REDUCING EXPOSURE TO VOCS IN THE INDOOR ENVIRONMENT, WHAT ARE THE DRIVERS AND WHAT COULD THIS MEAN FOR THE WOOD BASED PANEL INDUSTRY?

Simon Corbey[1], and Ceri Loxton[2]
[1]Alliance for Sustainable Building Products and [2]The BioComposites Centre

SUMMARY

The wood based panels industry is no stranger to changing regulations and the significant reductions in the emissions of formaldehyde from panel products over the last twenty years is testament to this. Increasing concerns over the impact of VOCs, including formaldehyde, on our internal air quality have been brought into the spotlight by a number of reports and campaigns. This paper details some of those reports and also includes examples, good and bad, where product selection has impacted on the internal air quality including a school monitored in 2016 with formaldehyde levels 10 times the WHO recommended levels – months after occupation. At present little monitoring of indoor air quality is undertaken but this may change with increased interest in initiatives such as the WELL Building Standard which requires monitoring on completion and after occupation. Use of personal monitors to determine individual exposure is now becoming more attainable and with some companies starting to look at how building 'health' can influence the productivity of their workforce, increased attention on products and source control is only going to increase.

INTRODUCTION

Volatile Organic Compounds (VOCs) arising from building materials, furnishings and fittings play a significant role in indoor air quality. The importance of indoor air quality is now being brought to the attention of politicians both because of its impacts on health and wellbeing but also as is increasing being acknowledged the effect it can have on performance and productivity. Whist it is very difficult to associate particular VOCs or products, directly with particular health complaints evidence is growing and for some chemicals the effects are known to some extent. Formaldehyde in one of the 'better known' VOCs and one with which the wood based industries are familiar and also due to historically high emission levels negatively associated with in some instances.

Healthy Buildings – The Role of Products

The political, economic and business case for healthy homes and buildings is one that has been gaining momentum over the last few years. A survey by Saint-Gobain in 2016 of homeowners and renters in the UK showed that 90% wanted a home that would not compromise their health and wellbeing and that 30% would be willing to pay for it. While at a political level in the UK the All Party Parliamentary Group for Healthy Homes and Buildings (2017) believes that delivering healthy homes and buildings means amongst other things; lower costs to the health service, better educational attainment, higher productivity and a lower carbon footprint.

Humans spend the majority of their lives, approximately 90% indoors (EU, 2005) consequently factors that impact on the quality of the indoor air that we breathe, such as dampness, presence of moulds and chemical exposure can impact considerably on health issues. Levels of VOCs indoors are often 2-5 times higher than outdoors, sometimes far greater (EEA 2013) and thus of increasing interest to a number of different groups, health and safety professionals, governments, campaign organisations as well as individuals. Increasing

data is coming to light on exposure to chemical pollutants over a life time. Mawditt (2017) reports findings indicating that 53% of our total exposure over a 70 year period comes from our homes and another 13% from work and public places. In total just 14% of our pollution exposure is from food and drink that we have ingested (and thus have some control over) the remaining 86% is via our lungs. These chemicals can then enter the blood stream and circulate around the body to different organs.

A WWF campaign in 2004, Bad Blood, highlighted just how many man-made chemicals have entered our blood stream. WWF tested the blood from 13 EU Environment Ministers for 103 different man-made chemicals and reported that a total of 55 different chemicals were found in the samples. Of these 25 were found in all the blood samples while the average number found was 37. A larger, ongoing data gathering exercises is reported in, The Fourth National Report on Human Exposure to Environmental Chemicals (2009). This report provides data on the exposure of the U.S. population to environmental chemicals. The 2017 update to this report includes data on a total of 308 chemicals, including six blood VOCs which have been included for the first time: 1,1,1,2-tetrachloroethane; 1,2,3-trichloropropane; 1,2-dibromoethane; furan; isopropylbenzene (cumene); and nitromethane.

