Roadmap for measurable sustainability indicators for the fire safety community

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BRANDFORSK
2023:3

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Support organisations

This project was funded 2022 by the organizations below

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The Swedish Fire Research Foundation - enables development of fire safety knowledge by research and other activities, and the spread of this knowledge to make a difference in our society.

This is possible trough raising money from all kinds of organisations with fire safety on their agenda as well as for altruistic reasons. The broad support from our society together with prosperous networks are key factors for our success.

Our mission is “A sustainable and fire safe society built on knowledge”

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Abstract

This pre-study aims to determine whether developing measurable sustainability indicators (MSI) to assess the sustainability of projects, ideas, and decisions related to fire safety would be useful for fire safety engineers, researchers, municipalities, authorities, policymakers, first responders and other stakeholders. A review of the literature, online sources, project reports and numerous interactions with representatives of several target groups within the fire safety community were conducted to assess their sustainability needs. The results show that the target groups included in this project had some overlapping and some unique sustainability needs. Fire service product suppliers are content at this time to self-declare their sustainability status. Fire and rescue services would like MSI to help them make tactical and strategic decision while responding to fires. They are also interested in MSI to help them convey their sustainability value to the communities they serve. Fire safety engineers would like MSI to support their suggestions for improvements in construction design. Researchers and educators will contribute to the development of MSI that serve the needs of the other target groups. Authorities could use MSI to evaluate progress toward improved sustainability in their jurisdictions and transfer data to other levels of government.

Keywords:

Measurable sustainability indicators, fire safety, social impacts, environmental impacts, economic impacts

RISE Report 2023:73

ISBN: 978-91-89821-37-8

DOI: 10.23699/wjvr-bb12

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Preface

This work was conducted to gain a better understanding of the potential role of measurable sustainability indicators that could be used by the fire safety community. It is intended to provide a foundation for further work in this area.

Acknowledgements

This project was made possible by funding from Brandforsk, and the opportunity to do the work is very much appreciated. The most valuable input collected during this project came from the reference group. Some of them became much more involved in the project than they initially anticipated when they volunteered to join the reference group. Their perseverance contributed significantly to the quality of the work.

Reference Group:

Aronsson, Marcus	UA Vision Nordic AB
Bergsjö, Marcus	Werma AB
Blomqvist, Per	RISE Research Institutes of Sweden
Davidsson, Jonas	Multiconsult AS
Delin, Mattias	Brandforsk
Eurenius, Francys	Brandforsk
Forsberg, Andreas	Myndigheten för samhällsskydd och beredskap (MSB)
Gehandler, Jonatan	RISE Research Institutes of Sweden
Gell, Thomas	Gellcon AB
Grimm, Helena	Räddningstjänsten Storgöteborg
Johanson, Martin	Red Fire Engineers AB
McNamee, Margaret	Lund University
Möller, Cecilia	Myndigheten för samhällsskydd och beredskap (MSB)
Pettersson, Carl	Red Fire Engineers AB
Schmidt, Niklas	RISE Research Institutes of Sweden
Wetterqvist, Cecilia	Bengt Dahlgren AB

1. Introduction

Activities, services, products, energy use, and other aspects of life are increasingly being appraised in terms of sustainability, at least partially due to the need to make progress toward achieving the very ambitious goals of the 2030 Agenda for Sustainable Development [1] or other sustainability goals. This is a very positive trend in the sense that it forces people to think about the sustainability consequences of their projects, ideas and decisions, but how can these appraisals be done in a meaningful way? How deep or broad should an appraisal be? Does sustainability mean the same thing to everyone? Would measurable sustainability indicators (MSI) help? Is it feasible to create useful, generally accepted MSI that can be used to monitor and compare the sustainability of projects, ideas and decisions? These questions are explored in this pre-study for selected target groups within the fire safety community.

Without MSI it is very difficult to evaluate sustainability in an objective way. A common phrase is *"if you don't measure it, you can't manage it"* [2]. On the surface, this phrase lends itself well to the goals of this work; however, the full statement is *"What gets measured gets managed — even when it's pointless to measure and manage it, and even if it harms the purpose of the organization to do so"* [3,4]. This latter statement puts this notion of creating MSI into a more balanced perspective, in the sense that some areas of fire safety might not need MSI while other areas could derive varying amounts of benefit from them.

This pre-study aims to determine whether developing MSI to assess the sustainability of projects, ideas, and decisions related to fire safety would be useful for fire safety engineers, researchers, municipalities, authorities, policymakers, first responders and other stakeholders. If so, what are the starting points and endpoints of the journey toward creating them? How different are the needs of the target groups? To answer these questions, the sustainability landscape was investigated for a selection of target groups.

1.1 Review of sustainability and fire safety

Sustainability is a broad concept. According to Agenda 2030 [1], sustainability evaluation usually consists of at least three pillars (the 3 Ps): social (People), environmental (Planet), and economic (Prosperity), although Peace and Partnerships are often included as pillars, see Figure 1, and other impact categories are sometimes considered. Methods of estimating the magnitude of the impacts to the pillars include environmental life cycle assessment (e-LCA), social LCA (s-LCA) and life cycle costing (LCC). These individual methods require expertise that is not always readily available, either separately or in an integrated manner, for the purpose of measuring sustainability. It is possible that simpler ways to assess sustainability can be developed within specific fire safety applications, although it is likely that there is no single sustainability indicator, or a common group of indicators, that can be used for all aspects of fire safety.

Figure 1: The relationship of the five pillars of sustainability, as designed by [1].

The fire safety community has a commitment to protect society from unwanted fire, therefore people are inherently a part of sustainable fire safety. Fire prevention is particularly important because energy, time and other resources are needed to restore built and natural environments that have suffered fire damage. Having more frequent and/or larger fires implies that more effort is needed to repair the fire damage, which decreases sustainability. However, if the level of fire safety is increased beyond the point where it affects the frequency and intensity of fires, the additional effort (fire safety systems, materials, etc) to prevent fires also decreases sustainability. This relationship is shown schematically in Figure 2. In addition, there are fire safety requirements established by regulatory bodies to provide a minimum level of protection to society.

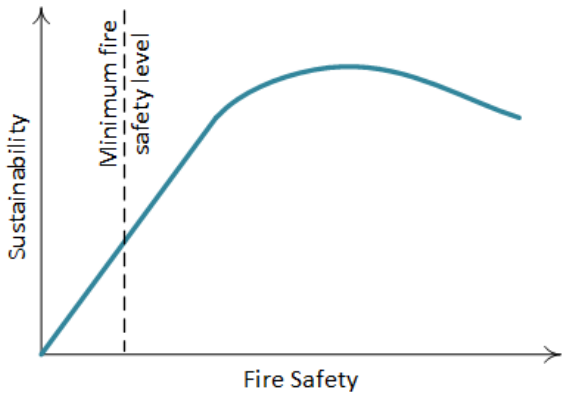

Figure 2: Schematic diagram of the relationship between fire safety and sustainability.

1.1.1. Standards, goals and guidelines

There are standards that, in a very general sense, address relevant issues such as quality management (ISO 9001 [5]) and environmental management (ISO 14001 [6]) systems, but they do not offer guidance about making sustainability assessments or developing sustainability indicators. ISO 26000 [7] provides guidance for companies and other

organisations to voluntarily operate in a socially responsible manner, encouraging them to go beyond legal compliance to contribute to sustainable development. In the building and civil engineering sectors, sustainability is addressed by ISO in a collection of 13 published standards, with an additional two standards under development [8]. These standards are based on environmental product declarations (EPDs) and do not specifically provide guidance for fire safety.

Product environmental footprints (PEFs) are similar to e-LCAs, except the methodology for creating a PEF follows a strict protocol, without the flexibility of e-LCA, so that PEFs can be compared between similar products, services and companies [9]. EPDs are documentation that states the environmental impact of materials and products during their lifecycle. Standards such as ISO 14040 [10], ISO 14044 [11], ISO 14025 [12], EN 15804 [13] and ISO 21930 [14] can be used for guidance for EPD construction. EPDs can also contribute to certifications in the construction industry such as LEED [15] and BREEAM [16]. A detailed description of the LEED and BREEAM certification systems, together with other very useful information about sustainability and fire safety in the built environment can be found in a recent SFPE report by Meacham, et al. [17].

