Sound

2. Observations about the presence of disease control signage

Usually

Never ——●—— Always

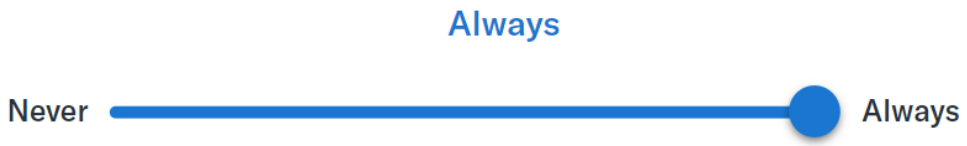
i. If not always, where is disease control signage missing?
   1. **7th floor kitchen**

Observations about occupant screening, such as temperature checks

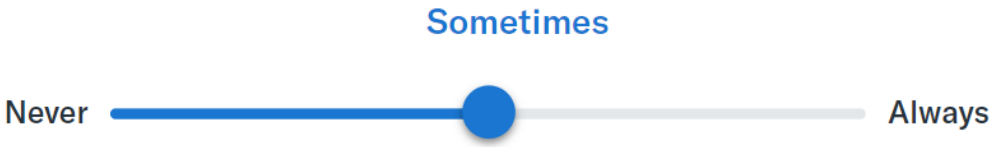
Always

Never ——●—— Always

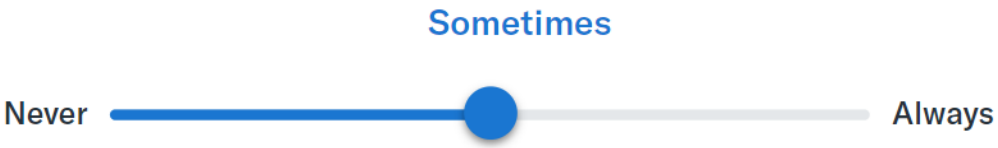
3. Do you have access to handwashing and disinfection?



4. Does the facility support social distancing?



5. Do people maintain social distance?



a. If not always, where is social distance not maintained?
    i. **Elevator lobby**

Occupant Observations Comprehensiveness Score

Arc will generate an Occupant Observations Comprehensiveness Score ("Comp Score"). The Comp Score will reflect a 0 to 100% measure of the fraction of positive responses compared to the total number of responses.

For Facility Management, this means that there are six scored data elements (questions), each with a maximum value of 4 on a 5-point 0-to-4 scale. This means that the most comprehensive possible is an average of "always" (a value of 4) for all six items -- a total potential value of 24. As a default, survey responses are aggregated over a rolling 31-day window and compared to this maximum value on a scale of 0 to 100%.

This means that a facility with uniformly positive responses for all six indicators will receive a score of 100% for a 30 day period. Data older than 30 days do not contribute to the Occupant Observations Comp Score.

Note: The occupant observation survey also contains a seventh question, "Do you feel protected from infectious disease in this facility?". Responses to this high level question can inform management. However, they are not directly related to comprehensiveness, and they are not scored.

Table 2. Comparison of the existing Arc occupant survey with the Re-entry occupant observation survey.

Existing Arc Occupant Survey	**Re-Entry Occupant Survey**
Occupant satisfaction plus: ● If satisfied, source of satisfaction ● If dissatisfied, source of dissatisfaction	Existing Arc occupant survey plus additional criteria: Disease control signage ● Present in the common areas ● Present in my workspace Presence of occupant screening ● Present in the common areas ● Present in my workspace Access to handwashing and disinfection ● Access in common areas ● Access in my workspace

Indoor Air Quality

Measurements of indoor air quality provide proxy measures for factors believed to be associated with disease transmission. It is important to note that none of the measurements identified below provide direct information about infectious agents. Rather, they describe proxies for conditions identified by scientific literature.

Measurements and interpretations include:

- **Relative humidity:** Relative humidity between approximately 40 and 60% has been correlated with reduced disease transmission. Recent reviews such as Wang et al. (2021) and Marr et al. (2019) summarize the literature.

- **CO_2 concentration:** High indoor CO_2 concentrations indicate inadequate ventilation or crowding. Building standards (e.g., ASHRAE 62, EN 16798-1) have consistently sought to encourage greater ventilation to dilute indoor pollutants and pathogens. High CO_2 concentration levels have also been correlated with reduced cognitive performance and alertness. Recent reviews such as Azuma et al. (2018) summarize the literature.

- **TVOC concentration:** TVOC concentrations are not directly related to disease transmission. They are included here, because they may provide information about excessive applications of cleaning products and/or inadequate ventilation. Reviews by the US Environmental Protection Agency and Lawrence Berkeley National Laboratory provide more information.

