Engineering X: Burning of waste workshops

Final report

For participants and community of practice members

Safer End of Engineered Life programme

Contents

1.0 Introduction

On 14 and 21 January 2021, Engineering X, an international collaboration founded by the Royal Academy of Engineering and Lloyd's Register Foundation, hosted two global workshops on the burning of waste in partnership with the International Solid Waste Association (ISWA). This work is part of the wider Safer End of Engineered Life (SEEL) programme.

This report summarises the activities and findings of each workshop, as well as presenting the recommendations made in each virtual workshop. In addition, it includes an outline of a possible programme to address the issue of waste burning, with a focus on low- and middle-income countries (LMICs) designed by the workshop convenors, Dr Mansoor Ali and Dr Terry Tudor. The overall goal of this report and its dissemination is to reduce safety risks for vulnerable groups of the population in LMICs.

The main target audience for this report is the workshop participants. This report aims to provide key recommendations for future programmes, which could be undertaken by other organisations.

We are very grateful to all workshop participants and members of the community of practice (CoP) for their valuable contributions and support of this work.

2.0 Background

Engineering X is an international collaboration founded by the Royal Academy of Engineering and Lloyd's Register Foundation that brings together some of the world's leading problem-solvers to address the great challenges of our age. It has a global network of expert engineers, academics, and business leaders, working in partnership to share best practice, explore new technologies, educate and train the next generation of engineers, build capacity, improve safety, and deliver impact. One of the issues the Engineering X programme has sought to address is the burning of waste. The Engineering X Safer End of Engineered Life programme aims to raise this issue on the global agenda, which it began by convening a free, multi-disciplinary workshop of diverse stakeholders in January 2021.

The uncontrolled burning of waste takes place worldwide, particularly in LMICs where there are often either limitations in the effectiveness of the existing waste management systems or there are no systems present. The evidence around the prevalence of this issue and its harmful effects are generally poor. The recently completed Global Review on Safer End of Engineered Life by the University of Leeds and partners identified open burning as a dangerous issue that needs urgent attention globally. This review provided the foundation for the workshops in January. Its recommendations are the starting point for the workshop and subsequent programme development.

Waste is burnt in residential areas and within industrial or commercial premises due to the lack of availability, the unreliability, or sometimes the complete absence of waste collection and disposal systems. The Global Review concluded that, "ending the practice could result in a requirement to treat and dispose of close to a billion tonnes of solid waste worldwide." Highly engineered final disposal options such as landfills require large investment and are therefore beyond the budgets of many cities and regions, particularly in LMICs.

The practice of burning waste can lead to a number of public and environmental health concerns. For example, there can often be direct health impacts for those undertaking burning in confined spaces (for example, in factories), and for waste workers who burn electronic waste to extract the metals. In addition, these e-wastes contain hazardous materials such as lead and arsenic. There are also risks posed to the communities where the waste is burnt, especially to the most vulnerable people, such as children, older people, pregnant women, and those with co-morbidities. The waste can also directly lead to contamination of the land and water (surface and ground water), leading to more wide-spread risks.

Despite the risks, the *Global Review* also concluded that there are several (perceived) benefits of burning waste. For example, burning occurs to 'get rid' of accumulated waste or in the form of regular burning as an accepted practice. The burning or partial controlled burning of waste is also an accepted practice in health emergencies and refugee and displacement camps. For the e-waste recyclers, burning the waste provides a 'quick and easy' method to access the enclosed metals.

Given the complexity of the issues around the burning of waste, developing strategies to effectively understand and address the issues requires a multi-disciplinary approach.

3.0 Burning of waste workshops

To convert the recommendations of the *Global Review* into a programme of action, Engineering X hosted a series of expert consultations and workshops between November 2020 and January 2021. The workshops were promoted and conducted in partnership with the International Solid Waste Association.

The overall purpose of the expert consultations and workshops was to validate the findings of the *Global Review* and gather input from diverse, global stakeholders on recommendations on the key issues, most urgent issues, groups most at risk and possible components for the programme of action. The workshops were also intended to act as starting points for action around this global challenge and create a community working to address it. Given the complexity and breadth of the topic, two workshops were held.

3.1 Workshop one

Workshop one took place 14 January 2021 and was attended by 75 participants from 23 countries. It was open registration and ran twice to cover different time zones and allow wider global participation.

This workshop aimed to understand the nature of the practice of burning waste from the perspective of the key stakeholders involved, and to receive recommendations regarding the nature of the future programme. Participants validated and contributed to the key findings from the *Global Review*, which identified several key issues and also proposed recommendations.

Participant breakdown

Participation was welcomed from all stakeholders; from practitioners, policymakers, those working within the community, industry, academia, and those who simply wished to positively contribute. Participation was encouraged from LMICs, young professionals, women, and other under-represented groups. The workshop was promoted through Engineering X's website, the Academy and ISWA newsletters, direct mail, and social media (the Academy, ISWA and the Lloyd's Register Foundation), including through a blog series on LinkedIn. The workshop one agenda is included as **Annex 1** and a list of all participants is included as **Annex 2** with a breakdown below to show split by country, gender, and sector.

- Female
- Male

- Academia
- Industry
- NGO/Charity
- Consultancy
- Government/Civil Service

- United Kingdom
- United States
- Pakistan
- Kenya
- Italy
- Japan
- South Africa
- Indonesia
- Trinidad and Tobago
- Lebanon
- Netherlands
- Nepal
- Ghana
- Bangladesh
- Tanzania
- Australia
- India
- Uruguay
- South Africa
- Senegal
- Canada
- Germany
- France
- Egypt
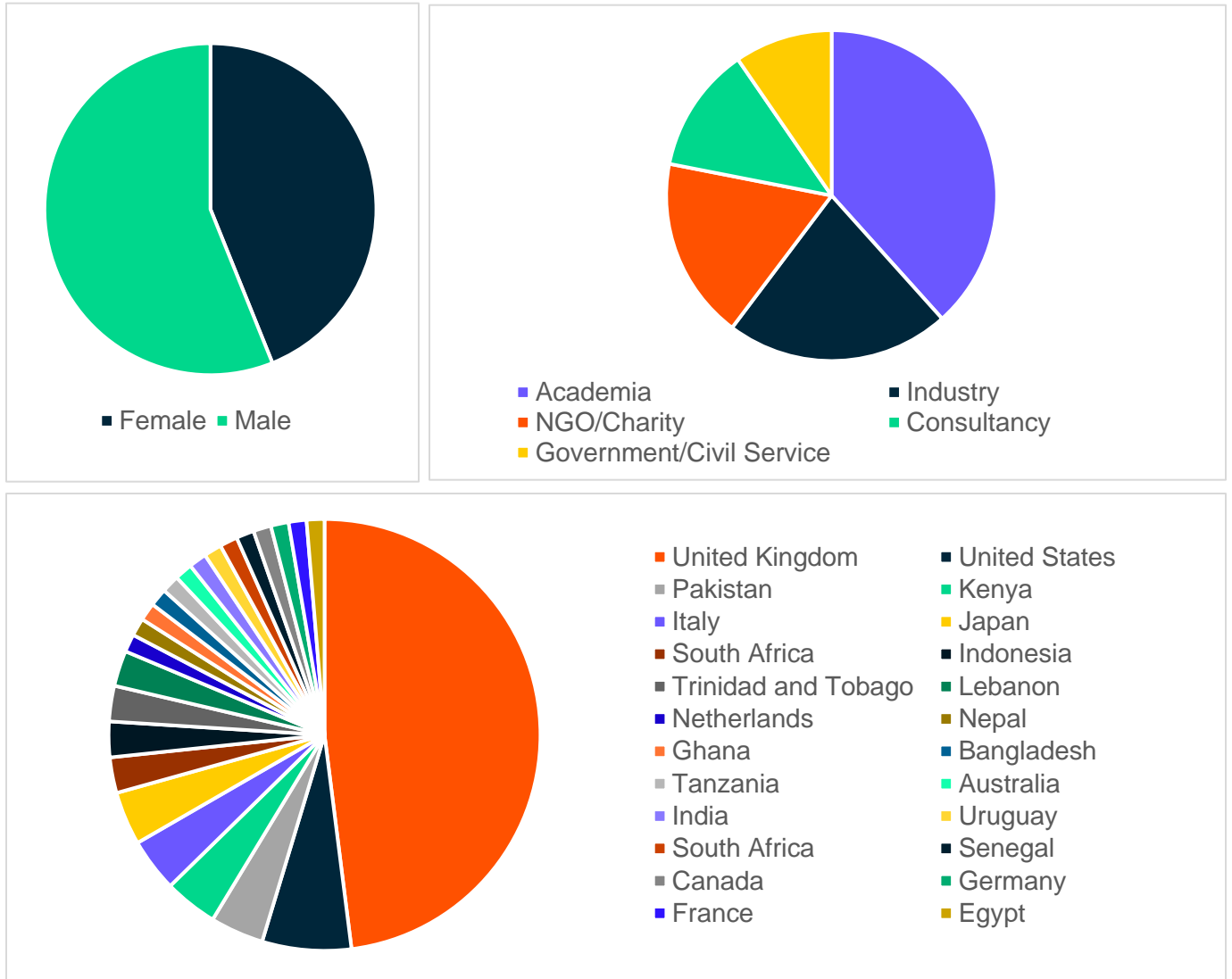
3.2 Workshop two

Workshop two took place on the 21 January 2021. This workshop was by invitation only and was attended by 40 experts. This was a multi-disciplinary and sector group with expertise on waste burning, solid waste management and programme design.