The Fire Safe Europe association's goal is to advocate for improved fire safety of buildings [18]. They promote sustainability, innovation and standardisation as the means by which to achieve their goal. From a standardisation perspective, there are currently no standards that directly apply to the sustainability of fire safety. It is likely that the ISO TC 92/SC 3 subcommittee, Fire threat to people and the environment, will eventually address this gap [19].

1.1.2. Sustainability measurement tools

Dozens of tools for measuring the sustainability of subjects such as organisations, investments, products, homes, lifestyles, etc can be found on the internet [20]. Some of these tools use an approach similar to lifecycle assessment and some use a keyword search mechanism to analyse the text of the Agenda 2030 goals and sub-goals. Unfortunately, fire safety does not appear to play a prominent role in any of the existing tools. However, schemes for developing index methods to include fire safety and sustainability in the construction industry are currently being developed [17,21].

1.1.3. Fire & sustainability research

Research is relatively active regarding sustainability and fire safety/engineering in the building and construction sector. In 2018 Bengt Dahlgren AB published a handbook entitled Hållbart brandskydd [22] that provides decision support regarding sustainable measures in fire engineering.

A recent student thesis from Lund University provides information from a literature study and survey about the sustainability of fire safe buildings [23]. The aforementioned SFPE study by Meacham, et al. [17] also addresses fire safety and sustainability in the built environment and proposes a framework for creating MSI for building designers and engineers. An ongoing project at Brandforsk examines the sustainable management of construction waste and reuse of fire-related products [24]. Brandforsk has also funded a project to collect knowledge about cultural heritage buildings and their fire safety [25] and a project about environmentally friendly flame retardants for cellulose-based materials [26]. An ongoing Vinnova funded project led by RISE focuses on determining the quality and properties of products made with recycled materials, like concrete in buildings, although fire performance is not a major part of the project [27].

While sustainability in the building and construction sector is very important, there is little information available about MSI for other areas of fire safety, such as emergency responder operations in the built environment and in response to natural or manmade disasters [28], planning for the amount and location of fire service resources, use and type of fire suppression media, development of fire safe materials and products, and fire safety of alternative energy sources. Some of these topics are mentioned in an online NFPA article about sustainability and fire safety [29].

Several tools were developed to help the fire service communicate the value of their services to society and to help them understand the environmental consequences of their operations. This process began with the ENVECO tool, which predicts the environmental and economic impacts to a community from a warehouse fire [30]. Later, the same basic approach was used to apply the tool, now called the Fire Impact tool, to vehicle and structure fires [31]. The Fire Impact tool does not include economic impacts. A recent alliance between Myndigheten för samhällsskydd och beredskap (MSB) and Räddningstjänsten Storgöteborg (RSG) has resulted in a National Development Centre (NUC) that includes a project to develop new ways of handling fire water run-off from urban fires where the drainage goes to concrete or asphalt surfaces [32].

MSB and Brandforsk co-hosted a group of three workshops entitled “Sustainable fire safety and protection against accidents" in December 2022 in which people with a range of viewpoints regarding sustainability and fire safety performed numerous exercises to share their thoughts and prioritise various aspects of sustainable fire safety [33]. The results of these workshops will be used by MSB and Brandforsk to shape their programmes in the coming years.

Flame retarded materials, particularly polymers, are important for fire safety in many situations. Flame retarded materials are used where large groups of people congregate and where there is no easy way to evacuate, e.g., aircraft. However, many flame retardants have been shown to be harmful to people and the environment. The pinfa organisation provides information and supports research about the development of safer and more effective flame retardants for polymers [34]. To support the development of flame retarded materials, tools based on the ENVECO tool were developed for graphene filled polymers [35] used in the aerospace and automotive industries, and for waste ash filled polymers for the automotive industry [36]. Both these tools provided lifecycle economic and environmental input for designing polymer formulations.

2. Approach

Understanding the sustainability needs of the fire safety community is the primary goal of this pre-study. A large part of the proposed work involves reaching out to fire safety engineers, researchers, authorities, standards organizations, first responders, etc, to learn about their needs. Their thoughts and needs regarding MSI are of particular interest.

2.1. Target group interactions

The reference group for this pre-study was used as representatives of several target groups of stakeholders interested in sustainability and fire safety. The target groups were authorities, fire researchers, fire safety engineers, the fire and rescue service, and suppliers to the fire and rescue service. The reference group was asked to answer a questionnaire consisting of 13 open-ended questions, listed in Table 1, about their understanding of sustainability, their MSI needs, and ideas and opportunities for future work. A workshop was scheduled to follow up on their answers. The workshop was held in fragments due to problems scheduling the reference group during a very busy season. The size of the fragments varied from one-on-one interviews to six participants.

Table 1: Open-ended questions answered by the project reference group.

Question 1 Please describe your organization and your role in it.	**Question 2** How do you define "sustainability" as it applies to your work/organization?	**Question 3** How does your organization currently work with sustainability?	**Question 4** How do you use sustainability to support decision-making?
Question 5 How do you think measurable sustainability indicators could improve your decision-making?	**Question 6** Would you find value in having measurable sustainability indicators, e.g., to rank options or monitor progress toward improved sustainability?	**Question 7** Which areas of your work would benefit most from having measurable sustainability indicators? (How?)	**Question 8** For these areas, what kind of indicators do you think would be most appropriate? (Don't worry about how to measure them now)
Question 9 How would you and your organization use measurable sustainability indicators?	**Question 10** What other organizations/ professionals could benefit from being included in this data collection effort?	**Question 11** What way of interacting with your organization would create the most benefit?	**Question 12** Are you aware of other sustainability work that could be useful for this pre-study?
Question 13 Do you have any other information to share about your organization's sustainability needs that would be helpful for this pre-study but wasn't included in the previous questions?			

During the final project meeting the reference group was asked to discuss these three points:

- Where do you hope to see sustainability (and indicators) go in the future?
- Where do you fear to see sustainability (and indicators) go in the future?
- What are your thoughts about ideas and opportunities for future work?

Some members of the reference groups volunteered additional information about how their organizations work with sustainability, relevant activities, and people that might be in a position to provide useful information. This input and the answers to the questions above were used to develop the sustainability roadmaps for the target groups.

2.2. Literature search

A literature/web search was conducted to identify existing sustainability indicators and the groups responsible for developing them, together with other relevant information. The results of this effort are found in Section **Error! Reference source not found.**. This search was limited by the resources available and is thus not comprehensive.

2.3. Ranking system development

It was originally intended to develop ranking systems by which to prioritise both the potential benefits of sustainability indicators for the identified areas of fire safety and the feasibility of implementing them. These systems were not developed because the input collected from the target groups indicated that much deeper and broader information should be gathered before attempting to create ranking systems. Therefore, this effort will be included in the list of topics for future work.

2.4. Roadmap development

The main output of the pre-study is roadmaps for future development of MSI relevant to the fire safety community. The roadmaps start with the current situation experienced by selected target groups and proceeds to the destination each group hopes will be the mature state of implementation.

3. Results and discussion

Much of the information was collected from the reference group, which represented several target groups, although there was some overlap among and between the target groups. The roadmaps were also constructed from input collected from the literature, online sources, and reports. The target groups that were directly represented in the roadmap input are listed in Table 2, where some people from the reference group represented more than one target group.

Table 2: Reference group members that contributed input to this project.

Reference Group Member	Organisation	Target Group(s)
Bergsjö, Marcus	Werma	Fire service product supplier
Blomqvist, Per	RISE Research Institutes of Sweden	Fire research, standards development
Davidsson, Jonas	Multiconsult	Fire safety engineering
Delin, Mattias	Brandforsk	Fire research, fire safety engineering
Forsberg, Andreas	MSB	Authority
Gell, Thomas	Gellcon	Fire research
Grimm, Helena	Räddningstjänsten Storgöteborg	Fire service
Johanson, Martin	Red Fire Engineers	Fire safety engineering
McNamee, Margaret	Lund University	Fire research, education, standards development
Möller, Cecilia	MSB	Authority
Pettersson, Carl	Red Fire Engineers	Fire safety engineering
Schmidt, Niklas	RISE Research Institutes of Sweden	Fire research
Wetterqvist, Cecilia	Bengt Dahlgren	Fire safety engineering

In summary, information was provided by one fire service product supplier, six fire researchers and three standards developers (including the author of this report), five fire safety engineers from companies of different sizes, two authority staff members, and one representative of the fire service. The information that these people provided was based on their experiences and opinions, which may not be representative of other members of their target group(s).