Delivering heathy homes and buildings includes improving indoor air quality and thus reducing chemical exposure. Delivery is complex with numerous factors involved some of which are easily controlled for while others factors are more complex and less easily controlled. Product selection is just one component of this extensive matrix, which needs to be considered to ensure a "healthy" built environment. Other factors of importance include; occupant behaviour, acoustics, ventilation, day lighting and lighting, thermal comfort, external and internal air quality, humidity and the passage of moisture.

VOCs and Health

Approximately 1,000 chemicals evaporate into the air that we breath, known collectively as Volatile Organic Compounds (VOCs) they are numerous, varied and ubiquitous. VOCs are released by wood products – solid wood, engineered products (OSB, MDF, plywood), flooring products, coatings (paints, finishes, sealants, waxes), adhesives, mastics, cements, roofing materials, furniture, insulation and cleaning products. Yu and Crump (2002) provide a summary of some VOC emission data, including the typical VOCs present for a number of different building products including particleboards, wall materials – MDF and plywood partitioning and lining as well as timber beams, frames and studs. The emission data for coating products and preservative treated timber, as expected, is particularly high.

The health effects of long-term exposure to low level of VOCs are poorly researched and the cumulative effect of emissions from all the different sources even less well understood. That said the health effects for VOCs are usually referred to as being acute or chronic in nature depending on dose and level of exposure;

Acute effects of VOCs

- Irritation of eyes and respiratory tract
- General headaches, dizziness, lack of coordination, nausea and visual disorders
- Allergic reactions such as asthma and rhinitis

Chronic effects of VOCs

- Damage to liver, kidney, circulatory systems and central nervous system
- Links to cancer

Individuals within a population will have different tolerances, so effects will vary making quantification of effects even harder to measure. However it is acknowledged that those most at risk from poor air quality are children, older people and those with pre-existing health issues. With reference to outdoor air pollution the EU (2013) states that "evidence is growing for a range of effects of prenatal exposure" the effects, reduced foetal growth, pre-term birth and spontaneous abortions are of the same order of magnitude as those reported for passive smoking. Weller et al, (2014) reported indoor air quality and the effects of new flooring on pregnant women they found a significant risk of infants to suffer from respiratory diseases in their first year of life. The authors of that report linked the observed health risks to increased concentrations of VOCs which had escaped from new laminate flooring and then been absorbed through respiratory air.

Formaldhyde

Formaldehyde is one VOC with which a lot of the wood based industries are familiar with, and one which the authors believes rightly or wrongly has becoming popularly linked with wood based products. The INDEX report (2005) includes formaldehyde because of "its high chemical reactivity" and says that formaldehyde is the most important sensory irritant among the chemicals assessed in the report. Some of the key findings from this report are:

- Formaldehyde is a ubiquitous pollutant in indoor environments
- Increasing evidence that children may be more sensitive than adults
- Considered a chemical of concern at levels exceeding 1 ug/m^3 a concentration more or less corresponding with the background level in rural areas.
- Exposure data, although limited confirm that almost the entire population is exposed to indoor levels higher than the background level
- At least 20% of the European population exposed at levels exceeding the no-observed-effect level (NOAEL:30ug/m^3).
- Long term exposure to elevated levels of formaldehyde in the occupational setting has been shown to result in upper and lower airway irritation and eye irritation in humans; degenerative, inflammatory and hyperplastic changes of the nasal mucosa in humans and animals

Sources of Formaldehyde

Within the indoor environment (homes, offices, schools, hospitals etc) formaldehyde emissions may arise from a variety of products and activities as detailed in Table 1. Formaldehyde which has arisen outdoors, can also enter the indoor environment and add to the total amount of formaldehyde present indoors.