The overall purpose of this workshop was to discuss the nature of potential programmes to address the issue of waste burning. Consequently, a substantial part of this workshop was used to develop recommendations for future programming for the Safer End of Engineered Life programme and beyond. For example, how do we best protect the livelihoods and the lives of stakeholders and their communities who are burning waste? How do we best assess the issue of opening burning to enable regular monitoring? What governance structures are required? How best might we engage/communicate with a range of stakeholders, particularly those who are 'on the ground'?

The workshop two agenda is included as **Annex 3** and a list of all participants is included as **Annex 4**.

Both the workshops and publicity in the run up to the events helped to develop a community of practice. This network was brought together in a LinkedIn group which was launched at the workshops and continues to be developed. Further details of this initiative are discussed in **Section 8**.

3.3 Polls

During both workshops, participants were invited to complete two polls to gather their views. The questions were:

Poll one

Q1. In your opinion, what is the major cause of harmful waste burning?

Q2. In your opinion, which group of people is most at risk from harmful waste burning?

Q3. Through, which approach could harmful waste burning be controlled in low- and middle-income countries?

Poll two

Q1. Based on the discussion so far, what could be the key drivers to address safety challenges from waste burning?

Q2. How would you like to engage with the post workshop activities?

The majority of the participants participated in these polls and complete results are attached as **Annex 5**, where exact proportion of responses can be seen. Participant responses were similar in both the workshops.

In Workshop one, poor waste systems and poor disposal sites were seen as the main cause of harmful burning. Nearby population, waste workers and waste pickers were identified as the groups at risk. Improving waste systems, training, and enforcing legislations were identified as

the approaches to control harmful waste burning in LMICs. Improving policies, waste legislations and citizens' awareness were the main recommendations made to drive positive changes.

Responses were similar in workshop two, although, participants also identified improved recycling and raising safety concerns as the key drivers for change, in addition to the above drivers.

4.0 Expert interviews

To inform the process of workshop planning and programme development, expert interviews were conducted with the Engineering X board members, Technical Advisory Group members and international experts. The following experts were interviewed:

1) Professor William Powrie FREng, SEEL Board Chair
2) Dr Ruth Boumphrey, SEEL Board Member
3) Professor David Wilson, Independent consultant
4) Crispian Lao, Government of Philippines
5) Aditi Ramola, International Solid Waste Association
6) Dr Costas Velis and Ed Cook, University of Leeds
7) Professor Linda Godfrey, CSIR
8) Keith Alverson, formerly of UNEP-IETC
9) Professor Robert Berry and Sukhmeet Singh, A2P Agri To Power
10) Zoë Lenkiewicz, Waste Aid

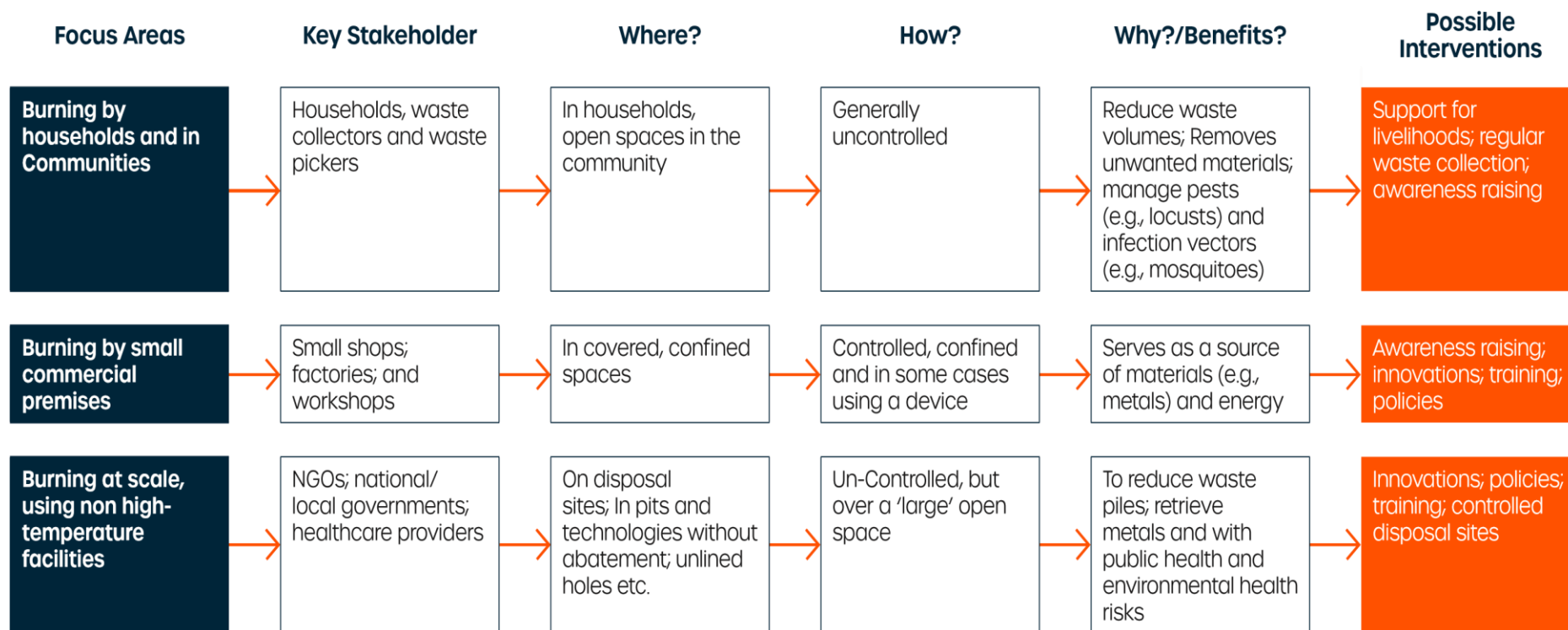The following key points were made by the interviewees:

- It is important to understand the key causes behind burning of waste, where burning takes place, and the reasons, behaviours, and attitudes behind it. Waste burning may take place in homes, in neighbourhoods, in disposal sites and within recycling factories in LMICs. These all occur for different reasons and a programme of funding must address some of these drivers. An important aspect to discuss in the workshop and programme development is the set of behaviours to address. Following this recommendation, a schema of key drivers for burning was developed and included below. A key recommendation here was to understand the causes of burning in different context, which was taken further within the workshop discussions.

- Although waste burning is common, it is a neglected issue with solid waste management improvement in LMICs. Programmes to improve waste systems often take place in large cities and urban areas, while burning may be common in small towns and villages in LMICs. It is important to put burning within the global development indicators with and within larger and emerging issues such as climate change, plastic pollution and air pollution. According to Professor Wilson, waste burning is an important contributor to greenhouse gases and programmes to reduce burning could have a higher chance of support from international organisations, including UN organisations and donors. Currently burning is considered as a local issue and there is no regional or international attention on burning. This theme continued in all of the workshops and an aspect of raising global awareness is included in the programme design and Theory of Change. Recommendations are made in **Section 8.0** to develop global partnerships and reach out to key UN agencies and donors. Global

Advocacy work must share such evidence for SDGs review, CoP26 and other international events.

- In many contexts, waste burning is seen as an accepted practice. It is considered a final disposal option, especially in those places where waste systems are not operational. Waste burning is also common in emergency contexts, where waste from camps, clinics and hospitals is burned in open spaces or in barrel incinerators. Where burning is an accepted option, there are often no other options available. As a result, a focus on small towns and villages in LMICs is included as a key recommendation. Healthcare waste work is not recommended further, as several emergency and relief organisations are already working on this.

- Government policies on waste burning rarely exist. Where policies exist, the implementation is ineffective, and ineffective institutional capacity to implement those policies is a challenge. There are very few examples of when a country has attempted to measure the occurrence of waste burning, and the projects are often short-term and not sustainable. Limitations of government policies were mentioned as a key barrier to the effective development of programmes though it was also noted that policies on their own are not enough to reduce burning. These must go hand in hand with effective institutions. These points were also raised by the workshop participants and baselines and policy strengthening is recommended.

- One important aspect mentioned in case of many LMICs is the challenge of sustaining project outcomes beyond funding. Projects also lack coordination and effective ways of learning and sharing. Even within governments, ministries do not collaborate and there are sometimes overlapping or parallel projects, disconnected from each other. This is a common issue with externally funded projects and more guidance, training and emphasis is needed. Some of this is included in the recommendations.