Other potential target groups were identified during the course of this work and are discussed in Chapter 0. Information will be gathered from these target groups if/when continuing work is conducted.

3.1. General comments

Some of the information collected for this project was of a general nature, relating to sustainability and/or fire safety, but not specifically applied to a target group. For example, there is concern that the concept of sustainability, whether or not it is applied to fire safety, will degenerate into a buzzword and thus lose its meaning and priority within society. Another concern is that economic factors will dominate other aspects of sustainability or that politics will shift the balance either toward fire safety or toward sustainability. The balance

should be found through science and education. In these situations Agenda 2030 will be unlikely to meet its goals or make a significant change in the world.

Society is adapting to ideas about measuring environmental impact, for example, not too many years ago carbon dioxide equivalents (CO_2 eq) were a virtually unknown concept, but now CO_2 eq are a required budget item for large construction projects [37], among other things, and many people equate environmental impact with CO_2 eq. And, of course, money is generally accepted as an indicator of value for products and services. Social impacts, however, are much more difficult to evaluate because they are hard to quantify and may occur indirectly, in a different location, or a long time after a fire event or fire safety decision is made. The causes and effects of fire may not be easy to connect to social impacts.

Another complication is related to how preventative measures or near misses for fire can be captured in sustainability assessment. While it is very difficult to predict the physical impact of fire, it is even more difficult to predict the social impact of a fire that was avoided.

When discussing sustainability in terms of organisational practices, all of the target groups apply some degree of due diligence by, for example, implementing guidelines for travel and purchases, reducing waste, and by providing working conditions that foster a sense of fairness, inclusion, health and well-being among employees. Several of the people that provided input to this study stated that their organisations follow standardized guidelines, such as ISO 26000 to improve social impacts or ISO 14001 to improve environmental impacts related to their business operations. On the other hand, it could be devasting for small companies to be required to report all their upstream and downstream sustainability impacts. A reasonable cut-off is needed.

3.2. Researchers & educators

Definitions

Fire researchers, educators and standards developers tended to define sustainability (or sustainable development) according to the Brundtland Commission report [38], which reads as follows:

> '… development that meets the needs of the present without compromising the ability of future generations to meet their own needs'.

This is frequently expressed as economic, environmental, and social sustainability, where economic development is reconciled with the need to protect the environment and society.

Another way of thinking about sustainability is as a safeguard that actions will have the least possible negative (and most probable positive) social, economic and environmental impacts, within the constraints of the situation.

Sustainability in general

Agenda 2030 is seen as a useful platform for communication, measurements and collaborations. Parties that are very different can work together using the sustainable development goals (SDGs) to keep everyone going in the same direction. As a result of heightened visibility coming from Agenda 2030, sustainability is now being included with other factors when choosing where to allocate resources, such as funding for research projects or time for writing proposals.

Sustainability has not traditionally been a part of the fire safety engineering curriculum. Students in engineering disciplines typically learn how to solve problems with the assumption that the problem can be defined and a solution can be found. However, due to its abstract

and complex nature, sustainability is not easily understood in the same way and may require more of a nuanced social science approach to be fully appreciated.

It is important not to lose track of the fact that unwanted fire can have huge negative impacts on the economy, environment and society, so making compromises between fire safety and sustainability must be done carefully and with a solid understanding of the acceptable minimum level of fire safety. As fire safety engineering students become more aware of how sustainability can be applied to fire safety, they can develop a better understanding of the consequences of the decisions they make later as professionals.

The time scales of sustainability and fire safety are quite different, which is another complication in understanding their relationship. Unwanted fire is usually thought of with a sense of urgency and immediacy; most people can envision fire incidents rather well. This is not the case with the sustainability impacts of fire, where, for example, climate change may not be felt for several generations. It would be beneficial to find a way to put fire safety impacts on the same time scale as fire impacts to sustainability so that people can appreciate their relative magnitudes better.

As the fire service becomes increasingly knowledgeable about sustainability issues related to their operations, it is important for accessible fire research to be continuously available to meet their needs. This concept can easily be generalised to society as a whole becoming more aware of sustainability and fire safety, and being ready to adopt new ideas.

There are many research projects about sustainability and about fire safety. There are also some research projects that combine aspects of sustainability and fire safety. Some of these projects are listed in Section 1.1.3. It is hoped that research in this area will help various stakeholders understand sustainability and fire safety better and include sustainability in their fire safety related decision-making processes.

Measurable sustainability indicators

This target group finds value in measurable (and validated) indicators for ranking options, for example, short vs long term or equity in effort/resources. MSI can also be used for monitoring the progress of fire and sustainability research, showing its value to society, and communicating research results more consistently.

There is a need to broaden our horizons when it comes to the consequences of fire. MSI can be used to express fire safety (and lack thereof) in more dimensions than money and casualties, which is the typical situation now. The impacts of fire on communities go far beyond money and casualties but there is currently no effective way to communicate it.

MSI could be aggregated through a hierarchical structure, and also be presented in a more granular way where the detail (an opportunity to compare) between different design objectives is not lost. Ideally, MSI would be intuitively understandable by most people, so they don't require a high level of expertise to use them.

Roadmap

A possible sustainability roadmap for fire researchers and educators is shown in Figure 3. This target group is aware of the need for sustainable business practices and has implemented procedures and guidelines that will likely evolve over time. Projects that relate in some way to sustainable fire safety have been completed, are ongoing, and are planned for the future.

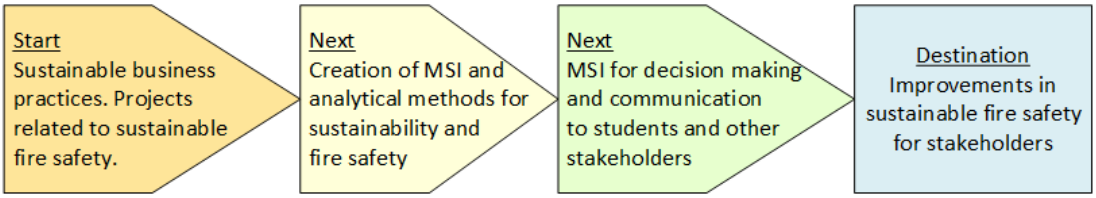

Figure 3: Possible sustainability roadmap for fire researchers and educators

Fire researchers can support the creation of MSI for other target groups and contribute to the development of a data transfer system for reporting MSI to other stakeholders and levels of government. MSI can also be created for educational purposes and to transparently communicate research results to funding organisations, the public, and other stakeholders. Fire research and education thus primarily supports improvements in sustainable fire safety for stakeholders that make use of the research produced.

3.3. Government, authorities & policy

Sustainability in general

Within MSB, there is no aggregated information or data that "measures" sustainability, however, there are social, economic and environmental goals and issues that are included in the work with databases and surveys. Sustainability is handled in different ways by different departments. This is in contrast to the Swedish army and military defence, who have an overall head of sustainability within their organizations.

On a more local level, planning departments could have a significant role in reducing the environmental and societal impacts of fire, especially in the earliest phases of planning the infrastructure for industrial or urban areas. Grey water could be stored for use as suppression media and facilities for capturing fire water run-off could be included in the design of the area. The occupants of the area may change over time and thus the risk of fire and the need for suppression media storage and fire water run-off containment may also change, which is a challenge for planners.

Issues such as high population density in combination with flammable construction materials create added pressure on the fire service and represent a shortcoming in community planning; however, planning departments cannot advocate solutions beyond the applicable rules and regulations and this makes it difficult for them to act in a creative or innovative way. Another challenge is the long-term view required to motivate policy makers to push resources toward a more sustainable and fire safe condition.

Measurable sustainability indicators

MSI could be used as decision support for resource allocation. They can also be used to identify areas where more knowledge is needed so that fire safety and sustainability can be included in decision-making processes, especially in community planning. Policy makers could use MSI to help them create rules and regulations that do not undermine fire safety or create unsustainable conditions within society.