Table 1. Possible sources of indoor formaldehyde

Building related materials	**Home based products**	**Activities**
Paints and varnishes	Air fresheners	Smoking
Adhesives	Cleaning products	Dry cleaning
Carpets and vinyl flooring	Cosmetics	Cooking
Composite wood products	Upholstery and foams	Burning fuels
Insulation products		

Within the wood base industries issues around formaldehyde have largely been around products that use formaldehyde based glues (such as particleboard, MDF and plywood). Tests to measure emissions have been agreed and categories of emission levels approved in

different countries. Over the last 30 years, emissions from wood based panels have fallen significantly from approximately 3ppm to 0.1ppm, Figure 1. Reducing the release of formaldehyde from wood based panels has been an area of intense research and activity for many years, alternative resins have been developed, formaldehyde scavengers employed all to reduce emissions to comply with ever more stringent requirements. Some would argue that if levels continue to fall they will be lower than natural background levels of formaldehyde released from solid wood.

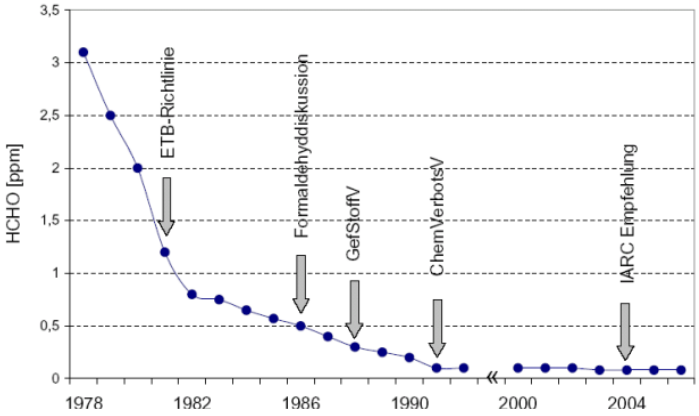

Figure 1. Formaldehyde (ppm) reduction for particleboard between 1978 and 2006. (Marutzky 2008)

Measurement of VOCS in Indoor Air Environments

When it comes to VOCs the wood based panels industry is familiar with product based testing techniques such as environmental chamber tests (ENV 12319) where single products are selected and tested for. Measuring indoor air quality in the built environment is not that specific and identifying which particular material may be the cause of unusually high readings can sometimes be difficult. Increasingly however people are starting to test their own home environments, particularly if they suffer from allergies and are trying to identify possible causes.

All available measurement methods for VOCs are selective in what they can measure and quantify accurately, none are capable of measuring all VOCs that are present. Some reports refer to "total volatile organic compound" or "TVOC" concentrations, the term refers to the total concentration of multiple airborne VOCs present simultaneously in the air, they do not measure all VOCs in the air but a subset of VOCs that are expected to be present. The method is cheaper than measuring the concentration of individual VOCs but does have some limitations, firstly different TVOC measurements can yield substantially different TVOC concentrations depending on what VOCs are included and secondly the toxicity of individual VOCs may be very different and thus the total concentration is not likely to provide a useful measure of total toxicity. That said these techniques are reported to be useful for characterizing levels of indoor pollution and for improving source control as required from the point of view of health, comfort.

Tim Roberson (2017) of Waverton Analytics has presented data at an ASBP event which summarised the findings of more than 8000 tests, predominantly requested by members of the public who were experiencing allergic symptoms. Figure 2 shows the type of data that is generated. The figure shows how the sample supplied (Your TVOC) compares to the total of

percentage of homes recording a particular TVOC level. Kits like the one supplied by Waverton Analytics and other companies are simple and cost effective (£140) they contain a tube and pump which the user plugs in for set period of time, eg 2 hours and then returns to the lab for analysis. Some companies will then make recommendations on how to improve your air quality.