- Compared to climate change or water resources, waste burning is not considered a global issue that needs a coordinated global effort. It has not received much attention within the UN Sustainable Development Goals (SDGs). Therefore, a good starting point to reduce waste burning and its risks is to start local, develop local solutions and develop national capacity. Recommendations include focusing on risk reduction for vulnerable populations and to build further from some of the work already being implemented to improve safety of waste workers.

- Burning of agriculture is a common practice in many LMICs, though agriculture is not an example of engineering waste. The impact of agriculture waste burning is not heavily monitored. A2P has developed an enterprise model to convert agricultural waste into fuel in India, engaging with farmers and influencing the national policy in India. This organisation demonstrates a model to connect different stakeholders and to convert agricultural waste into a useful product. A2P's model offers learning to reduce waste in rural contexts.

In addition to the summary of the above points, experts also recommended organisations working in the sector, most notably UN-Habitat, UNEP, Basel Convention, WHO and Tearfund. Experts also recommended the need to explore the interest of big brands to fund parts of the programme within their sustainability portfolio.

Following these expert interviews, a schema was developed to highlight waste burning behaviour and drivers by different stakeholders:

Focus Areas	Key Stakeholder	Where?	How?	Why?/Benefits?	Possible Interventions
Burning by households and in Communities	Households, waste collectors and waste pickers	In households, open spaces in the community	Generally uncontrolled	Reduce waste volumes; Removes unwanted materials; manage pests (e.g., locusts) and infection vectors (e.g., mosquitoes)	Support for livelihoods; regular waste collection; awareness raising
Burning by small commercial premises	Small shops; factories; and workshops	In covered, confined spaces	Controlled, confined and in some cases using a device	Serves as a source of materials (e.g., metals) and energy	Awareness raising; innovations; training; policies
Burning at scale, using non high-temperature facilities	NGOs; national/ local governments; healthcare providers	On disposal sites; In pits and technologies without abatement; unlined holes etc.	Un-Controlled, but over a 'large' open space	To reduce waste piles; retrieve metals and with public health and environmental health risks	Innovations; policies; training; controlled disposal sites

5.0 Workshop findings

5.1 Workshop one findings

Comments on the *Global Review*

In both the morning and afternoon sessions of workshop one, and across all of the groups, there was general agreement with the risks identified in the *Global Review* (for example, air pollution, and public health risks).

A notable point that was mentioned in both the health impacts and controlled burning groups was that the document highlighted the motivations and 'benefits' of waste burning (for example as a source of fuel, to get rid of unwanted items and to reduce public health risks). Indeed, the 'perceived benefits' of waste burning is one that participants noted had not been outlined in previous reports. There was a need for further study to quantify the nature of these benefits.

However, participants across all groups stated that there were various gaps in the work. For example, some noted that it had not examined wider environmental impacts such as pollution to water. Discussions on cultural issues, as well as risk-receptor pathways were also missing. It had also not examined issues related to environmental policy, legislation, and their regulation. Finally, there had not been any mention of the (international) movement of waste. This practice resulted in the flow of waste (such as e-waste), primarily to LMICs. Participants suggested efforts to further disseminate the *Global Review*, including summaries and translations.

Key causes of the issues

LMICs generally lack the necessary resources to effectively manage their waste (for example, funding, infrastructure, and, in the case of small islands, the physical space). These countries also have high population densities, which exacerbate exposure to the risks (for example, the close geographical proximity of urban populations to dump sites). For example, in the controlled burning group, one delegate noted that in Zambia, there is only one landfill site in the city and another reported regular burning of waste on the final disposal site in Dakar. The councils in several low-income countries in Africa can only afford to clear the area once a year. Just before the wet season the council clears the site, and the people closest to that area can use it to grow maize. The community can use the land when it mattered most, thus providing benefits, even though waste burning is not actively encouraged.

Indeed, widespread limitations in waste collection systems and infrastructure were outlined by various groups (including on controlled burning and the informal sector) as a key reason why waste is burnt, particularly in LMICs. For example, one participant said that:

> "In Pakistan, there is a lot of dumping sites around rivers and canals and burning is often because they can't find an alternate site and that is the biggest issue. Burning is common in villages and small towns."

While another stated that:

> "Burning waste does not cost anything but an alternative will cost you."

An underlying reason for the challenges faced was a lack of credible data on the occurrence and impact. This was mentioned across all groups. Many participants spoke of the need for

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credible baseline data to inform decision-making and more effective interventions. For example, one delegate noted that:

> "When we want to do assessment when we look at the inventories, we don't have the baseline in developing countries. When we try to quantify, we are misled – in the impact of operation in developing countries. Maybe some research is needed to quantify the impact of emissions."

Similarly, another delegate stated that:

> "There is usually a problem of data availability in waste management. Lacking collecting infrastructure is a problem in the first hand, consultants take data from municipalities, but these are guesstimates."

Across all groups, limitations in awareness of the risks posed, as well as implementation gaps (for example in enforcement measures) were also noted by various individuals as key contributing factors. A delegate stated that:

> "Children play with batteries at the end of life. And we know how dangerous it is for the children. Most of the time it is coming from lack of knowledge or ignorance."

However, issues were not confined only to LMICs, with 50% of dioxin production in the UK linked to burning in backyards and bonfires.

Other challenges included items not generally being designed for reuse or recycling, and most approaches are in 'sectoral silos', rather than focusing on a holistic approach (waste, health, humanitarian, and water).

An important point that was made in the group on e-waste and plastics: in some cases, waste is burnt as a form of protest. This practice makes interventions that focused solely on waste management, difficult. Similarly, some municipalities are reluctant to acknowledge the issue as it would lead to wider societal challenges having to be addressed.

Finally, it was noted in the group on controlled burning that in some cases, waste burning, though frowned upon or considered illegal, is allowed. For example, in some countries, municipal/government own dumpsites and landfills and conduct open burning to reduce the volume of the waste.

How could the risks be addressed?

Facilitating waste collection, recycling, and reuse

Less than 50% of waste is collected nationally in many LMICs. While there is an increase in collection coverage in large cities, most small towns and villages do not have any system for waste collection and disposal. Therefore, effective waste collection systems are crucial. Initiatives should also focus on facilitating separation of waste at source (particularly hazardous waste), reuse and recycling, as these approaches would enhance safety. Collaboration between the informal and formal sectors is also vital, as the informal sector is not recognised and accepted in many LMICs, despite its major role and potential vulnerability.

Initiatives should focus on specific waste streams (such as e-waste, medical waste, and agricultural waste), and the technologies to manage these streams. For example, there should

be an evaluation of the use of small-scale treatment technologies for managing waste from healthcare facilities in LMICs. In many cases, the efficiency and operational capacity of these technologies/systems are limited. One participant also spoke about the need for the more widespread distribution of affordable technologies that could be used to cut the cables associated with e-waste.

The need for more research

The need for further research was mentioned several times across all groups. For example, studies to quantify the key public health risks were required. One participant stated that research should include epidemiological studies to provide an understanding of the impact on the public health of individuals in the communities. There should also be more research into the public health impacts of the burning of plastics (for example on levels of emissions and air pollution). Such studies would also help in making a business case for the use of biofuels, rather than plastics as a fuel, as biofuels are more expensive. However, one participant in the health impacts group cautioned that there were challenges in undertaking such studies. For example:

> "Problems of multiple exposures and lifestyle factors make linkages between health outcomes and a particular pollutant very challenging. If you go up the chain and concentrate on measures of exposure (integrators of exposure - food types, blood levels) it can help."

Research into the quantities of waste generated and collected is also required. These studies could use digital approaches and satellites to monitor and track the flow of materials. This research could potentially be linked to population densities and geographical spread. Research is also needed into the cultural reasons for burning waste. These cultural studies need to be disaggregated according to factors such as gender. Small grants for university students to undertake some of this research was suggested.

In the health impacts group, it was suggested that there should be standardised approaches for data collection and the reporting of risks. This would assist with monitoring and benchmarking. In addition, it would be good to have standardised approaches or guidelines on how to estimate the associated public health implications/costs. This would be helpful for justifying how to develop new programmes and to show decision-makers the health-cost benefits of how to do this.

Localised and targeted interventions

It is important for interventions to be targeted and to take account of localised issues. For example, a delegate in the controlled burning group stated that:

> "Agricultural crops are burnt over large areas, because farms producing similar crops at similar times of the year, while urban waste is local in scale and heterogeneous."

Thus, the interventions that would work for agricultural waste would not be suitable for waste being burnt in an urban context. Any intervention should also not negatively impact on the livelihoods of the communities.

Across all groups, it was noted that interventions need to be practical, community-based and bottom-up in order to improve their chances of success.

With regards to facilitating local recycling markets, a key issue related to the setting of tariffs/thresholds. In some countries (such as Egypt), the calculation of tariffs is top down (it is set by the state agency), resulting in no full cost recovery taking place in some areas. However, in other countries, a bottom-up approach is used, where there is a state regulator and local authorities can calculate their own tariffs.

Awareness raising and stakeholder engagement

In the group on health impacts, it was stated that there is a need to outline the links between the burning of waste and climate change impacts to move the issue higher up the global agenda. The issue also needs to be more closely aligned with global environmental and public health concerns. Making these links would better capture the attention of donors and policymakers.