MSB has provided examples of available data that might be useful for the development of MSI. The examples listed below include data that might have relevance for social/cultural, economic and environmental sustainability, although they don't explicitly address sustainability.

- **Nationell strategi för stärkt brandskydd:** Innehåller mätbara mål med relevans för hållbarhet https://www.msb.se/sv/amnesomraden/skydd-mot-olyckor-och-farliga-amnen/brandskydd/nationell-strategi-for-starkt-brandskydd/

- **Årsuppföljning LSO:** enkäten inkluderar en fråga om formaliserade samarbeten mellan Rtj och andra aktörer, bland annat äldreomsorgen, i syfte att stärka skyddet för särskilt riskutsatta. https://www.msb.se/sv/amnesomraden/skydd-mot-olyckor-och-farliga-amnen/tillsyn-lagen-om-skydd-mot-olyckor/tillsyn-over-kommunerna-enligt-lso/
- **Öppna jämförelser (SKR)**: Antal utvecklade bränder per 1000 invånare https://skr.se/skr/tjanster/statistik/oppnajamforelser/trygghetochsakerhet.1123.html
- **VÄGLEDNING - Effekter på miljön från kontaminerat släckvatten. Kunskapsöversikt och nuläge inom området**. https://rib.msb.se/filer/pdf/30336.pdf
- **Statistik om olyckor, skador och räddningsinsatser – IDA**: https://www.msb.se/sv/verktyg--tjanster/statistik/
  - T ex: åtgärder vid byggnadsbränder Räddningstjänstens åtgärder vid byggnadsbränder (omfattar skadetyp och släckmetod).https://ida.msb.se/ida2#page=465ed10e-6c1b-4c2f-aea6-241809f93407
- **Brandvarnare kopplade till trygghetslarm (E-hälsa och välfärdsteknik i kommunerna, Socialstyrelsen)**: https://www.socialstyrelsen.se/globalassets/sharepoint-dokument/artikelkatalog/ovrigt/2022-5-7897.pdf
- **Drönare (UAS).** VI ”mäter” användandet av dessa vid räddningsinsatser genom händelserapporter. Användningsområdet för drönare är brett, men man kan tänka sig ett antal hållbarhetsvinster genom användandet av sådana vid insatser. Data kan tas ut genom MSB:s händelserapporteringssystem.
- **MSB och SKR har tillsammans ett basbilsavtal** – som stöd till kommunerna vid köp av basbilar. Avtalet revideras nu och nytt är bland annat utsläppssnåla eller utsläppsfria helt emissionsfria basbilar. RISE driver flr övrigt ett projekt avseende el-basbilar, tillsammans med bland annat några räddningstjänste. Annat som angränsar till området är att det finns kommuner som satsar på miljöanpassade (och kontinuitetsanpassade) brandstationer, som Sjöbo.
- Orientation for increased equality and diversity in the rescue service in 2030 with associated action plan https://rib.msb.se/filer/pdf/29815.pdf

Roadmap

A possible sustainability roadmap for (national) authorities is shown in Figure 4. The first two steps could also apply to regional authorities such as municipal planning departments, but the destination would be different and could be, for example, safer and more sustainable communities.

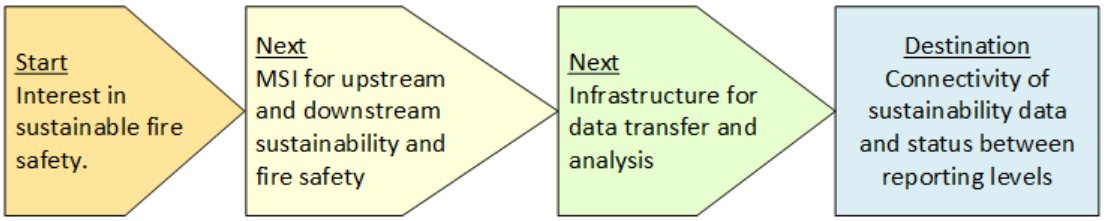

Figure 4: Possible sustainability roadmap for (national) authorities.

It is envisioned that a national authority would be responsible for developing a system to collect MSI data from lower levels of government, analysing the data, and feeding it forward to higher levels of government. A system such as this could seamlessly connect the sustainable and fire safe MSI used by, e.g., the fire and rescue services to, e.g., European or global sustainability goals.

3.4. Fire Safety Engineers

Definition

Basically, sustainability means finding solutions that are good for nature, will stand over time and don't cost too much. The specific definition varies from project to project. Sometimes fire safety engineers trust environmental and/or social experts to tell them which is the most sustainable option for a project.

Sustainability in general

Fire safety engineers can manage their upstream social and environmental impacts through project specifications and recommendations, but they have very little control over downstream impacts, which could have a much larger magnitude over the lifecycle of a structure.

Fire safety projects that have a sustainability or 'green' component could be strategically valuable to fire safety engineering companies. However, it is difficult for fire safety engineers to influence the design of a structure because they typically don't come into the project at an early enough stage. In Sweden the role of overall management and control of a project belongs to the construction company, although this arrangement varies among countries. Other professionals are added at later stages and can affect the structure design to varying degrees. In other words, it takes a strong argument for a fire safety engineer to cause changes to be made for the sake of sustainability, or for any reason. Since construction companies are typically more concerned with the costs of the construction phase than with the costs associated with the whole lifecycle of the structure, the incentive to design structures with lower lifecycle impacts is rarely included in the design process. Hopefully, this process will move toward a more integrated approach in which design is shared among the various participants so that important considerations (such as sustainability and fire safety) can be optimized.

Prescriptive-based fire safety designs follow fire safety codes and regulations and provide an established minimum level of fire safety. These codes and regulations are not flexible, although fire safety engineers sometimes include extra materials in their designs to increase their safety factors. Performance-based fire safety design, however, allows fire safety engineers more freedom to choose different approaches to fire safety, as long as they can show that the designs are safe enough. Some examples of the types of sustainable decisions that can be made by fire safety engineers, given the right circumstances, include the type and amount of materials used and whether to use recycled materials. These decisions are not simple and can lead to false claims that a design is sustainable; materials that are consumed in fire are fundamentally not sustainable. Wood is renewable, people like to have wood in their homes, but wood is also very good fuel for a fire. Material choices may also affect the amount of maintenance required. Cost usually plays the most dominant role in decision making but sometimes cost and sustainability go together, for example, a fire safety engineer might find that it is possible to use less material while still maintaining a sufficient level of fire safety.

It is undesirable to create a situation where the need to meet fire safety codes and regulations could be used as a reason not to choose sustainable solutions. Conversely, when prioritizing sustainable solutions, fire safety codes and regulations may not provide adequate fire safety if the design does not follow well established methods.

Regarding reuse of construction materials, new legislation in Sweden is coming into effect that requires a declaration of all the materials from demolition projects that are suitable for recycling or reuse [39]. In separate Swedish legislation, the environmental impact of large

construction projects (foundation, façade, and inner walls) must be declared in CO_2 eq according to the guidelines of EN 15804 [37]. These requirements serve both to bring environmental impacts to the attention of the construction industry and to promote the use of recycled materials, as they have a zero contribution to the CO_2 calculation.

The social sustainability side of fire safety engineering is difficult to pin down. There is a basic need for people to feel safe where they live, work, and go to school. It is important for the well-being of society to have confidence that a fire will not occur, and if a fire does occur that it will be detected while it is small, that there is plenty of time for evacuation, that people will know what to do to keep themselves safe, and that the fire and rescue service will arrive quickly.

Measurable sustainability indicators

Developing MSI that can characterize the whole lifecycle of a structure from the earliest stages of design would help decision makers understand the long term impacts of their choices. According to the work by Meacham et al. there are clear differences between the environmental sustainability and fire safety of design choices [17]. Indicators could motivate not only fire safety engineers, but also other designers, engineers, and architects to find ways of improving sustainability in their projects without compromising safety, or even finding ways to improve both sustainability and safety. In a similar manner, MSI can also help construction companies justify their overall design and construction decisions to their clients and other stakeholders.