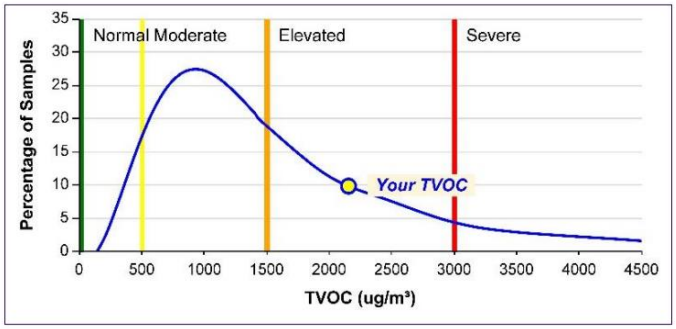

Figure 2. Analysis of over 8000 samples of IAQ over 4 years from Waverton Analyics

Currently however most post occupancy evaluation studies of buildings use CO_2 as a proxy for air quality, with the recommended guideline of 1,000 ppm. McGill et al, (2015) carried out a study on homes in Ireland built to Code for Sustainable Homes, level 3 and 4. The study found that in winter, carbon dioxide levels in the living room and main bedroom peaked above 1,000 ppm in all Code 3 and Code 4 dwellings, reaching levels as high as 3,427 ppm in the living room and 4,456 ppm in the main bedroom the authors report "the high prevalence of Sick Building Syndrome (SBS) symptoms in Code 3 dwellings suggests further investigation may be needed to identify the causes". SBS symptoms include fatigue, headache, breathing difficulties, strained eyes and itchy skin, ie symptoms linked to VOCs and poor indoor air quality.

Guidance on Air Quality

Guidance on air quality and VOCs is readily available through the internet, possibly not all of it is helpful and it can certainly be overwhelming to a non-specialist. In March 2017 the Local Government Association (LGA 2017) published "Air Quality. A briefing for directors of public health" which condenses, to some extent, findings and information available on outdoor air pollution. This paper (all 116 pages of it) focuses particularly on how to communicate with the public during air pollution episodes. It will be interesting to see how long it is before we have a similar indoor air quality briefing available.

Any guidance on air quality and VOCs is likely to continue to change over time as more data sets become available. Additionally the links between certain chemical groups and specific health effects may become better understood, effects of short term / long term and life time exposure is better understood, cumulative responses and interactions with other chemicals come to light. It is clearly a complicated area and one requiring much more work and attention.

Control Measures

There are a number of options that can be used to manage indoor VOCs exposure of these those related to 'source control' are key for individual products.

Indoor air risk management options include the following;

- IAQ Standards and guidelines
- Equipment standards and permits (these mostly relate to ventilation)
- Mandatory maintenance and inspections (again often relate to ventilation systems)

And the following options where the wood based industries could pay particular attention

- Building codes and ventilation standards
- Limits, labelling and reporting of the contents of or releases from building products, furnishing materials, equipment and consumer products
- Public awareness raising and information

Policy, legislation, standards and regulation

There is no dedicated European legislation on indoor air quality the EEA (2013) reports. Whilst banning of tobacco smoke in public buildings and commercial establishments has been implemented and a number of ventilation standards in residential and non-residential buildings incorporated into building codes there is currently no overriding legislation on indoor air quality. The report concludes that, "the need for a horizontal policy framework which bridges safety, health, energy efficiency and sustainability aspects across existing legislative instruments and standardisation activities related to the built environment is widely recognised."

These findings are echoed in the NICE guideline "Indoor air quality at home" (NICE 2017) which suggested that in the UK no single government body was responsible for indoor air quality. With regulation of air quality indoors and outdoors involving a number of different departments. Of these the following are of particular interest when considering indoor air quality, VOCs and where the future push to link products with indoor air quality may come from;