- **Particulate matter concentration:** The presence of relatively high concentrations of particulates may indicate inadequate ventilation or filtration. There is limited evidence that particulate matter concentrations may be related to the rate of viral spread under specific circumstances (e.g., Setti et al. 2020 based on data from Northern Italy). High ambient particulate concentrations have been linked to greater incidence of chronic respiratory diseases such as COPD and asthma, and a host of other health issues. The respiratory conditions may in turn exacerbate the susceptibility to, and impact of, COVID-19 on individuals.

Each metric will be assessed to determine the fraction of occupied space and time covered by measurements. In turn, these data are interpreted to estimate the fraction of occupied hours when conditions are in the good, acceptable, or "investigate" range.

IAQ Measurement Strategies

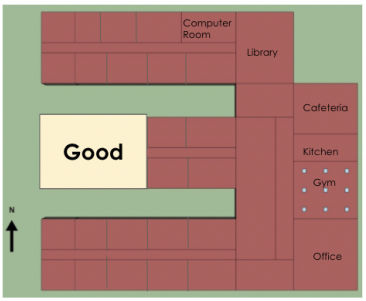
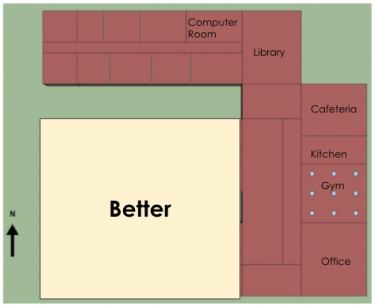
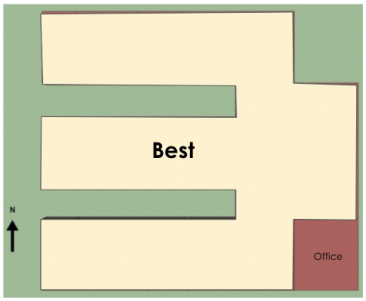
The effective measurement of IAQ is not as easy as walking around with a sensor or sticking a monitor on the wall. Generating relevant, representative data requires a systematic, hypothesis-driven measurement strategy. There is targeted guidance for the measurement of CO_2 and $PM_{2.5}$:

- Re-Entry: Guide for CO_2 Measurement
- Re-Entry: Guide for $PM_{2.5}$ Measurement

More information and training is available for both of these resources, including YouTube videos and Education @ USGBC courses:

- USGBC Course: CO_2 and $PM_{2.5}$ Guides for Schools in Arc Re-Entry
- Youtube: Measuring Indoor Air Quality in Schools

Below is an example of IAQ measurement thresholds for floor area coverage in a school:

IAQ measurement covering <25% of school floor area	IAQ measurement covering approximately 50% of school floor area	IAQ measurement covering approximately >90% of school floor area
		

Sample IAQ Measurements

Projects may have any combination of IAQ measurements. The following example illustrates information that may be provided for a project with relative humidity (RH) and carbon dioxide.

Relative humidity

Spatial coverage

- RH is measured by stationary, in situ sensors for each HVAC zone
- The spatial coverage is estimated at 100% for the period

Temporal coverage

- RH is measured by in situ sensors for each HVAC zone at 5 min intervals
- The facility HVAC service operates 60 hours.
- There is at least one RH measurement per zone for all 60 hours
- The temporal coverage is estimated at 100% for the period

Performance

- RH data ranged from 41% to 58% across all zones and all measurements during operating hours.
- The performance value is 100% in "good" status, 0% in "warning", and 0% in "investigate".

Carbon dioxide

Spatial coverage

- CO_2 is measured by hand-held sensors in 10 out of 100 rooms or enclosed spaces.
- The spatial coverage is estimated at 10%.

Temporal coverage

- CO_2 measurements occurred over 2 hours during the period
- The facility operates 60 hours.
- The temporal coverage is estimated at 3% for the period

Performance

- CO_2 measurements ranged from 500 ppm to 1,300 ppm.
- The performance value is 50% "good" (≲750 ppm), 30% in "warning" (750-1000 ppm), and 20% in "investigate" (>1,000 ppm).

The other variables follow a similar pattern.

IAQ Comprehensiveness Score

Arc will generate an IAQ Comprehensiveness Score ("Comp Score"). The Comp Score will reflect a 0 to 100% measure based on spatial coverage (floor area, rooms, or HVAC zones), temporal coverage (operating hours), and performance (time in "good" range). Each of these factors has a maximum value of 100, so the maximum value per measurement is 300. This is repeated across all six measurements (relative humidity, CO_2, TVOC, PM_1, $PM_{2.5}$, and PM_{10}).