The presence of MSI could make fire safety engineers and related professionals more aware of the impact of the decisions they make, even if the MSI are not formally adopted as decision support criteria. MSI can also facilitate working in teams with diverse expertise, guiding people having different focuses to work toward the same goals.

Tying MSI to existing procedures, such as climate declarations, can help fire safety engineers communicate to their clients that there is more to consider beyond economic value. Another potentially useful platform for MSI is the EU taxonomy for sustainable activities. This is a classification system that clarifies which investments are environmentally sustainable [40]. It may also be possible to connect MSI to certification systems like LEED and BREEAM, which are already known to the construction industry.

Roadmap

As shown in Figure 5, fire safety engineers are aware of the need for sustainable business practices and have either already implemented procedures or are in the process of doing so. They are interested in projects that have a ‘green’ or sustainability aspect and may even give priority to these projects. Their biggest need is to have MSI that provide support for decision making regarding the balance between sustainability and fire safety in the built environment. These MSI, or perhaps another layer of MSI, are needed to enable fire safety engineers to communicate their suggestions for improvements in construction design to other design professionals and decision makers, resulting in an improved built environment.

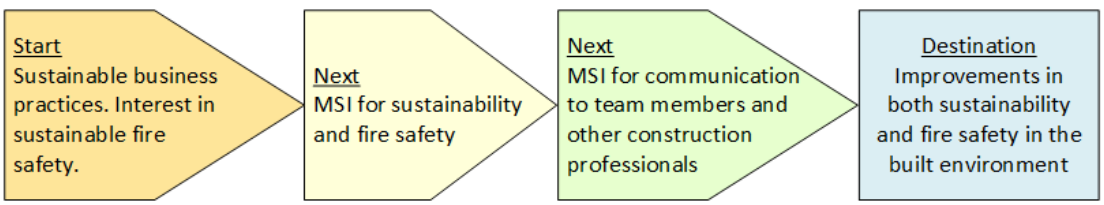

Figure 5: Possible sustainability roadmap for fire safety engineers.

3.5. Fire & rescue services

Sustainability in general

Fire and rescue services have a unique situation among the other target groups in this pre-study in the sense that they must prioritise saving lives, the environment and property while they are responding to a fire event or other crisis. They must arrive at the incident as quickly as possible and do whatever they can safely do to understand the situation, rescue victims and reduce damage.

In addition to 'normal' business operations, fire and rescue services handle chemicals such as fire suppression media and must clean their gear after it has been exposed to smoke, toxic gases or other hazardous substances. Careful handling of these sources of pollutants is necessary to reduce the amount of harmful chemicals in water. Their procurement procedures can require vendors to have a sustainability profile, such as compliance with ISO 14001 or ISO 26000.

From a strategic and tactical perspective, fire and rescue teams are sometimes faced with situations where they may need to decide how to proceed in a way that reduces the environmental impacts of their actions. For example, if an electric vehicle is burning it may be advantageous to concentrate on saving the battery if the fire is burning in a different part of the vehicle. Minimizing the amount of fire water run-off is also a very important goal, although there might be situations where trade-offs must be made between the amount of water used, the amount of smoke generated, and the amount of damage caused by the fire.

The fire service responds to fire events with the goal of limiting damage to humans and the environment during the fire. Anything can happen to the site of a fire event between the time the firefighters leave and restoration work begins. Contamination in the form of fire residue, e.g. ash, soot, water, may spread beyond the original site.

Unwanted fire can be devastating to communities and have far reaching social, environmental and economic impacts that spread out over time and space. Thus, it is vitally important that the fire and rescue services, together with the other organisations that they cooperate with, operate as effectively as possible to minimize these impacts.

Over time the fire service is expanding their appreciation of the complexities of sustainability issues associated with fire. There has historically been a gap between theory (fire research) and practice (fire service operations), especially regarding environmental impacts, but this gap is narrowing. It is incumbent upon both sides to continue to move closer together to find innovative and practicable solutions to improve fire service sustainability.

Measurable sustainability indicators

The fire and rescue services conduct preventative work to reduce the amount and/or severity of fires. It is uncertain how these activities can be assessed with MSI. This is a good subject for future work.

MSI could help the fire and rescue services monitor their progress toward different aspects of sustainability. This information can then be used to communicate the magnitude of benefit that society derives from their presence. MSI can also be used to compare the benefits of fire prevention programs, technologies and equipment, new firefighting strategies and tactics, etc. If MSI can be used to show progress and make comparisons, the fire and rescue services can make better choices and evolve in a more sustainable direction.

The fire and rescue services would like to have specific MSI that measure the amount and type of pollutants in fire water run-off and smoke for common fires (cars, containers, houses, industry) so that they can track them over time.

Roadmap

A roadmap for possible steps toward improved sustainability for the fire and rescue services is shown in Figure 6. The fire and rescue services are aware of the need for sustainable business practices and have either already implemented procedures or are in the process of doing so. They would like to use MSI that represent the environmental impacts to water and air from firefighting operations, among other things. They would also use MSI for communication purposes and to support decision making and monitor improvements in a transparent way.

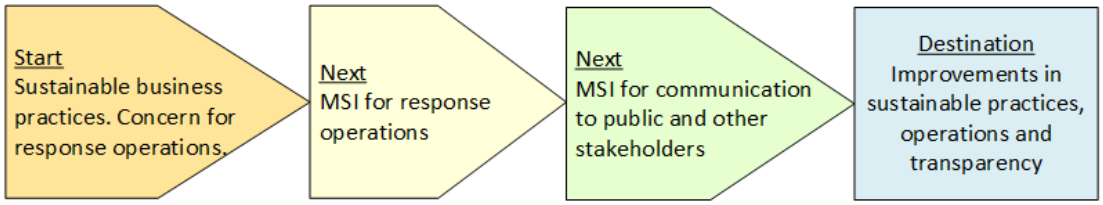

Figure 6: Possible sustainability roadmap for the fire and rescue services.

3.6. Product suppliers and procurement

Definition

It is easy to connect sustainability to only environmental definitions, but there is more than that. Another aspect of sustainability is about business ethics, equality and spreading technology that develops society.

Sustainability in general

Agenda 2030 is seen as being too wide for small companies to connect with; however, it is possible to break it down into 8 or 9 relevant areas that can be applied to product suppliers and procurement procedures. For larger companies, there are incentives, laws and regulations, depending on the location of the company, to improve their impacts on communities and the environment. To achieve this, many larger companies have corporate social responsibility (CSR) departments.

It takes a lot of effort, especially for a relatively small fire service product supplier, to develop a sustainability profile or self-declaration in compliance with ISO 26000 or a third-party certification system, in a thoughtful manner without greenwashing. An example of this process was given by the target group representative as follows:

- Sustainability targets are set for the products offered by the supplier.
- Checklists are used to ensure that all products match the sustainability targets.
- Each year an evaluation is made to ensure that the targets are still valid.
- The products are re-evaluated if the targets change.

From the purchaser's perspective, an opportunity to contribute to sustainability exists when the procurement specifications are written. In the future there may be pressure, especially on government organisations, to consider sustainability in addition to cost when making purchasing decisions. On the other hand, if too much sustainability analysis or accreditation is required, there may not be vendors available that qualify to provide a tender. The key is for the purchasing organisations and vendors to move in the same direction together.

Measurable sustainability indicators

MSI are seen as being unnecessary at this point in time because most product suppliers are just beginning to think about how they want to handle sustainability. The first step would likely be to create a self-declaration and guidelines for internal business procedures.

The current ISO 26000 has multiple areas of sustainability for a company to choose in their analysis. These areas will be different depending on the needs and goals of the company. For this reason it would be very difficult to develop MSI to compare companies based on their self-declaration. To begin with, the only indicator necessary is that companies can prove that they have an active sustainability profile.

A potential benefit of MSI could be for communicating the sustainability status and achievements of vendors, i.e., they could be used for marketing purposes.

Roadmap

A possible roadmap for fire service equipment suppliers is shown in Figure 7. As discussed above, sustainability is currently just beginning to be considered by this target group. Some suppliers, such as the one that provided input to this pre-study, have prepared a sustainability self-declaration in anticipation of procurement requirements for vendors. The logical next step would be a more formal sustainability certification. Finally, perhaps, a rating system could be devised that indicates the level of sustainability of the supplier.