- The Public Health Outcomes Framework (2016 to 2019) makes local authorities responsible for improving air quality. Domain 4 covers premature death from preventable causes, including those linked to indoor air pollution. This includes death from respiratory diseases, all cardiovascular disease and cancer.
- The UK Building Regulations Part ADF, specify total VOCs or TVOCs emission should be below 300µg/m^3 over 8 hours measured post completion but before occupation. However it has been suggested by the European Protection Agency that these limits are without toxicological justification (EEA, 2013) "Domestic exposure to VOCs at lower levels may increase the risk of childhood asthma". They report on studies indicating that children exposed to concentrations of VOCs higher than a median of 60µg/m^3, have a fourfold risk of asthma. So it seems highly likely that these figures will change as more data is gathered and our understanding of the links between specific VOCs and health issues increases.
- The Department for Education's revised Building Bulleting BB101 "Guidelines on ventilation, thermal comfort and air quality in schools" was due to be published in May/June 2017 but as of submission of this paper in July had still not been. The 2017 publication will supersede the 2006 edition of BB101: Ventilation of School Buildings. The addition of the term 'air quality' to the title reflects the increased importance government and other organisations are now giving to maintain good indoor air quality in schools. A draft of the update mentions the "suggested links between VOC levels and behavioural problems in children." Of additional interest to

the wood based panels industry it the mention of MDF fibres in this report in relation to particulate matter "typical indoor particles include smoke particles, spores, biological fragments and fibres. Some of these particles are known to be hazardous to health, for example, fibres from MDF".

When it comes to using source control to help improve indoor air quality CEN TC 351 has a remit for the development of horizontal standardised assessment methods for harmonised approaches relating to the release of regulated dangerous substances, under the Construction Products Directive (CPD) including emission to indoor air.

While the UK doesn't specifically regulate for source control. This is in direct contrast to France, which has established mandatory labelling Anses, covering VOC emission classes for most construction products; walls, ceiling, floor coverings and coatings, insulation products, doors, windows and more. Germany has similar legislated AgBB, as has Belgium. Germany is currently attempting to adopt standards beyond those of the Construction Product Regulations and voluntary schemes exist in Finland, Sweden and Denmark. (Corby and Newman 2016)

DRIVERS

Increasing awareness and research on outdoor air quality and the impacts of that on human health has already led to calls for air quality to be improved, tighter controls and fines when limits are not achieved. Whilst many causes of poor outdoor air quality do not have an immediate local cause – and are therefore difficult for individuals to control, the situation indoors is slightly different and the chain between cause and effect is much shorter. This then starts to bring the focus and responsibility/liability back to individuals, products, manufacturers, builders, specifies, architects etc and the choices that they make. Summarised below are some key reports and sources of information as well as key drivers that the authours think, from the point of view of the ASBP, are influencing the discussion around indoor air quality.

(1) Reports and Information

Every breath we take

In 2016 external air quality was catapulted into the mainstream by the publication of a report authored by the Royal College of Physicians, "Every breath we take". The report linked health problems, illness and premature death resulting from air pollution with the cost to health services and business. "In the UK these costs add up to more than £20 billion every year". Whist this report focused on external air quality is did mention chemical pollutants arising from other sources, "The building itself, the materials from which it is built and those with which it is decorated are also important potential sources of chemical pollutants – these include the construction materials, as well as paints, glues, furniture, wall paper and drapery".

Better homes, better air, better health

Following on from the Every Breath We Take report and the comments about indoor air quality a multi-partner led workshop (April 2017) then followed which engaged the built environment, medical sectors, researchers, policy makers and practitioners in how to improve indoor air quality. The results of that workshop were summarised in a report "Better homes, better air, better health," Turner (2017). The report summaries the motivation and drivers around tackling poor indoor air quality, summarised evidence, solutions and knowledge needs

before detailing priorities for health professionals and built environmental professionals to focus on and highlighted the strategies for action put forward by one of the discussion groups.

Key points raised in report Better homes, better air, better health that are particularly aligned to the materials built environment sector – and therefore the wood based panels industry include:

- Reducing pollutant emissions from construction products – they even ask "could all UK products be made free of volatile organic chemicals? The WBPI might want to ask what about natural VOCs and how will these be dealt with?
- Education of the building supply chain in the causes and impacts of poor air quality and how to improve it. Included here could be the implementation of labelling schemes and also regulation of certain materials.
- Develop mechanism to monitor and investigate poor indoor air quality consistently
- Establish a hierarchy of indoor air pollutants – the industry should ask itself where formaldehyde and other chemicals it uses would sit within this hierarchy and how should it respond?
- Material science, consider incentivising and stimulating production of indoor air quality enhancing materials. Here mention is made of work on enhancing sheep wool to absorb VOCs.
- Look at how other countries monitor base line pollutants.