A few details about how this is computed:

Spatial coverage indicates the fraction of the project covered by each type of sensor. Users should assume that an individual sensor covers approximately 500 square meters (5,280 square feet) (RESET Air Standard for Commercial Interiors) or following guidance from their vendor or product manufacturer (e.g., arbnco Best Practice Guide). While sensor coverage will differ based on building layouts and installation practicalities, projects should aim for the smallest effective coverage area of a sensor, and the coverage area of a single sensor should not

exceed 500 m^2. For example, at least one sensor in each HVAC zone or enclosed room could suffice for adequate coverage, provided those zones or enclosed rooms are smaller than 500 m^2 each. .

As examples:

- Measurements from one relative humidity sensor covering 500 m^2 in a 5,000 square meter open space would be presumed and documented to provide a coverage of 10% (500 m^2 / 5000 m^2).
- Estimate an effective radius around each sensor and derive the covered area based on manufacturer or vendor guidance (e.g., arbnco Best Practice Guide).
- Follow and reference guidance from a third-party standard, such the RESET Air Standard 2.0 for the design and operation of monitoring networks.

Another strategy would be to use in-duct or air distribution system-based measurements. These may provide an efficient way to cover large fractions of a facility. In this case, coverage is based on the floor area covered by the air distribution system:

- Air quality can be monitored within the mechanical system. communicating the quality of the air being delivered by landlords and operators to occupants. An in-duct strategy should ensure that sensors are installed on supply air ducts and cover a combined floor area equivalent to no less than **30%** of the building area (RESET Air Standard for Core & Shell).

Arc assumes that coverage continues from the last reported value through the present unless this value is changed due to reorganization of space or sensor layouts. Arc combines values as an average of daily values to provide an estimate for a given time period.

Tips for Entering Spatial Data Coverage

Some users may not be able to provide a quantitative estimate of spatial data coverage. We know that there are many potentially confounding factors and unknowns (e.g., the area covered by any given sensor). It is important to remember that the purpose is to provide a rough estimate of the fraction occupied space associated with each measurement (i.e., are you covering a small fraction of the area, most of the space, or all of the space).

If a quantitative estimate is not possible, users may estimate coverage and enter the following values:

- **Low Coverage:** <25% of occupied space is associated with measurements

- *Enter 25% for the applicable date range*

- **Medium Coverage:** 25%-75% of occupied space is associated with measurements
  - *Enter 50% for the applicable date range*

- **High Coverage:** >75% of occupied space is associated with measurements
  - *Enter 100% for the applicable date range*

Describe your estimate with a piece of document. This can be a simple note explaining your rationale.

Temporal coverage indicates the fraction of time covered by IAQ measurements during the last 30 days. For Arc, a time period is "covered" if at least one measurement is taken during the period in a project.

For the purpose of infection control, we are assuming 24/7 operations and 1 hour as a fundamental unit of temporal coverage (a.k.a., freshness period for measurements). Consequently, temporal coverage is defined as the percentage of hours within a period that have one or more readings for a given parameter. Additional measurements during a given period do not increase coverage (i.e., temporal coverage has a maximum value of 100% which is satisfied by at least one reading each hour). This means that 1 day has a maximum of 24 readings that will count towards temporal coverage.

As an example, one measurement taken during a 1-year period would provide a coverage of 0.01% (1/8760); presuming 24/7 operations. Considerations for the calculation include measurement rate (interval between observations) and reporting interval (period over which measurements are aggregated and sent to Arc).

A high measurement rate, e.g., those recommended by standards such as WELL and RESET, are better for a richer, more representative characterisation of IEQ. To keep this metric simple, Arc requires a report only every hour (i.e., the reporting interval).

Arc assumes that coverage continues from the last reported value through the present unless this value is changed with new value. Arc combines values as an average of daily values to provide an estimate for a given time period.

Tips for Entering Temporal Data Coverage

Some users may not be able to provide a quantitative estimate of temporal data coverage.

We know that there are many potentially confounding factors and unknowns. It is important to remember that the purpose is to provide a rough estimate of the fraction occupied hours associated with each measurement (i.e., are you covering a small fraction, most hours, or all of them).

If a quantitative estimate is not possible, users may estimate coverage and enter the following values:

- **Low Coverage:** <25% of occupied hours are associated with a measurement
  - *Enter 25% for the applicable date range.*
- **Medium Coverage:** 25%-75% of occupied hours are associated with a measurement
  - *Enter 50% for the applicable date range.*
- **High Coverage:** >75% of occupied hours are associated with a measurement
  - *Enter 100% for the applicable date range.*

Describe your estimate with a piece of document. This can be a simple note explaining your rationale.