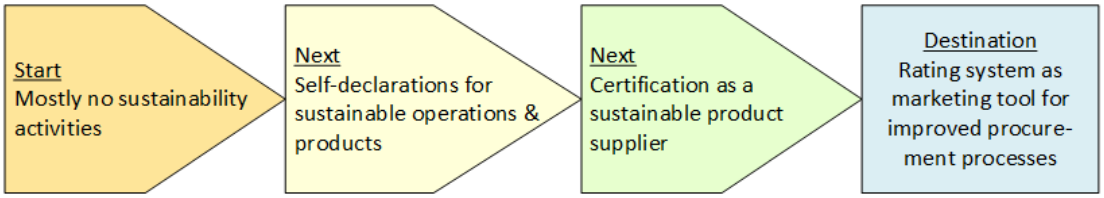

Figure 7: Possible sustainability roadmap for fire service product suppliers

Alongside this journey, it is assumed that procurement processes will evolve and require increasing levels of sustainability from vendors. If this does not happen, the value of self-declarations, certifications and ratings as marketing tools will be limited.

3.7. MSI suggestions

The target groups were asked for suggestions about the type of MSI that could be useful for them, without going into details about source data or the actual calculation of the suggested MSI. Their answers are presented in following list. The suggested MSI have not been categorised by target group because many of them could be useful for several, or all, target groups.

- Person-days for people displaced from their homes by fires
- Student-hours for students displaced from school due to fires or false alarms
- Fresh water consumption, use of grey water
- Transition to electric vehicles
- Type of chemicals used to clean gear and equipment
- Percentage of female firefighters, employment equality
- Length of service life of firefighting equipment
- Amount of new equipment used by the fire service
- Percentage of organisations that require sustainability certifications for procurement
- Number of firefighter sick days
- Number of locations contaminated by PFAS
- Number of locations contaminated by PFAS that are cleaned
- Connect MSI to established systems, such as EU taxonomy, LEED, BREEAM

3.8. Limitations

Information for this pre-study was provided by 15 people representing 5 target groups. Their input was based on their own experiences and opinions, which may not be representative of other members of their target groups. It would be beneficial to add input from more people and other target groups to strengthen the conclusions of this work. See Section 0 for a discussion about future work.

4. Traceability

If MSI are developed and implemented within the fire safety community, could they also have value elsewhere? Pressure is increasing from global, regional and national organisations to consider sustainability and has already had a significant influence on decision making in fire safety and other communities. Methods for reporting MSI in a consistent manner are being developed so that sustainability progress can be monitored and is traceable from ground level (our projects, ideas and decisions) upward through various channels to higher levels.

This is not a new concept; governments and other organisations have been tracking environmental impacts resulting from climate change, such as wildfires, for many years [41,42], as well as social impact indicators such as death and injuries caused by fires. Another example is risk factors for structure fires causing an increase in CO_2 emissions, which have been developed and used by insurance companies [43].

The target groups overwhelmingly stated that politicians would be the recipient of their MSI. Sponsors, funding organisations, leaders of companies and the public were also identified. In other words, traceability should be possible in both the upstream and downstream directions.

If MSI are implemented at a local level, and if they are collected and analysed at higher governmental levels, possibly even at a European or United Nations level as shown in Figure 8, the data should be structured in a way that makes sense at every level and can be stored in existing databases. Some countries have already developed data transfer schemes to accommodate reporting and analysis of MSI at various levels.

UN ← EU ← Member states ← Agencies ← Municipalities ← Practitioners → Clients → Public

Figure 8: Potential flow of MSI data

It may be that MSI should be designed to connect with the Agenda 2030 SDGs, or perhaps a different set of goals. In any case, linking the MSI to broadly defined goals can be challenging. There may be differences in viewpoint, such as short-term vs long-term goals, or a lack of connection of local goals to global goals. These types of challenges can be minimised by standardisation.

An example of the challenges associated with linking local MSI with higher level sustainability goals is illustrated in Figure 9, where the local goals are shown in the grey box in the lower right corner. Suppose the fire and rescue service has an MSI for the number of false alarms they respond to. This MSI would have environmental impacts related to wear and tear of vehicles, energy consumption, emissions to air, etc. It would also have social impacts related to the dangers of driving response vehicles to the scene, frustration of first responders, annoyance of citizens that must evacuate buildings. It would have economic impacts related to the maintenance and fuel for the vehicles and time disruption of both the first responders and the citizens affected by the alarm. These impacts could be measured separately or, at a local level it may be acceptable to use a single MSI without further analysis.

SDG	Target (by 2030…)
7.1	Ensure universal access to affordable, reliable and modern energy sources ***KPIs: proportion of population with access to electricity, clean fuels, technology***
7.2	Increase substantially the share of renewable energy in the global energy mix ***KPI: renewable energy share in the total final energy consumption***
7.3	Double the global rate of improvement in energy efficiency ***KPI: energy intensity measured in terms of primary energy and GDP***
11.1	Ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums ***KPI: proportion of urban population living in slums, informal settlements or inadequate housing***
11.4	Strengthen efforts to protect and safeguard the world's cultural and natural heritage ***KPI: total per capita expenditure on the preservation, protection and conservation of all cultural and natural heritage, by source of funding (public, private), type of heritage (cultural, natural) and level of government (national, regional, and local/ municipal)***

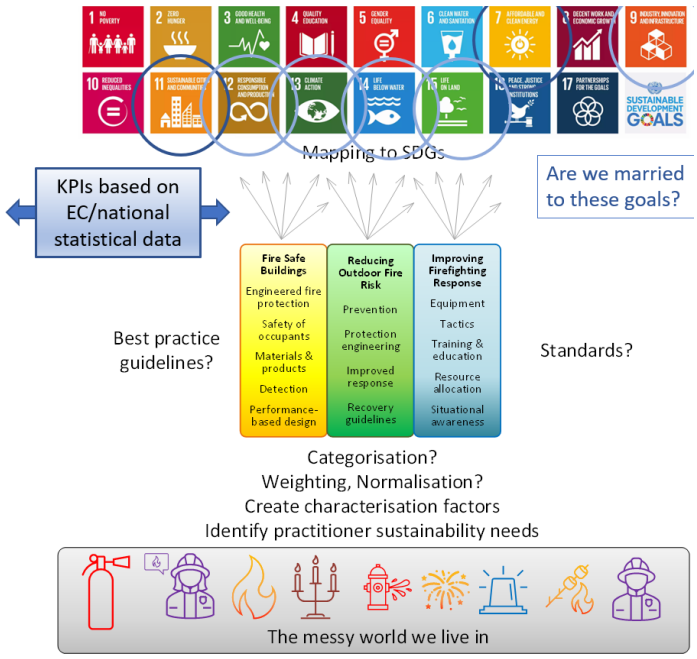

Figure 9: Example of challenges in data flow of local MSI toward higher level sustainability goals.

If the local MSI is linked to another MSI at a higher level it might be necessary to disaggregate the impacts so that all or part of them fit into other categories. For example, there may be a national level MSI that measures the societal impacts of traffic accidents and another national MSI for workplace disruptions. A scheme for assigning new categories and weights to the parts of the original MSI would be needed to connect it to the next level. This process may be required several times, until the data can feed into the highest desired or required sustainability goals. It may be that the original MSI become unrecognizable by the time they arrive at the ultimate goal.

To continue the false alarm example using Figure 9, suppose the MSI fits into a national MSI called "Improving Firefighting Response", along with many other MSI. Suppose also that the end goal is to link with the Agenda 2030 SDGs. The global SDGs have key performance indicators (KPIs) that rely on statistics collected at lower levels. To connect the MSI to SDG 7 (Affordable and clean energy), which is related to wasting energy by responding to false alarms, the MSI must be incorporated into at least one of the following KPIs [44]:

- Target 7.1: By 2030, ensure universal access to affordable, reliable and modern energy services
- Target 7.2: By 2030, increase substantially the share of renewable energy in the global energy mix
- Target 7.3: By 2030, double the global rate of improvement in energy efficiency
- Target 7.a: By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology
- Target 7.b: By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programmes of support

It is clear that the original MSI must undergo one or more transformations to be included in SDG 7. The same situation exists to connect it to SDG 11 (Make cities and human settlements inclusive, safe, resilient and sustainable), for which the following KPIs apply [45]:

- Target 11.1: By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums
- Target 11.2: By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons
- Target 11.3: By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries
- Target 11.4: Strengthen efforts to protect and safeguard the world's cultural and natural heritage
- Target 11.5: By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations
- Target 11.6: By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management
- Target 11.7: By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities
- Target 11.A: Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning
- Target 11.B: By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels
- Target 11.C: Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials

Again, it is very difficult to see the connection between the original MSI and the KPIs for SDG 11. Even if it is not desired or required to link local MSI with the Agenda 2030 SDGs, it is very likely that transformation(s) will be necessary to convert the original MSI into a form that is compatible with MSI schemes at other levels. Additionally, the data must conform to a structure that is compatible with various databases into which it will be stored and used for analysis.