<u>Building our Future. Laying the foundations for healthy homes and buildings</u>

This draft report, released in July 2017 by the all party parliamentary group for healthy homes and buildings points out that while outdoor air quality has received a lot of political, public and media attention lack of ventilation and "poor indoor air quality is now becoming a major issue for our nation's health too." The report mentions not only studies which link poor air quality to allergy, asthma, lung cancer, chronic obstructive pulmonary disease and cardiovascular disease but also more recently links to dementia. The report goes on to say that Prof Abwi predicted in 2015 that by 2050, without action to tackle indoor air pollution, "there could be an 80% rise in those suffering asthma symptoms and volatile organic compound concentrations could rise to 60% above WHO 24-hour limit levels." The subsequent burden on the public health service alone giving reason to control indoor air quality.

<u>The INDEX project</u>

The INDEX project ran from 2002 until 2004 and was financially supported by DG SANCO (European Commission Directorate-General for Health and Consumers). Its scope was to identify priorities and assess the needs for a community strategy and action plan in the area of indoor air pollution including setting up a list of compounds to be regulated with priority given on the basis of health criteria. The report also provided suggestions and recommendations on potential exposure limits for these compounds.

The INDEX project points out that for many chemicals occurring indoors the risk for human health and comfort is almost unknown and difficult to predict, particularly the risk associated with chronic low level exposures as there is limited toxicological data. The report recommends the development of a strategy for indoor air quality assessment and management in Europe and that future policy take into account the total air exposure of citizens – ie to include pollutants from both indoor and outdoor sources.

Formaldehyde was identified by the project as one of the chemical compounds to be considered with high priority along with benzene, acetaldehyde, CO and NO_2, this classification was based on the potential/estimated population risk caused by concentrations from indoor sources, toxicological properties including hypersensitivity for allergy and asthma as well as other health effects and comfort. "Because of its high chemical reactivity formaldehyde is the most important sensory irritant among the chemicals assessed in the present report"

(2) Regulation, Standards and Policy

In general, issues of indoor air pollution have been overshadowed by the attention focused on outdoor air pollution related to industry and transport emissions. However this is starting to change and will continue to do so as evidence and understanding of the effects of VOCs become more widely researched and understood. Regulation and policies that will drive indoor air quality are most likely to come initially from public buildings (schools, hospitals, workplaces) where links and responsibilities are more easily identified. This is likely to then have trickle down effect into design and building of homes. Schools are one area where more attention is likely to be paid in the future as increasing research shows links between indoor air quality and performance. Also there have been and are likely to be increased number of studies looking at air quality in schools as monitoring becomes relatively easy and cheap.

In 2016, a concerned head teacher in the UK, reacting to high levels of reported pupil and staff discomfort, requested an IAQ test for a school classroom. Formaldehyde levels were found to be 10 x WHO guidelines at 950ppm some 12 months after occupation. A repeated test by another provider was conducted with similar results. The classroom provider/developer admitted in a telecom with the author that he knew very little about specifying for low formaldehyde. This case study is extremely sensitive, so no further comment/detail is currently available but highlights that developers do not have a good understanding of the effects of product selection/substitution can have on overall performance and air quality.

The effect that product selection can have on TVOC in a classroom context was reported by Voljer Gutzeit of Sentinel Haus at an ASBP Seminar on 21/01/16 (http://asbp.org.uk/past-events). The research project involved two small children's class rooms being reconstructed in a laboratory. The first room used products that a builder normally utilised and the second used only Sentinel Haus approved products. TVOC was measured over the following eight week period, see figure 3. The results show significant difference is the TVOC for the two different rooms.