Performance is divided by thresholds into three categories: good, warning, and investigate. Each period is assigned to one of the three categories.

Performance is typically integrated over some period of time, most often hours or days. These periods may contain any number of sensor readings. The intent is to communicate the percentage of time in each category. For example:

- If hourly (for sub-hourly) data are available, Performance would be calculated as the average of hourly values. Missing values would be excluded from Performance, because they are already accounted for in the preceding metrics.
- If daily data are available, Performance would be calculated as the average of daily values. Again, missing values would be excluded.

The result would be the average fraction of periods in each of the three categories over the last 30 days. Data older than 30 days do not contribute to the IAQ Comprehensiveness Comp Score.

The IAQ Comp Score combines the three equal elements:

- Spatial Coverage

- Temporal Coverage
- Performance (as the fraction of time in the "good" condition)

The result is that a project has a maximum score of 300 reflecting the comprehensiveness of data and measured performance. The same structure is used for each of the sub-components (i.e., relative humidity, CO_2, TVOC, and PM).

Table 3. Draft thresholds used to assign time in each condition: good, warning, investigate. These thresholds are subject to further review and adjustment based on sensor uncertainty. Source: Parag Rastogi, arbnco.

Parameter	Investigate	Low Warning (Acceptable)	Good	High Warning (Acceptable)	Investigate	Units	Included in Comp Score	Source
CO_2	350	n/a	350-750	1,000	>1000	ppm	Yes	CIBSE Guide A 2018 (Table 4.1, 4.5) LEED v4.1 O+M Beta Guide
RH	30	30-40	40-60	60-70	>70	%	Yes	CIBSE Guide A 2018
TVOC[2]	0	n/a	0-175	175-200	>200	$\mu g/m^3$	Yes	RESET v2 2018
PM_1	0	n/a	0-12	12-15	>15	$\mu g/m^3$	No	TBD
$PM_{2.5}$	0	n/a	0-12	12-15	>15	$\mu g/m^3$	Yes	RESET v2 2018 WELL v2 2020, Optimization 1
PM_{10}	0	n/a	0-30	30-35	>35	$\mu g/m^3$	No	WELL v2 2020, Optimization 1

[2] TVOC measurements in ppb should be converted to $\mu g/m^3$ using a conversion factor of 3.767.

Note on Data Quality

Objective measures of data quality are not currently part of the IAQ Comp Score. However, the quality of IAQ measurements is a significant management issue, and it varies significantly based on a variety of factors, including sampling design, sensor placement, sensor capabilities, sensor maintenance, data processing, and more (RESET Standard). An extensive peer-review literature is emerging in this area with publications such as Sun et al. 2019 and Chojer et al. 2020, and the U.S. Environmental Protection Agency Air Sensor Toolbox. Arc Re-Entry users may consider the benefits of third-party accredited hardware as one element of a comprehensive strategy to promote data quality.

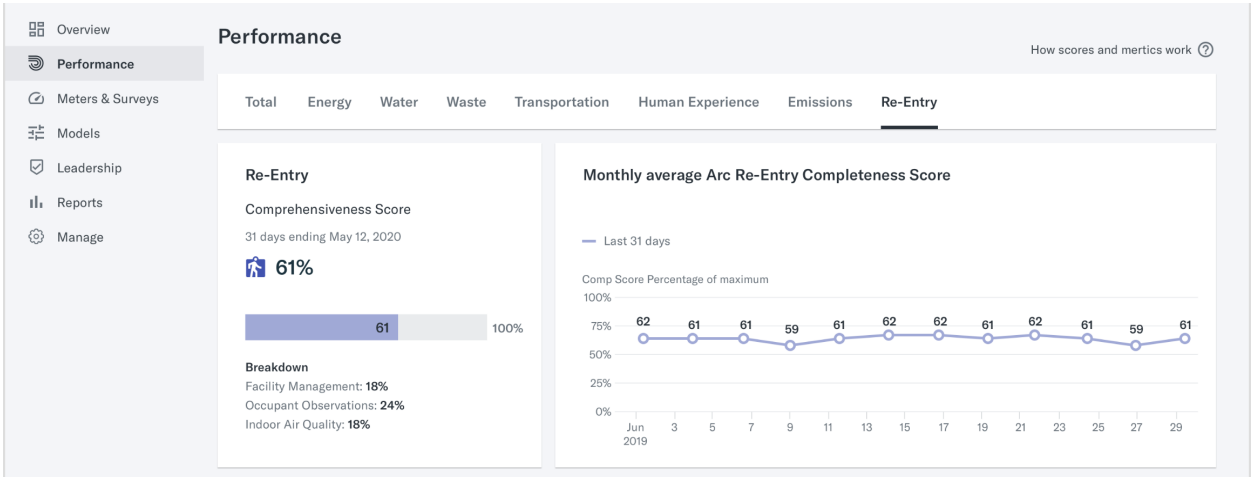
Table 4. Comparison of the existing Arc indoor air quality with the new re-entry enhanced indoor air quality.