There is a need for further investigation to provide information on this topic at a more detailed level.

5. Future work

One of the goals of this pre-study was to create a foundation for the development of MSI for the fire safety community. This foundation could then be used for guidance toward future work in this area. Several ideas for future work were identified during this project and are described in the following text; these ideas are not listed in a prioritized manner.

- Do a deeper and more comprehensive literature review on sustainability and fire safety.
- Create ranking systems for 1) the areas of fire safety that could benefit the most from using MSI, and 2) prioritising the feasibility of implementing MSI within various target groups.
- Explore existing databases at various levels of government for statistics and/or other data that can be used for the possible development of MSI related to fire safety.
- Investigate the flow of data, data structures, and transformations needed to link local MSI to higher levels of MSI.
- Study the re-use of products, focussing on changes in the fire technical properties and burning characteristics of materials and products, including wood construction, to determine whether they can safely be used again. What kind of certification process would be necessary to accommodate this?
- Create an effective method of communicating market value for companies having a sustainability profile, and the sustainability-based procurement processes that could link to it.
- Find a way to include fire prevention activities in MSI.
- Explore how certification systems such as LEED, BREEAM and others, can be used as a platform or for guidance for MSI for the construction industry.
- Study the impacts of false alarms (evacuations, responder staff fatigue, dangerous driving conditions, etc…) and how they can be reduced.
- Create and monitor “heat” maps using geo-data to show where fires are clustered among selected factors. This can be used to investigate commonalities and maybe find useful MSI. Look to humanitarian efforts, e.g., United Nations Humanitarian Response (UNHR) that are connected to geo-data, to better understand the relationships between potential MSI, e.g., long vs short term, planning vs crisis.
- Find a way to put fire safety impacts on the same time scale as the impacts to sustainability of fire so that people can appreciate their relative magnitudes better.
- Create case studies to investigate data availability and how MSI can be developed for well-defined areas of fire safety.

Other target groups have been identified in addition to the target groups that were involved in this pre-study. These target groups could be used in reference groups or steering committees and some of them might also be a source of funding or be interested in future collaborations. They are listed below:

- Insurance companies
- Policy makers
- Fire brigades of different sizes and different regions
- Architects, engineers and other professionals involved in the construction industry
- Boverket
- Local authorities (e.g. miljö) and municipalities
- Naturvårdsverket
- Owners of infrastructure and large properties

- National Fire Protection Association (NFPA)
- Building construction companies
- Stocholm Resilience Center
- Trafickverket
- Materials developers
- Financial institutions
- Planning departments

6. Conclusions

The aim of this pre-study was to determine whether developing MSI to assess the sustainability of projects, ideas, and decisions related to fire safety would be useful for fire safety engineers, researchers, municipalities, authorities, policymakers, first responders and other stakeholders. It represents the beginning of the process and, hopefully, the results will be useful for continued research in the future.

A roadmap implies that there is a beginning point, a route, and a destination; these locations might not be the same for all target groups. This pre-study investigated the sustainability landscape for the target groups listed above, the following conclusions are based on the results of interviews, workshops, literature, online sources and project reports.

All the target groups have implemented some form of sustainability as it applies to their standard business operations, e.g., energy efficiency, traveling, consumption, personnel equality and well-being, etc.

Fire service product suppliers

Aside from adapting business operations to be more sustainable, this target group is primarily focused on creating a unique presence among the competition by having a sustainability profile or certification. It is anticipated that customers will eventually require their vendors to have such a profile and therefore it has a high marketing value. Related to this, including sustainability in addition to monetary cost in procurement processes could have a large impact and therefore should be included in organisation sustainability plans.

For now a sustainability profile is seen as enough. MSI are not considered to be needed and might even be detrimental to the overall process of improving sustainability, although they could be used as a marketing tool at some point in the future.

Fire and Rescue Services

MSI are needed that can help the public, other municipal organisations and policy makers understand the social and environmental value of the fire and rescue services. MSI could be monitored over time to improve operations and convey those improvements to stakeholders.

MSI that quantify the impacts of firefighting tactics, e.g., fire water run-off and smoke, would help for making tactical decisions.

Fire Safety Engineers

Currently, fire safety engineers don't have much influence in the construction design process in Sweden, so they need as much support as possible to convey their ideas and suggestions for changes.

MSI would help fire safety engineers communicate the need for, and balance between, sustainable and fire safe buildings to designers and other stakeholders in construction projects.

Fire Researchers and Educators

Researchers and educators provide information to other stakeholders that can help them improve their appreciation for sustainability and fire safety and supports their efforts to make innovative changes in their ways of doing business. Researchers can develop MSI and a system for transferring information between various levels of organisations.

MSI that could be used for decision making and monitoring of progress would help resource planning efforts and assist in communication with funding sources and the public.

Authorities

The regional and/or national authorities are in a position to provide the necessary connections and support if MSI data are required to be collected from lower levels, e.g., municipalities, companies, fire and rescue services, etc. and reported to higher levels of government, e.g., national, European, global levels. It is unknown at this time whether this need will be realised or when it might come to pass. It is also unknown if the situation has been anticipated or, if so, whether work has begun on creating the infrastructure needed to make this process work.

References

[1] See https://sdgs.un.org/2030agenda for a description of the goals of the 2030 Agenda for Sustainable Development.

[2] This statement is usually attributed to Peter Drucker, a well-regarded management theorist, however, according to https://medium.com/centre-for-public-impact/what-gets-measured-gets-managed-its-wrong-and-drucker-never-said-it-fe95886d3df6, it was actually the work of V.F. Ridgway.

[3] This statement is attributed to a columnist named Simon Caulkin, a management editor for The Guardian, https://www.theguardian.com/business/2008/feb/10/businesscomment1, who was summarizing the contents of a paper by V.F. Ridgway.

[4] Ridgway, V.F., Administrative Science Quarterly, vol. 1, no. 2 (1956), pp. 240-247, Sage Publications, Inc., https://doi.org/10.2307/2390989.

[5] ISO 9001:2015 Quality management systems — Requirements, International Organization for Standardization, see https://www.iso.org/standard/62085.html.

[6] ISO 14001:2015 Environmental management systems — Requirements with guidance for use, International Organization for Standardization, see https://www.iso.org/standard/60857.html

[7] ISO 26000:2010 Guidance on social responsibility, International Organization for Standardization, see https://www.iso.org/standard/42546.html, accessed 2023-06-23

[8] ISO/TC 59/SC 17 Sustainability in buildings and civil engineering works, International Organization for Standardization, see https://www.iso.org/committee/322621.html

[9] European Platform on LCA/EPLCA environmental footprint, see https://eplca.jrc.ec.europa.eu/EnvironmentalFootprint.html, accessed 2023-06-23

[10] ISO 14040:2006 Environmental management — Life cycle assessment — Principles and framework, International Organization for Standardization, see https://www.iso.org/standard/37456.html, accessed 2023-06-23

[11] ISO 14044:2006 Environmental management — Life cycle assessment — Requirements and guidelines, International Organization for Standardization, see https://www.iso.org/standard/38498.html, accessed 2023-06-23

[12] ISO 14025:2006 Environmental labels and declarations — Type III environmental declarations — Principles and procedures, International Organization for Standardization, see https://www.iso.org/standard/38131.html, accessed 2023-06-23

[13] SS-EN 15804:2012+A2:2019 Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products, Swedish Institue for Standards, see https://www.sis.se/en/produkter/construction-materials-and-building/construction-industry/other-aspects/ss-en-158042012a22019/, accessed 2023-06-23