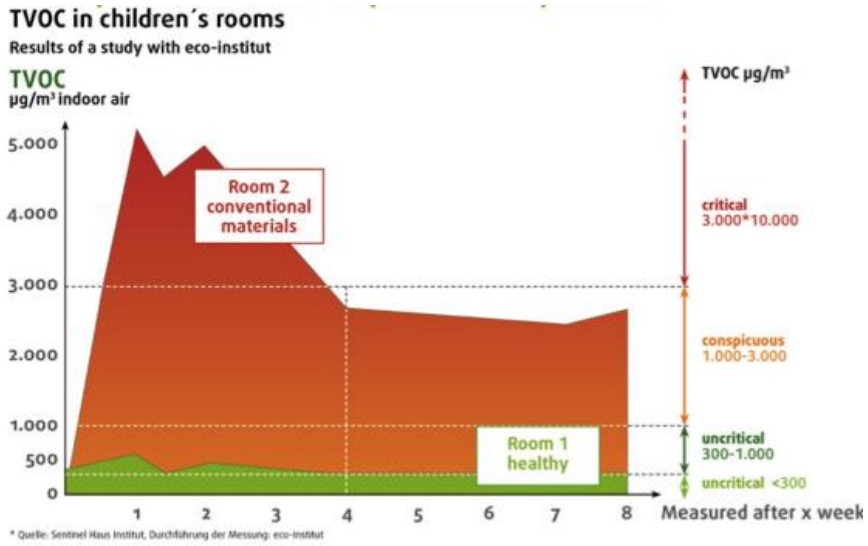

Figure 3. TVOCs measured over 8 weeks, comparing results from 2 rooms

With conventional materials, 5,000 µg/m^3 TVOC was measured in week 1 reducing to 2,800 µg/m^3 at 4 weeks and eventually reducing 2,700 µg/m^3 at 8 weeks. The German Environment Protection Agency suggests that anything over 1,000 µg/m^3 is not recommended for long term exposure. Results also demonstrated that when furniture was introduced, TVOC levels rose to 8,100 µg/m^3, a good argument for pre-off gassed furniture.

The 2006 revision of the UK Building Regulations concerning ventilation (ADF) set performance criteria for several air pollutants, including TVOCs, nitrogen dioxide and carbon monoxide. The guideline concentration value for TVOCs is 300 µg/m^3 averaged over 8 hours. It is suggested that controlling pollutants depends on tackling their sources and having adequate ventilation with 'fresh' air.

(3) The Health Case

The burden of poor air quality in the UK in 2008 was estimated (UK Government statics) to be equivalent to nearly 29,000 deaths, and the economic costs from the impact of air pollution (particularly particulate air pollution) to be £9-£19 billion every year or 3.7% of GDP. (https://laqm.defra.gov.uk/documents/air_quality_note_v7a-(3).pdf). Across the European economies WHO estimates that indoor and outdoor pollution costs as much as £1.05 trillion each year in deaths and diseases. The importance of the effect of air pollution on public health is reflected by the inclusion of an indicator of mortality associated with air pollution in the Public Health Outcomes Framework for England.

(4) The Business Case

The business case for green and healthy buildings is gaining momentum with benefits reported across different areas (World Green Building Council) including savings to utility bills, lower construction costs and higher property values. For most businesses, their most significant outgoings are staff wages, so any measures which increase productivity and wellbeing can have a significant effect on the bottom line. This is supported by research conducted at the Harvard T.H. Chan School of Public Health's Centre for Health and the Global Environment

(Allen et al. 2016) which shows that working in high-performing, green-certified buildings can improve employee decision-making.