Across all groups and in the chat discussions, the development of awareness-raising campaigns and stakeholder engagement activities were deemed to be crucial. These campaigns need to highlight the risks posed and should be targeted towards various segments in the community (such as schools, farmers, the informal sector, individuals living close to dump sites and landfills, and children). A 'community of waste champions' could be created. Crucially, the campaigns should be simple and use diagrams, schematics, and images to enhance impact. Messages should also be translated into local languages to enable wider uptake. For example, there was a suggestion of developing of a simple booklet for community health workers, which presented key public health issues, and that built on existing projects being carried out by NGOs such as WasteAid and Tearfund. Another suggestion was for a 'good practice guide' of solutions to waste management in small, under-resourced towns, especially where the town has grown organically out of a rural area. Such documents could be translated into various languages.

Across all the groups, it was suggested that there is a need to engage with stakeholders, including **policymakers and municipal government officials**, as they could enact policies and facilitate the implementation of initiatives. However, engaging with them is difficult. In addition, managing the issues associated with waste burning span several different agencies (for example public health, waste/environmental management, planning, climate change, and socioeconomics), and various levels (local, regional, national, and international). One delegate noted that routes in might be through international platforms and agencies such as the United Cities and Local Government (UCLG), which brought together local government agencies, and national agencies such as the Waste and Resources Action Programme (WRAP), in the UK. **Private sector organisations** could potentially be appealed to via their corporate social responsibility (CSR) agenda, whereby they could be made aware of community initiatives that they could fund. For example, a delegate stated that such engagement activities had been successfully undertaken at organisations such as Lafarge and the World Wide Fund for Nature (WWF). Fast moving consumer goods (FMCG) businesses, particularly those involved in the manufacture and distribution of items in plastic packaging (for example food and drink), should also be targeted as a means of reducing the production of packaging wastes in the first place. However, having good points of contact with the private sector organisations was crucial. **Migrant camps** should be another target segment. In some cases, individuals in camps are burning waste materials as a source of fuel for fires to cook and/or to stay warm. With an expected increase in the global movement of vulnerable individuals (due to the impacts of COVID-19), it was felt that this segment of the population would increase. Links should also be forged with **public health officials** to collect related data (for example the prevalence of disease/impact as reported by hospitals and health ministries). This data could then be

employed to make the case on the basis of reduced public health impacts. **Urban planners** within municipalities should also be engaged with to facilitate improved infrastructure design and planning. **Mobile network operators**, who had responsibility for electronic products, were another potential target to engage with and **civic organisations (such as churches and NGOs – like Exnora in India)**, which were active in the community, including in waste management should also be approached.

Within the chat discussions there was mention of a need for a community/forum that forges links with other stakeholders to lobby for action. For example, **international environmental agencies** (like the WWF) to lobby for the removal or replacement of polyvinyl chloride (PVC) and polystyrene (PS) in the global plastics agreements; **local government officials and policy makers** for the development and enforcement of policies and legislation, as well as improved waste collection systems, and links between the burning of waste and climate change; **large multinational corporations** (for example, food and drink manufacturers) to encourage producer responsibility related to packaging; **national associations** for the setting of more financial viable tariffs/thresholds; and the **UCLG and international platforms** to engage with local government agencies.

Ensuring long-term sustainability

Throughout the workshop, participants shared knowledge of several global projects and initiatives already being undertaken.

This included:

1) Agri2Power company in India, which was concerned with reducing the burning of agricultural waste.
2) Various projects by the organisation Waste Aid.
3) A project in Nepal, which led to improved recycling due to better coordination between the closure of shops and the collection of waste materials by the informal sector.
4) The use of plastic credits being utilised by companies such as Empower to reduce pollution.
5) GIZ in Ghana was providing the informal sector with a financial supplement to purchase cable burners if the cable had not been burned.
6) MTN was working with Coliba in Cote d'ivoire and Ghana, doing work on door-to-door waste collection and digital technology solutions.
7) Project on reducing packaging waste in the Philippines, which involves working with waste pickers.
8) Project in Durban, South Africa to separate out nappies from municipal waste.

It was noted that there is a need either for the sharing of information on these projects to build capacity, and/or funding to either scale these initiatives or ensure their long-term viability.

Summary of key recommendations from workshop one

Global advocacy

Reduction of open burning will contribute to a few global goals, including the UN Sustainable Development Goals 3 (Good Health and Wellbeing), 5 (Gender Equality), 6 (Clean Water and Sanitation) and 12 (Responsible Consumption and Production), 13 (Climate Action) and 15 (Life on Land). It is also linked with the global agreements on the transboundary movement of hazardous waste, which includes a large proportion of rejects, which are sometimes open burnt in countries where final disposal sites are not fully developed. There is also an important link between open burning and global climate goals. There are estimates of open burning of waste contributing 2% to 10% of emissions and its reduction could therefore contribute to reduction in greenhouse gas emissions and reducing its impact on climate change.

Sector learnings

Burning is common in rural areas and small towns**.**

There is a lack of data, evidence, and quantification on waste burning. A systematic review is required to understand the potentially constructive aspects of open burning to understand what could replace or mitigate the loss of the perceived 'benefits' of burning. There is also limited disaggregated data on the impacts of women, who are often involved in the burning (for example through using waste materials as fuel for cooking), and children (who might for example work on dumpsites).

Effective education and communication of the issue is urgently required at all levels. This issue should be higher on the agenda – participants were uncertain as to why it has not been before. There is a need to create links between air pollution, emissions, fire risks, and climate change. The opportunity to build on existing networks, such as community health networks in many LMICs, should be used.

Programme development

The health and safety of waste recyclers and waste pickers should be a crucial component of programme development.

There is a need for the conversion of the *Global Review's* findings into programme development, which could include baseline studies in some selected or relevant contexts.

How do we take the findings of the *Global Review* to countries and governments (and make it actionable)?

It is important to develop more effective municipal solid waste management systems, and to build the capability of local stakeholders in the management of these systems.

Waste burning is 'free.' Therefore, alternatives need to highlight the other benefits if they are to gain significant uptake.

Other recommendations

In some countries there are issues concerned with failing standards for incinerators. New technologies in treating healthcare waste have good potential**.**

5.2   Workshop two findings

Summary of key recommendations from workshop two

Participants in workshop two made recommendations in many areas. Some of those recommendations were similar to those made in workshop one, by experts or included in the *Global Review*. This section includes new recommendations made in workshop two or where a greater emphasis was made on an existing recommendation.

Sector learnings

The participants emphasised the need to reduce toxic materials going into the waste chain that can ultimately be burnt. In addition to PVC, composite and layered materials, nappies also pose a threat. Many manufacturers of nappies are known brands. Brands must be informed of the issues of waste burning via direct advocacy or through other policy pathways, such as Extended Producers Responsibilities (EPR). A community-led project in South Africa is examining the issues associated with nappies in general waste through a UK Research Council Fund.

Ideas were shared about projects to reduce the risk of waste burning on vulnerable groups. These projects must work with the existing livelihoods opportunities and not restrict them. For example, replacing cable burning with cable stripping and other tools to take out metals that replace burning methods. Reaching out to vulnerable groups, such as girls and women pickers is important. Sometimes faith-based organisations working with waste workers and pickers are effective.

Large projects often overlook vulnerable groups, as sometimes consultants are not very committed to the local conditions and do not understand the local stakeholders and systems. Thus, the process of developing and maintaining large-scale (internationally funded) projects can often be a time-consuming and difficult process. However, once the systems are in place, some projects can become self-sustaining.

Many large projects deal with national ministries, while municipal councils are closer to, and in a better position to, address the issues. National institutions have a lack of coordination and ability to work collectively, even in ne country. In large countries, national to local institutions are not aligned. It is important to support leadership at the level of villages, small towns, and cities, for example mayors.

Programme development

The participants suggested that it is crucial to raise the importance of reducing waste burning at the global level. The forthcoming CoP26 in 2021 is an opportunity, and a side event could be proposed with organisations collaborating. For implementation projects, a country focus must be established. This can start with baseline studies. These studies must also find potential champions and leadership at the country levels. Once the shape of the programme is agreed, certain UN organisations must be informed/involved. For example, UNICEF has an agenda on children's health, and in certain countries, it overlaps with the objectives of reducing waste burning for child waste pickers. Involvement of UN organisations would also help in attracting the attention of policymakers.

It was emphasised that more and new projects to address waste burning in small towns and villages must be developed. Waste burning is also an issue in urban slum areas and densely populated low-income areas. Baseline studies to understand this at the city or country levels were recommended.

Other recommendations

Awareness raising can be undertaken using social and traditional media. This would help in getting the attention of policymakers.

6.0 Recommendations from the Global Review

This section looks at all the recommendations made in the *Global Review*, workshops and expert interviews to start formulating a programme design.