Existing Arc Indoor Air Quality	**Re-Entry Enhanced Indoor Air Quality**
Annual measurement of: • 95th percentile CO_2 concentration • Maximum TVOC concentration	Existing Arc occupant survey plus additional criteria: Data coverage • Fraction of occupied space and time covered by sensing Relative humidity • Fraction of occupied hours within optimal RH range Particulate matter • Fraction of occupied hours below threshold

Analysis

Arc provides all users information through the Re-Entry under the Performance tab. This provides a summary of the overall Comp Score, along with sub-scores for Facility Management, Occupant Observations, and Indoor Air Quality. This allows users to track the comprehensiveness of re-entry efforts day-by-day. Note that this contrasts with other Arc reporting, which provides month-by-month trends. Users can view occupant experiences for specific scopes and groups with the selection tool.

Figure 5. *The Arc Re-Entry dashboard provides a day-by-day overview of the comprehensiveness of infection control practices, along with sub-scores for facility management, occupant observations, and indoor air quality.*



Arc Essential users can also create and customize a Re-Entry Report. This is available through the Report tab. Users can select the default Arc logo or upload their own image.

The project Re-Entry Report provides all the information in the Performance tab, plus a comparison between the project and all other Re-Entry participants. Over time, Arc expects to allow users to refine the comparison, such as comparing a project to a specific portfolio or group. This capability will be more valuable as more data becomes available.

Figure 6. *The Arc Re-Entry Report (available to Arc Essentials subscribers) provides a one-page overview of policy elements and the presence of data from occupants and IAQ measurements.*

The Re-Entry Report provides a one-page overview of activities, described as a "scorecard". The

Arc Re-Entry Scorecard

Facility Management

Last response: Jun 15, 2020

Measure	Response	Documentation
Disease control plans, policies and procedures	Yes	NA
Policies, plans, and procedures aligned with authorities	Yes	No
Disease control communication and signage	Yes	No
Cleaning and disinfection	Yes	No
Occupant screening	No	No
Sick leave for staff and contractors	Yes	No
Employee health insurance	Yes	No
Social distancing	Yes	No
HVAC system operation	No	No
HVAC - increase outdoor air supply	Yes	No
HVAC - increase ventilation rates	Yes	No
HVAC - filtration	Yes	No
Elevator management	No	No
Potable water system operation	No	No

Indoor Air Quality

May 16, 2020 through Jun 15, 2020

Meter	IAQ Comprehensiveness Score	Response
Relative Humidity	Included	Yes
Indoor Carbon Dioxide	Included	Yes
Indoor TVOC	Included	Yes
Indoor PM 1.0	Excluded	Yes
Indoor PM 2.5	Included	Yes
Indoor PM 10	Excluded	Yes

scorecard can be distributed separately from the report as an "at-a-glance" summary of infection-control efforts. The check marks indicate a positive response, the presence of occupant feedback, and the availability of at least some measured IAQ data in each category. There are no minimums for these elements at this time; the presence of any data is sufficient to receive a check mark.

The following sections provide more detailed information about each category, including details about the relationship between management expectations (plans and policies) and occupant observations.

Conclusion

The Arc Re-Entry provides practical tools to collect, manage, and interpret information about facility management, occupant experience, and indoor environmental conditions. These tools can help inform and improve facility management and support effective communications with occupants.

Arc Re-Entry does not stand alone. Ideally, it should be deployed as part of a comprehensive infection control management system which includes input from public health and industrial hygiene specialists. This type of comprehensive system recognizes that protection comes from the consistent, end-to-end operation of the management process, not any single strategy or technology. Arc can support this process, but it cannot guarantee outcomes.

As part of the right management system, Arc Re-Entry can help build the knowledge and confidence needed to safely occupy the places where we live, work, and play.

Contact

Contact Chris Pyke (cpyke@arcskoru.com) to provide feedback or get more information.

About Arc

ArcSkoru (Arc) is a wholly-owned subsidiary of the Green Business Certification, Inc. It is based in Washington, DC dedicated to making real world performance measurement an integral and ubiquitous part of green building practice.

Learn more at www.arcskoru.com