[14] ISO 21930:2017 Sustainability in buildings and civil engineering works — Core rules for environmental product declarations of construction products and services, International Organization for Standardization, see https://www.iso.org/standard/61694.html, accessed 2023-06-23

[15] LEED Green building certification system, see https://www.usgbc.org/leed, accessed 2023-06-23

[16] BREEAM Sustainabile built environment certification system, see https://bregroup.com/products/, accessed 2023-06-23

[17] Meacham, B., Frantzich, H., McNamee, M., and Kimblad, E., Risk and performance assessment framework for a sustainable and fire resilient building environment (SAFR-BE), edited by Amanda

Tarbet, SFPE Foundation, June 2023, https://www.researchgate.net/profile/Brian-Meacham-2/publication/371598768_Risk_and_Performance_Assessment_Framework_for_a_Sustainable_and_Fire_Resilient_Building_Environment_SAFR-BE/links/648cab1d95bbbe0c6ecd2cdc/Risk-and-Performance-Assessment-Framework-for-a-Sustainable-and-Fire-Resilient-Building-Environment-SAFR-BE.pdf

[18] Fire Safe Europé, see https://www.firesafeeurope.eu/, accessed 2023-06-23.

[19] ISO TC 92/SC 3 Fire threat to people and the environment, see https://www.iso.org/committee/50540.html, accessed 2023-06-24

[20] Using the search phrase ”sustainability tools for assessing and rating” generates a long list of different types of tools.

[21] Brzezinska, D., Bryant, P., Risk Index Method – A Tool for Sustaianable, Holistic Building Fire Strategies, Sustainability, MDPI, 2020, https://mdpi-res.com/d_attachment/sustainability/sustainability-12-04469/article_deploy/sustainability-12-04469-v2.pdf?version=1591248972, accessed 2023-07-06.

[22] Olsson, N. and Göras, T., Hållbart brandskydd, Svensk Byggtjänst, https://byggtjanst.se/bokhandel/byggteknik/byggnadsfysik/brand/hallbart-brandskydd

[23] Blomqvist, T. and Spennare, L., ”Hållbart brandskydd – Har vid råd att inte investera?”, Lunds Universitet, 2021, https://www.lu.se/lup/publication/9069248

[24] McNamee, M., Göras, T., Wetterqvist, C., Lundh, K., Blomqvist, P., and Blomqvist, S., Sustainable management of construction waste, reuse of fire-rated products, Brandforsk project 721 001, 2022, see https://www.brandforsk.se/forskningsprojekt/2022/hallbar-hantering-av-byggavfall-aterbruk-av-brandklassade-produkter/

[25] Fire safety for buildings with cultural values, see https://www.brandforsk.se/forskningsprojekt/2021/brandsakerhet-for-byggnader-med-kulturvarden/, accessed 2023-06-23

[26] Larsson, A-C and Anuttam, P., Studies of environmentally friendly flame retardants for cellulose-based materials - Focus cotton, Brandforsk project 720-005, 2021, see https://www.brandforsk.se/forskningsprojekt/2021/studier-av-miljovanliga-flamskyddsmedel-for-cellulosabaserade-material-fortsattning-2/, accessed 2023-06-23

[27] Återhus – att bygga hus av hus, see https://www.vinnova.se/p/aterhus---att-bygga-hus-av-hus/, accessed 2023-06-23

[28] In 2020 NFPA had a workshop about the sustainability of wildfires. https://www.nfpa.org/News-andResearch/Publications-and-media/Blogs-Landing-Page/NFPA-Today/Blog-Posts/2021/01/06/FPRF-WebinarPanel-Discussion-on-Engaging-Local-Officials

[29] NFPA’s Tracy Vecchiarelli wrote a short undated article about fire safety in a sustainable world. https://www.nfpa.org/News-and-Research/Resources/Emergency-Responders/Job-tools-andresources/NFPA-and-sustainability/Fire-safety-in-a-sustainable-world

[30] Amon, F., Gehandler, J., Stahl, S., Tomida, M., Meacham, B., Development of an Environmental and Economic Assessment Tool (Enveco Tool) for Fire Events, Springer Briefs in Fire, editor James A. Milke, The Fire Protection Research Foundation, 2016, DOI 10.1007/978-1-4939-6559-5.

[31] Amon, F., Gehandler, J., McNamee, R., McNamee, M., Vilic, A., Fire Impact Tool- Measuring the impact of fire suppression operations on the environment, Fire Safety Journal, v120, 2021, https://doi.org/10.1016/j.firesaf.2020.103071.

[32] This information came from a reference group member. See https://www.rsgbg.se/aktuellt/2022/innovativ-raddningstjanst-med-nationellt-utvecklingscenter/, accessed 2023-06-23

[33] Möller, C., Summering av workshopen ”Hållbar brandsäkerhet och skydd mot olyckor”, Myndigheten för samhällsskydd och beredskap, report dated 2023-06-15

[34] Phosphorus, Inorganic and Nitrogen Flame Retardants Association (Pinfa), see https://www.pinfa.eu/about-pinfa/who-is-pinfa/#gsc.tab=0, accessed 2023-06-24

[35] Amon, F., Stahl, S., Life Cycle Analysis of End Products Carried Out, ”PolyGraph - "Up-Scaled Production of Graphene Reinforced Thermosetting Polymers for Composite, Coating and Adhesive Applications", Report D7.6, EU FP 7 project, grant agreement 604143, 2014.

[36] Amon, F., Blomqvist, P., Dahlbom, S., Gehandler, J., Life Cycle Costing & Environmental Impact Considerations, WAPOL Project – Sustainable polymer flame retardants, 2020, https://projects.dii.unipd.it/wapol/wp-content/uploads/sites/3/2021/02/WAPOL-Life-Cycle-Costing-Environmental-Impact-Considerations.pdf

[37] Boverket, see https://www.oneclicklca.com/se/klimatdeklaration/?utm_source=google&utm_medium=paidsearch&utm_campaign=SE&utm_content=lca&gclid=CjwKCAjwzJmIBhBBEiwAEJyLu6lLcngWjoK8sg_4kncooYnvKt-9jV2qIyT_Msh-eS_grB9Z4fZTgxoCDocQAvD_BwE, accessed 2023-07-06.

[38] The Brundtland Commission, United Nations report “Report of the World Commission on Environment and Development: Our Common Future”, https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf, 1987

[39] Miliute-Plepiene, J., Moalem, R.M., Increasing re-use of construction and demolition materials and products- Measures for prevention of waste at Swedish recycling centres, IVL Report C 547, 2020, ISBN 978-91-7883-207-1, https://www.diva-portal.org/smash/get/diva2:1549459/FULLTEXT01.pdf

[40] EU taxonomy for sustainable activities, see https://en.wikipedia.org/wiki/EU_taxonomy_for_sustainable_activities, accessed 2023-07-05.

[41] Climate Change Indicators – Wildfires, US EPA, see https://www.epa.gov/climate-indicators/climate-change-indicators-wildfires, accessed 2023-07-06.

[42] Climate ADAPT, see https://climate-adapt.eea.europa.eu/en/metadata/indicators/fire-weather-index, accessed 2023-07-06.

[43] Gritzo, L.A., Doerr, W., Bill, R., Ali, H., Nong, S., and Krasner, L., The Influence of Risk Factors on Sustainable Development, FM Global, 2009.

[44] Sustainable Development Goals, see https://www.unep.org/explore-topics/sustainable-development-goals/why-do-sustainable-development-goals-matter/goal-7#:~:text=Target%207.1%3A%20By%202030%2C%20ensure,of%20improvement%20in%20energy%20efficiency

[45] Sustainable Development Goals, see https://www.un.org/sustainabledevelopment/cities/#:~:text=Goal%2011%3A%20Make%20cities%20inclusive%2C%20safe%2C%20resilient%20and%20sustainable&text=Goal%2011%20is%20about%20making,likely%20live%20in%20urban%20areas, accessed 2023-07-06.

This report constitutes a final working manuscript for the headlined project. The official project report, to which reference should be made, can be found on the RISE´s website

”Roadmap for measurable sustainability indicators for the fire safety community”

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