The top-level recommendations from the *Global Review*, as included in the executive summary, are adapted for the programme design, and given below. Recommendations made in the *Global Review* sets the scene for the start of the programme design process:

A systemic approach to change

To reduce the harmful impact of global burning and to sustain this change, **a systemic approach to change** is necessary. This includes working at various 'pressure points[1]' in the system, which is composed of different interconnected aspects, such as policies, regulation, citizens' behaviour, the capacity of relevant institutions, and potential pathways for change. This is to be put in the context of making an economic case based on the larger goals, such as climate change targets, health indicators and the impact on natural resources such as land, water, and air. This can also be used to make a case for the overall wellbeing of citizens. For example, a recently concluded global study on reducing plastic pollution proposed a systemic approach to reduce plastic pollution in oceans and rivers.

Improved waste management practices

Open burning is an outcome of poor solid waste management in LMICs. Current estimates suggest that 41% of the world's municipal solid waste undergoes open burning. This burning mainly takes place in areas where waste collection is poor, and waste disposal sites are overflowing. Thus, one of the important routes to address the issue of waste burning is to improve waste collection and disposal practices. Indeed, one of the recommendations of the Global Review is to invest in **improving the waste systems**, where it can contribute to reducing open burning.

Improved data and quantification

Very little is known about the quantities of solid waste that undergo open burning globally. In addition, information on issues such as burning hotspots, the motivations for burning, seasonality and the key groups involved, is limited. There is also a need for more information on specific waste, such as e-waste, agricultural waste, and waste used as a fuel for cooking. This information and data are important for advocacy, global monitoring and making a case for

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[1] Pressure points are those elements in the system, which can potentially deliver maximum impact.

enhanced attention, including programme funding. The *Global Review* identified several areas where there are data and quantification gaps.

Replacement or removal of materials in product streams

The presence of certain materials in waste can pose a risk when burnt. Several materials **should be excluded from products in areas where open burning is likely to take place**. For instance, the Secretariat of the Basel Convention recommends that PVC and other chlorinated plastics are avoided in open fires because of dioxin formation. PS is also of concern because of the high particulates' emission compared to other plastics. Given that packaging is a major component of municipal solid waste, and, therefore, it is at high risk of being burnt in some areas, PVC and PS packaging should be removed to protect human health. The *Global Review* recommends removal of harmful materials and introduction of replacement products.

Burning as a disposal option

There are circumstances where open burning is perceived as the safest option for the disposal of waste. For instance, in the case of potentially infectious medical waste, open burning offers a cost-free method of neutralising pathogens, which could otherwise threaten the health of those who encounter it post disposal. The World Health Organization (WHO) recommends open burning as a last resort treatment option when there are no alternatives, citing it as a 'safe final disposal' method for sharps and infectious waste. Whether or not the WHO has quantitatively assessed the relative risk of emissions from open burning in comparison to the risk of infection from medical waste that has been buried or open dumped is not clear, and the *Global Review* found no published evidence to substantiate the advice. The *Global Review* therefore recommended that further research is conducted to assess the evidence for the WHO's advice in more detail to ascertain whether it is still up to date given the current state of knowledge in this area.

Potential benefits and motivation

Open burning brings tremendous benefits (perceived or actual) to people who have no access to solid waste management. These benefits include the reduction in mass and volume, malarial mosquito control, and the reduction of odour and bioactivity. Moreover, for people and organisations that cannot dispose of their hazardous waste by any other method, open burning offers the opportunity to reduce pathogen levels. The present study has reviewed some of these benefits, but it is noteworthy that most studies that include narratives of open burning focus attention on the negative outcomes. While these are important, developing an understanding of the benefits open burning brings to those who carry it out is vital for designing interventions to mitigate the negative effects or to reduce its prevalence. Therefore, it is a recommendation of this research that further studies are carried out to better understand the reasons why open burning is carried out by different actors so that interventions can be tailored toward the mitigation of this practice. This must include studies to understand waste burning practices in neighbourhoods and disposal sites. In addition, this must also look at the burning by waste pickers to retrieve metals and waste burning within recycling factories of plastics, rubbers and metals within confined spaces. Waste is an important livelihood asset for informal sector workers, and the majority of them are the poorest of poor and most vulnerable.

Policies and institutions

The current suspected high prevalence of the open burning of waste indicates a substantial challenge in addressing the culture of burning and accepting this as a 'harmless' practice. It is recommended that a set of evidence-based, practice frameworks and guides are developed to assist policymakers, governments and businesses with the protocols and steps towards the managed reduction and elimination of the practice, combining behavioural change theory with risk assessment and targeting areas where prevalence is high.

Guidance on open burning tends to recommend prohibition, alternative treatment, or waste avoidance in places where open burning practices are commonplace. Only one document from the Secretariat of the Basel Convention acknowledges the potential benefits of open burning as a last resort and provides best practice guidance for those who have no choice but to undertake the activity. The report strongly discourages open burning; however, where it is necessary, for instance to manage pathogen-infected medical waste, the guidance encourages practitioners to maintain temperature, airflow, and careful control of feedstock, which should avoid halogenated plastic content as well as BFRs and other POPs.

Poorly managed incinerators

For incinerators that operate without effective emissions mitigation technology, engineering controls exist that effectively abate emissions. In Europe, an exhaustive list of these 'best available techniques', compiled by the Joint Research Centre, assists operators and facility designers with engineering decisions to ensure compliance with the Industrial Emissions Directive 2010/75/EU.

Specific recommendations from the *Global Review* and their potential

In addition to the above group of recommendations, the *Global Review* included detailed recommendations. All the recommendations were reviewed considering their potential for programme development. Those that are most relevant to an applied programme, potentially within the scope of SEEL programme, are included below. The right-hand column includes the programme development potential for each recommendation.

Global Review recommendation	Programme development potential
Directly relevant to waste burning	
Manage waste so that populations do not have to manage their own and open burn.	This can address the causes of the problem and a range of donors are working on this. Though too large in scope for the Engineering X programme, some key components could be chosen and addressed, such as improving primary collection.
Managed continuation of open burning by providing guidance on carrying out safer combustion.	This is innovative, but very hard to sell, especially if it comes from an international organisation. Within Engineering X's scope, organisations can improve safety where burning is common, for example in small towns and villages in LMICs.

Remove or substitute selected substances used in the product system in areas where open burning is prevalent.	Good recommendation in terms of systemic thinking. However, perhaps too large a scope for the Engineering X programme.
Reduce or eliminate waste deposits on dumpsites.	A large investment and large scope for the Engineering X programme.
Transform existing dumpsites through a series of cost-effective transitionary steps.	A large investment and large scope for the Engineering X programme.
Identify, assess, and evacuate sites at risk of waste-slope failure.	Possible at pilot scale but would be very complex for the Engineering X programme.
Restrict access to hazardous environments in close collaboration with informal waste workers.	Possible action, through capacity development, training, and education. Some NGOs and universities are already involved in such actions.
Facilitate managed access to land disposal sites to benefit waste pickers.	Possible action, through capacity development, training, and education. Some NGOs and universities are already involved in such actions.
Restrict supply chain for certain items and materials (e-waste and medical waste).	Possible at pilot scale but would be very complex for the Engineering X programme as municipal waste collection is often not source segregated. This is beyond the scope of Engineering X programme.
Integrate waste pickers into municipal solid waste management plans.	A good recommendation and possible within the Engineering X programme.
Research and innovation recommendations	
Collect primary data on the prevalence of open burning.	A study on drivers, hotspots and stakeholders involved in selected countries would be beneficial. This will need close links with policy engagement.
Risk comparison between emissions and pathogen elimination.	A good one within the scope of healthcare waste management. There are some good possibilities for emergency and development contexts.
Assess the benefits and motivations for open burning.	Possible with a narrow focus and manageable research question. Could be an interesting study from different perspectives.
Identification of dumpsites.	Possible in partnership with ISWA's ongoing work.
Carry out high-quality, comparable and actionable research that quantifies risk.	A recommendation to research funders and other donors.
Link epidemiological observations to risk exposure evidence in global burden of disease type studies.	A recommendation to research funders and other donors.
Establish a global observatory to facilitate targeted intervention design.	A possible group within ISWA, with Engineering X support.

7.0 Potential programme development

In this section, all the recommendations were analysed together as key issues and key outcomes to formulate a programme of action. This section presents a broad programme, which must be in place to address the issues of global burning in LMICs and to raise awareness of the issue at all the levels.

Key issues

A programme to address burning of waste will address the following key issues:

Low global awareness

There is limited global awareness of waste burning. There is limited data to engage with global and national policies and not many donor champions. The issue is also not within the scope of large investment programmes, which are increasingly urban and use international consultants. It is not a significant topic of discussion within emerging areas, such as climate change, plastics waste, and innovation to reduce waste, and health risks. However, international organisations such as ISWA (through risky disposal sites), UNICEF (children involved in burning) and WHO on global health risks are potentially attracted to the issue.

Lack of data and information (for programmes and policy)

It is known that waste burning is common. However, not much is known about the drivers for burning, hotspots, seasonality, and the key stakeholders who are involved in waste burning. Baseline data about a range of aspects is not available. One of the reasons for this is the lack of reliable data about waste collection and disposal practices. As burning takes place within a broad scope of poor solid waste systems, little is known about the scope of the baseline data.

National policies, actions, and monitoring

National policies do not cover waste burning adequately within waste policies. Municipal institutions are relevant, but with little capacity. Most international donors deal with ministries to achieve better coordination.

Understanding burning and waste systems in low-income countries

Burning is a common and neglected issue. It takes place in small towns and villages, where there is no (or a limited) waste collection system. It also takes place at landfill sites to reduce waste, and by waste pickers to retrieve metals from cables. Overall, waste burning is primarily an outcome of poor waste systems in small towns, villages, and high-density slum areas.

Building capacity of national organisations

Municipal organisations are most relevant to the waste-burning issue. However, the issue depends on the waste eco-system, which is often not very well coordinated. As waste systems improve, new infrastructure develops, and services are introduced, a better coordination is expected between different ministries and government departments. Strengths of all stakeholders are not fully used, for example NGOs, especially faith-based NGOs, work with the most vulnerable groups such as waste pickers and sweepers and their work could integrate with the improved system. Local-level champions and leadership are important to address a neglected issue.

Most vulnerable groups

Waste pickers, waste workers and communities within close range of burning areas are most at risk. Gender is an important dimension; in LMICs women work as waste workers and there are also female waste pickers, recycling workers and women staying at homes in slum areas close to waste dumping sites. These groups are vulnerable, and their livelihoods are linked with burning are at risk, but they also have an incentive to burn the waste. In these contexts, where waste streams are mixed, potentially harmful components can often be present. These components can in some cases produce toxic gases. The risks will increase with the introduction of new materials, the increase in plastics and packaging, and more individuals looking to make their livelihoods from the burning of waste.

The above issues were qualitatively analysed to see the trends, repetition, and emphasis on certain issues. The issues then converted into the constructive statements as programme outcomes. Figure below has five programme outcomes:

Pathways for change

Improved global awareness	Relevant data for policy and programmes	Improved understanding and local capacity building	Improved national policies and their effectiveness	Reduced risks for the most vulnerable groups
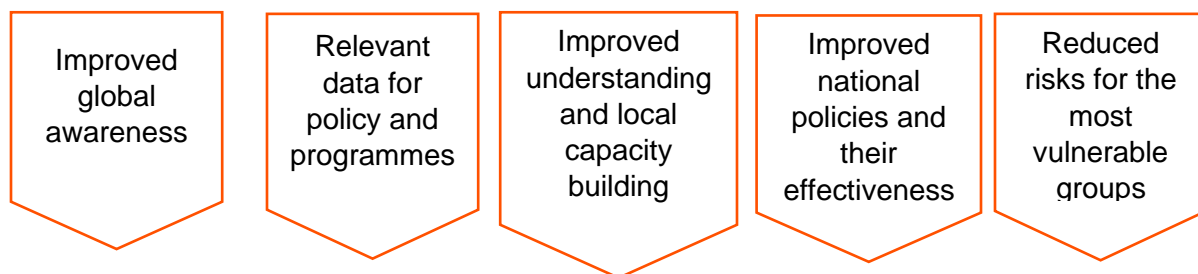
Overall outcome

To reduce the risks from waste burning for the most vulnerable segments of the population.

Integrating diversity as a cross-cutting theme

In all the outputs and activities, diversity must be integrated as a cross-cutting aspect. This is due to the proportionally higher presence and stake of vulnerable groups within waste systems, recycling and burning. As mentioned above, poorest of poor people and women have a stake in burning practices. This deserves a greater focus on the poorest people, reaching out to low-income areas, to ensure that policies and programmes includes gender mainstreaming, and that staff are fully aware and trained on delivering diversity. SEEL programme may offer training and support to ensure this.

Global programme theory of change

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┌─────────────────────────────────────────────────────────────────┐
│  Overall result; Reduced risks from waste burning for the most    │
│          vulnerable segments of the population in LMICs           │
└─────────────────────────────────────────────────────────────────┘
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   ▲                 ▲                 ▲                 ▲
Improved          Data-            Improved            More
global            informed         national            targeted
awareness         national         capacity            projects
                  policies
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┌─────────────────────────────────────────────────────────────────┐
│  Key activities: global partnerships; global and national         │
│  advocacy; focus countries selection; baseline data; use of       │
│  social and traditional media; project implementation;            │
│  project learning; project results into policies.                 │
└─────────────────────────────────────────────────────────────────┘
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┌─────────────────────────────────────────────────────────────────┐
│  Exit and sustainability: changes in policies; increased          │
│  capacities of institutions; more knowledge is available;         │
│  better data for policies and action; informed media;             │
│  informed civil societies; potential interest from large brands.  │
└─────────────────────────────────────────────────────────────────┘
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8.0 Recommendations for the Safer End of Engineered Life programme

The previous section presented a global programme structure to reduce open burning of waste and its adverse impact. This section makes specific recommendations for the Safer End of Engineered Life (SEEL) programme, considering a finite time and budget availability. These recommendations also considered the value addition of Engineering X and its founders, the Royal Academy of Engineering and Lloyd's Register Foundation, and the valuable resources its partners could bring.

- Prepare a communication piece to reach out to key donors, UN bodies and international financing agencies to inform them of the key issues, recommendations made and possibilities of partnerships on the global programme. This communication piece must show a compelling narrative for the external organisations to understand the issue, consider partnerships and to extend their support.
- Extend ISWA partnership for the implementation of the programme, especially the national policy and institutional strengthening components of the programme. Potential

partnerships must also be explored with UNEP, WIEGO and WHO to work on the global advocacy on waste burning.

- Consider forthcoming global events, such as CoP26 to look into the possibility of organising a side event or networking event to raise the profile of the issues. Partnerships are key to organising side or networking events.

- In consultation with the workshop convenors, community of practice, and technical advisory group, shortlist six to eight LMICs where the needs are greatest. The shortlisting of the countries will be based on selected criteria, such as major challenges, evidence of the existence of open burning, presence of local leadership, potential for government support, and presence of a large vulnerable group.

- As a follow up to the *Global Review*, a baseline study should be carried out in six countries (three in sub-Saharan Africa and three in South Asia) through a separate consultancy/action research project. The purpose of the baseline would be to investigate the current situation on open burning, including a review of the policies, institutional capacity, and hot spots. The work must be completed within three months, starting from April 2021.

- Following the baseline, announce a programme to raise national awareness on open burning of waste through innovative approaches using social media and traditional media. This may involve production of educational videos, television programmes, a social media campaign and newspaper articles. Typically, NGOs in partnership with communication agencies/advertisement companies/production houses must apply for such funding. The programme outputs must be delivered within six months.

- Launch a leadership award on open burning. This can be awarded to an organisation or individual involved in reducing impact of waste open burning on health, improving the wellbeing of waste pickers, and bringing innovative solutions to reduce the health impact of open burning. City mayors, village leaders, academics and other similar individuals could apply for such a programme. This programme may be launched in partnership with ISWA. A short video, written submission or a presentation can be invited. Winners might receive a cash award/ trophy, and recognition in the media and the SEEL website.

- Sign a partnership agreement with ISWA and possibly with WHO and UNEP to prepare a programme for global advocacy on open burning of waste. The programme must target key international events, ISWA annual conferences and relevant UN agencies to put open waste burning on the global map.

- Announce a programme of funding open to NGOs, universities, and other similar organisations to launch and support programmes to reduce the health risks for vulnerable population segments.

- Systematically support a movement of change on open burning, which includes funding the continuation of community of practice for at least the next 12 months. An overarching aim of the project was to identify a mechanism to facilitate long-term capacity building among stakeholders working in the field of the uncontrolled burning of waste. This mechanism would serve to build upon interest shown in the two workshops by developing of a community of experts. Any capacity building should bring together stakeholders from a range of disciplines, genders, and countries. Further details are given below.

All recommendations will be implemented with the following cross-cutting principles.

- Raising awareness must take place at all levels of policies, from global to local. It must also be done with different stakeholders.
- The programme must continue to work towards a global movement of change through continuity of activities with the community of practice.
- Continuing to develop proactive partnerships with other networks and organisations is central to success.
- Existing work, especially projects already being implemented by NGOs, must be used rather than starting completely new initiatives.
- In all the activities, diversity must be adopted to include all different groups.
- The engineering advantage and value addition from the SEEL brand name must be used in all the expected outputs.
- National capacity must be built, and local leadership enhanced to address the challenge of waste burning.
- Outputs including learning and reflections must be created and disseminated in simple language and for practitioners.

Community of practice

Background

On January 14, 2021, a community of practice (CoP) was launched at the end of workshop one, using LinkedIn as its platform. The CoP aimed to serve as a forum for stakeholders in the field to: network; share resources (for example data), ideas, expertise, and knowledge; and develop collaborative programmes that best address the challenges faced, and in a manner that enhances safety and the protection of livelihoods.

As of 8 March 2021, there were 107 members in the CoP. These stakeholders were from a range of disciplines and countries. Given the interest shown, it has tremendous potential to serve as an established international forum for Engineering X to promote awareness of the issue, build capacity and facilitate global change to reduce the risks associated with the uncontrolled burning of waste.

Recommendation

With the assistance of a dedicated facilitator, the site could be transitioned into a forum that facilitates capacity building, networking, lobbying, and dissemination of information, as well as acts as a credible source for baseline data, sourcing experts, and funding from a range of sources. However, while membership has thus far been strong and growing, the CoP will require a dedicated facilitator. This role could either by undertaken by one individual or be split between two individuals. If one person, it would not necessarily require specialist knowledge of open burning. Rather, the person would be someone with expertise in organising and networking to coordinate the experts. Alternatively, if split into two roles, one could be a person with expertise in networking, while the other (who would have knowledge of open burning), would lead on developing the resources (such sa case studies and databases) to enable the:

- facilitation of the discussions on the site around selected key themes (such as climate change, public health, enforcement or policies and regulations, and waste collection)

- development of short best practice (technical) guidance on selected topics (such as waste mapping, risk analyses, or costs or technical requirements for equipment/strategies)
- creation of publicly available databases on waste burning related to:
  - funding streams
  - key international organisations
  - key expertise/competencies (this could be used for example, to build project teams, or individuals to direct queries to
  - international successful/best practice case studies
- facilitation of engagement between key stakeholders (donors, corporations, policymakers, local community health networks, universities, and local government) and initiatives
- development and dissemination of best practice guidelines for awareness raising and engagement approaches with key stakeholders (the informal sector, municipalities, and multinational companies).

Recommendations beyond SEEL

In addition to the above principles, some larger recommendations were not taken forward as these are beyond the scope of the SEEL programme, or other organisations are already working on these issues. These include:

- improvements in solid waste systems and final disposal sites (which requires a much larger investment)
- working with the market system of hazardous materials to change the composition or restricting materials use in certain contexts. This recommendation requires dealing with a much larger market system, which is beyond the capacity of SEEL and replacing hazardous material is a long-term and intensive process.

The above issues may be addressed through the development of strategic partnerships.

Annex 1: Workshop one agenda

All timings are in GMT

10.00am / 2.00pm	**Welcome and introduction** Professor William Powrie FREng, Programme Chair Dr Mansoor Ali and Dr Terry Tudor, Workshop Convenors
10.15am / 2.15pm	*Global Review* **presentation** Dr Costas Velis, Lecturer, University of Leeds Ed Cook, Research Fellow, University of Leeds
10.35am / 2.35pm	**Group work** 1. *Global Review* 2. Controlled burning and burning as a waste disposal option where services are not available 3. Health impacts of burning 4. Burning of electronic and plastic waste 5. Informal waste picking and burning of waste
11.05am / 3.05pm	**Comfort break**
11.10am / 3.10pm	**Group work feedback**
11.50am / 3.50pm	**Closing remarks**
12.00am / 4.00pm	**Event close**

Annex 2: Workshop one list of participants

Name	Organisation
Professor Robert Berry	A2P Energy and Energy Harvest Trust
Sukhmeet Singh	A2P Energy Solution Private Limited
Dr Amani Maalouf	American University of Beirut
Dr Veronica di Bella	CDC Group (Facilitator)
Chiara Fioretto	CEGRU
Dr Hester Roberts	Central University of Technology
Walt Patterson	Chatham House
Dr Sumsun Naher	City, University of London
Amod Karmacharya	Clean up Nepal
Sandra Mazo-Nix	Climate and Clean Air Coalition Secretariat
Dr Tariq Yousuf	Dhaka North City Corporation
Mohamed Kamal	EcoConServ Environmental Solutions
Trisha Beejai	Environmental Management Authority
Renata Waithe	Environmental Management Authority
Taisuke Watanabe	EX Research Institute Ltd.
Brian Reed	Freelance
Yvette Powell	IMC Worldwide
Akintunde Kuye	Imperial College London
Professor David C. Wilson	Imperial College London
Dr Marco Caniato	Independent
Joanne Beale	Independent
Keith Alverson	Independent
Dr Terry Tudor	Independent (Workshop convenor)
Karim Hashash	Independent Consultant
Dr Anne Woolridge	Independent Safety Services Ltd
Dr Gabriela Garcés	Indo German Centre for Sustainability, University of Stuttgart
Dr Premakumara Jagath Dickella Gamaralalage	Institute for Global Environmental Strategies (IGES)
Aditi Ramola	International Solid Waste Association (Facilitator)
Dr Anncarol Karanja	Kenyatta University
Danielle Antonellis	Kindling
Dr Mansoor Ali	Learning in Development Ltd (Workshop convenor)
Dr Andy Pitman	LIGNIA Wood Company
Dr Ruth Boumphrey	Lloyd's Register Foundation
Dr Julia King	London School of Economics
Dr Gaurav Goel	London South Bank University
Dr Anh Phan	Newcastle University
Leticia Muchangos	Osaka University
Daniela Giardina	Oxfam

Patrick Dyke	PD Consulting
Dr Francesca Villa	Politecnico di Milano
Ali Abdullah	Project Procurement International
Saadat Ali	Project Procurement International
Joseph Hwang	PT Gikoko Kogyo Indonesia
Bryan Dawson Mwangi	Pyro-degrade Energy
Dr Naeimeh Jafarifar	Robert Gordon University
Professor Susan Gourvenec	Royal Academy of Engineering
Shaarad Sharma	Royal Academy of Engineering (Facilitator)
Dr Karina Zile	Samudra.world
Marie Gouttebroze	Seureca
Dr Federico Magalini	Sofies
Alex Clarke	Sofies UK
Daniel Thompson	Somerset Group
Mike Webster	SYSTEMIQ / Project STOP
Dr Charles Hans Komakech	The Nelson Mandela African Institutions of Science and Technology
Sophia Huda	The New School
Dr Dame Bop	UCAD
Nele Kapp	UN-Habitat
Dr Elizabeth Tilley	Uni Malawi/Eawag/ETH
Dr Marta Domini	Università di Brescia
Professor Francis Pope	University of Birmingham
Dr Giovanni Vinti	University of Brescia (Italy)
Dr Siming You	University of Glasgow
Dr Marc Kalina	University of KwaZulu-Natal
Dr Costas Velis	University of Leeds
Ed Cook	University of Leeds
Professor William Powrie FREng	University of Southampton
Dr Patrick O'Hare	University of St Andrews
Azhar Ali	Urban Unit
Nicole Garofano	Use Plastic Better/University of Queensland
Maria Mahon	Verdis Waste Management Ltd.
Dr Patrick Bowan	Wa Technical University
Etia Ndarake	Willend Associates
Dr Ramy Salemdeeb	Zero Waste Scotland

Annex 3: Workshop two agenda

All timings are in GMT

10.30am	**Welcome and introduction** Professor William Powrie FREng, Programme Chair
10.40am	***Global Review* presentation** Dr Costas Velis, Lecturer, University of Leeds Ed Cook, Research Fellow, University of Leeds
10.55am	**Q&A, workshop one update and workshop aims**
11.15am	**Group work one** Scoping a programme
11.45am	**Comfort break (10 mins)**
11.50am	**Group work one** Feedback
12.10pm	**Group work two** Learning from the sector
12.45pm	**Group work two** Feedback
1.05pm	**Q&A**
1.15pm	**Closing remarks**
1.30pm	**Event close**

Annex 4: Workshop two list of participants

Name	Organisation
Sigve Andera	Avfall Norge
Dr Natalia Reyna-Bensusan	C40
Dr Veronica di Bella	CDC Group (Facilitator)
Dr Hester Roberts	Central University of Technology
Dr Sumsun Naher	City, University of London
Dr Shafiul Ahmed	Commitment Consultants
Professor Linda Godfrey	CSIR
Dr Muyiwa Oyinlola	De Montfort University
Professor Christian Zurbrugg	Eawag
Roland Ramusch	European Bank for Reconstruction and Development
Harrison Kwach	Freelance
Dr Marco Caniato	Freelance consultant
Professor Dr Cleber Dutra	Gestor - Sustainability Research
Dr Jonathan Parkinson	IMC Worldwide
Professor David C. Wilson	Imperial College London
Dr Terry Tudor	Independent (Workshop Convenor)
Aditi Ramola	International Solid Waste Association (Facilitator)
Dr Mansoor Ali	Learning in Development Ltd (Workshop convenor)
Dr Ruth Boumphrey	Lloyd's Register Foundation
Crispian Lao	National Solid Waste Management Commission
Dr Saeed Ahmed	NED University
Prof Anil Namdeo	Northumbria University
Patrick Dyke	PD-Consulting
Dr Lucy Stevens	Practical Action
David Lerpiniere	Resource Futures
Dr Andrew Clark	Royal Academy of Engineering
Professor Susan Gourvenec	Royal Academy of Engineering
Karina Zile	Samudra.world
Sian Cuffy-Young	Siel Environmental Services Limited
Joanne Green	Tearfund
Dr Priti Parikh	University College London
Mentore Vacari	University of Brescia
Dr Claudia Loggia	University of KwaZulu-Natal
Dr Costas Velis	University of Leeds
Dr Josh Cottom	University of Leeds
Ed Cook	University of Leeds
Professor William Powrie FREng	University of Southampton
Andreas Beavor	UrbanEmerge
Verele de Vreede	WASTE Foundation
Zoë Lenkiewicz	WasteAid
Dr Sonia Dias	WIEGO

Annex 5: Poll results

Poll 1

Workshop one AM

1. In your opinion, what is the major cause of harmful waste burning? (Multiple choice)

1. Poor waste collection systems	(17/31)	55%
2. Poor disposal sites	(7/31)	23%
3. Limited training and capacity building	(4/31)	13%
4. Waste pickers in streets and disposal sites	(2/31)	6%
5. All of the above	(9/31)	29%
6. None of the above	(2/31)	6%

2. In your opinion, which group of people is most at risk from harmful waste burning?

1. Waste collection staff	(0)	0%
2. Nearby population and citizens in general	(16)	52%
3. Waste pickers and recyclers	(12)	39%
4. Workers and pickers at disposal sites	(3)	10%

3. Through which approach could harmful waste burning be controlled in low and middle income countries? (Multiple choice)

1. By improving waste systems	(26/31)	84%
2. By providing training to waste workers	(11/31)	35%
3. By enforcing legislations	(10/31)	32%
4. Through reporting to popular media	(4/31)	13%
5. Through strict monitoring	(7/31)	23%
6. None of the above	(1/31)	3%

Workshop one PM

1. In your opinion, what is the major cause of harmful waste burning?

1. Poor waste collection systems	(13)	42%
2. Poor disposal sites	(6)	19%
3. Limited training and capacity building	(0)	0%
4. Waste pickers in streets and disposal sites	(0)	0%
5. All of the above	(12)	39%
6. None of the above	(0)	0%

2. In your opinion, which group of people is most at risk from harmful waste burning?

1. Waste collection staff	(0)	0%
2. Nearby population and citizens in general	(10)	32%
3. Waste pickers and recyclers	(12)	39%
4. Workers and pickers at disposal sites	(9)	29%

3. Through which approach could harmful waste burning be controlled in low and middle income countries? (Multiple choice)

1. By improving waste systems	(24/31)	77%
2. By providing training to waste workers	(10/31)	32%
3. By enforcing legislations	(11/31)	35%
4. Through reporting to popular media	(5/31)	16%
5. Through strict monitoring	(8/31)	26%
6. None of the above	(2/31)	6%

Workshop two

1. In your opinion, what is the major cause of harmful waste burning?

1. Poor waste collection systems	(18)	53%
2. Poor disposal sites	(3)	9%
3. Limited training and capacity building	(2)	6%
4. Waste pickers in streets and disposal sites	(1)	3%
5. All of the above	(10)	29%
6. None of the above	(0)	0%

2. In your opinion, which group of people is most at risk from harmful waste burning?

1. Waste collection staff	(2)	6%
2. Nearby population and citizens in general	(14)	41%
3. Waste pickers and recyclers	(9)	26%
4. Workers and pickers at disposal sites	(9)	26%

3. Through which approach could harmful waste burning be controlled in low and middle income countries?

1. By improving waste systems	(32)	94%
2. By providing training to waste workers	(1)	3%
3. By enforcing legislations	(1)	3%
4. Through reporting to popular media	(0)	0%
5. Through strict monitoring	(0)	0%
6. None of the above	(0)	0%

Poll 2

Workshop one AM

1. Based on the discussion so far, what could be the key drivers to address safety challenges from waste burning? (Multiple choice)

1. Policies on waste management	(6/33) 18%
2. Legislation on effective waste management	(7/33) 21%
3. Improved citizens awareness and knowledge	(17/33) 52%
4. Health and Safety concerns	(7/33) 21%
5. Improved Waste Systems	(24/33) 73%
6. Incentives to Recycling	(15/33) 45%
7. Other	(3/33) 9%

2. How you would like to engage with the post workshop activities? (Multiple choice)

1. Joining the community of practice	(26/33) 79%
2. Applying for the funding call	(15/33) 45%
3. Regular visit to Engineering X website	(10/33) 30%
4. Sharing my own research	(7/33) 21%
5. Accessing and sharing research and knowledge	(21/33) 64%
6. Talking to my colleagues	(13/33) 39%
7. None of the above	(0/33) 0%

Workshop one PM

1. Based on the discussion so far, what could be the key drivers to address safety challenges from waste burning? (Multiple choice)

1. Policies on waste management	(11/31) 35%
2. Legislation on effective waste management	(6/31) 19%
3. Improved citizens awareness and knowledge	(17/31) 55%
4. Health and Safety concerns	(7/31) 23%
5. Improved Waste Systems	(17/31) 55%
6. Incentives to Recycling	(15/31) 48%
7. Other	(3/31) 10%

2. How you would like to engage with the post workshop activities? (Multiple choice)

1. Joining the community of practice	(26/31) 84%
2. Applying for the funding call	(16/31) 52%
3. Regular visit to Engineering X website	(10/31) 32%
4. Sharing my own research	(10/31) 32%
5. Accessing and sharing research and knowledge	(17/31) 55%
6. Talking to my colleagues	(14/31) 45%
7. None of the above	(0/31) 0%

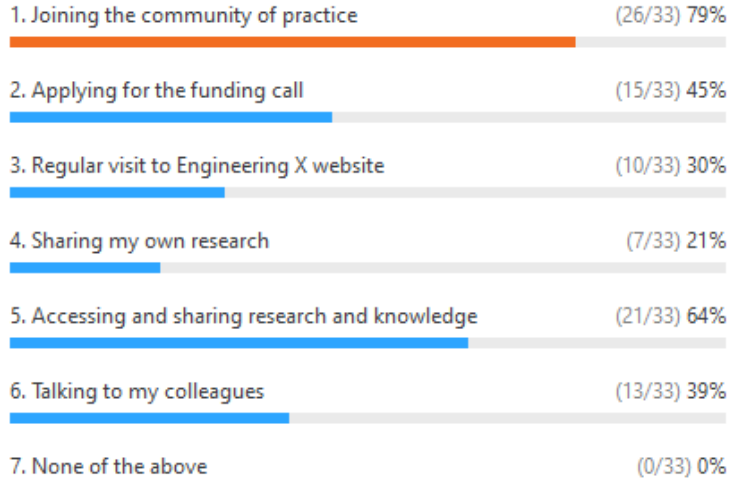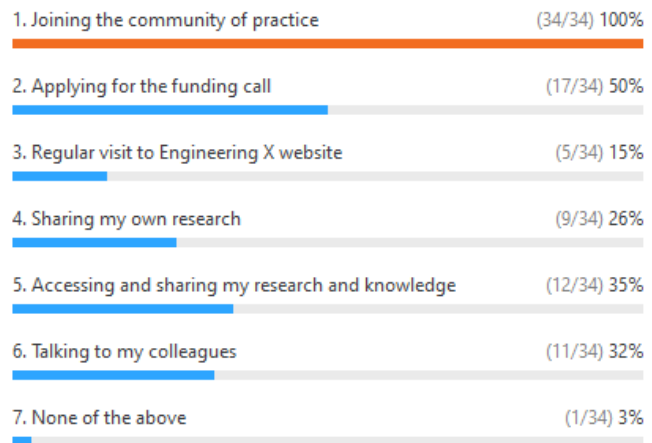## Workshop two

1. Based on the discussion so far, what could be the key drivers to address safety challenges from waste burning? (Multiple choice)

1. Policies on waste management — (7/34) 21%

2. Legislation on effective waste management — (10/34) 29%

3. Improved citizens awareness and knowledge — (14/34) 41%

4. Health and Safety Concerns — (6/34) 18%

5. Improved Waste Systems — (22/34) 65%

6. Incentives to Recycling — (12/34) 35%

7. Other — (2/34) 6%

2. How would you like to engage with the post workshop activities? (Multiple choice)

1. Joining the community of practice — (34/34) 100%

2. Applying for the funding call — (17/34) 50%

3. Regular visit to Engineering X website — (5/34) 15%

4. Sharing my own research — (9/34) 26%

5. Accessing and sharing my research and knowledge — (12/34) 35%

6. Talking to my colleagues — (11/34) 32%

7. None of the above — (1/34) 3%

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Partners

Engineering X

Engineering X is a new international collaboration founded by the Royal Academy of Engineering and Lloyd's Register Foundation that brings together global experts together to engineer change. Our global network of expert engineers, academics and business leaders are working in partnership to share best practice, explore new technologies, educate, and train the next generation of engineers, build capacity, improve safety, and deliver impact.

International Solid Waste Association Partnership

The International Solid Waste Association (ISWA) is an international network of waste professionals and experts from around the world whose mission is to promote and develop sustainable and professional waste management worldwide.

Engineering X is delighted to partner with ISWA on this important work that seeks to bring much needed attention to the urgent issue of burning of waste. Through this partnership and workshop, we hope together to raise the profile of this issue and facilitate the creation of a global community of practice, incorporating the impressive ISWA membership network, around the burning of waste worldwide.

Contact

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