Typical operating costs for an office building are reported (Chris Pottage 2016) as being 1% energy costs, 9% rental costs and 90% staff costs in salaries and benefits. Interventions that impact on those staff costs could therefore potentially have a significant impact on overall building operating costs. The Stoddart Review points out that not enough organisations measure workplace effectiveness and that the workplace can be a barrier to higher productivity, "just a 1% increase in the UK's productivity will add £20 bn to the UK Economy" Duncan Weldon, economist, writes in the Stoddard Review. Mark Tyson, also writing in the Stoddard Review however points out that we do not have a "one-size-fits-all answer to measuring productivity" and that the solution lies with individual companies own productivity measures and linking them to the built environment they occupy.

The WELL Building certification system is one of the few certification schemes at present which demands air quality testing for formaldehyde and TVOCs before and after occupation. The Cundall's building in London was the first building in the UK to achieve a WELL building certification and they have been able to start putting monetary values on the additional costs of lifting the building up to achieve the WELL standard (£150/per person) which they estimate will be paid back within one year based on a 50% reduction in absenteeism (£90k) and savings from reduced staff churn (£100k).

DRIVERS AND TOOLS TO IMPROVE SOURCE CONTROL

A key challenge for the whole of the wood sector is that the construction industry does not have the time or skill to grapple with complex chemistry and uncertain clinical evidence. In the absence of strong policy drivers, IAQ is an area where voluntary standards and procurement tools can play a helpful role and why people start to turn towards product labelling schemes. However there is a bewildering array of labelling systems to choose from. The Ecolabel Index website (www.ecolabelindex.com) claims to be the largest global directory of ecolabels tracking 465 labels (accessed on 12 July 2017) of these 120 relate to construction products. When the ASBP was first established it spent a considerable amount of time deciding whether to set up its own scheme for sustainable building products or to work with one of the existing schemes. Following this analysis ASBP decided that the Natureplus (www.natureplus.org) label was a credible tool and started working with them to promote the scheme in the UK.

Natureplus

The Nautreplus label takes an evidence based and holistic approach and considers product performance and sustainability, as well as impacts on human health in production and use. Exacting VOC emission limits are set down in a product standard and only products that meet this level can be certified. To date 625 building products are certified by Natureplus (website accessed 12 July 2017) of these four relate to cross laminated timber or glued laminated timber while 136 relate to various wood based insulation products. As far as the authors could determine no plywood, OSB or particleboards are currently listed.

Baubook

Product data bases such as Natureplus are now being linked to procurement tools such as Baubook (www.baubook.info). Baubook provides an on-line platform to support sustainable construction projects and healthy living giving information for manufactures, traders,

developers, building contractors, planners and advisors including in-depth information on the technology, state of health and environmental impacts of construction products. Baubook also provides health related procurement clauses for tender documents and links to products that meet these requirements.

Portico

Portico is another web based application managed by The Healthy Building Network (www.healthybuilding.net) and created in partnership with Google. Portico is designed to simplify the analysis, selection and specification of building products that meet health and transparency objectives. Portico integrates project management functions and a growing database of over 2,500 building materials and products evaluated using Pharos Chemical Hazard database. "Portico will ultimately allow large-scale owners and operators to articulate the value they place on health, which will drive more transparency and demand for healthier products in the building materials market" (https://healthybuilding.net/content/portico-early-access-program)

Seal of Approval scheme

This scheme was set up by Allergy UK in order to certify products proven, scientifically, to reduce or remove an indicated allergen from the environment or significantly reduce allergen content. The scheme is now used by over 100 companies worldwide and over 200 product ranges, from air purifiers to home care products are now certified. In response to the debate around pollutants released by building materials and their associated negative health effects, Allergy UK is in the process of expanding the Seal of Approval endorsement to include DIY and home building products, an area where the wood based industries could engage.

WELL Building Standard

WELL was developed by integrating scientific and medical research and literature on environmental health, behavioural factors, health outcomes and demographic risk factors that affect health with leading practices in building design and management. It also requires, amongst other things, that the VOC (and therefore formaldehyde) rating of all materials, office fixtures, fittings as well as the fabric of the building must be between negligible and zero. Alan Fogarty of Cundall's has explained that satisfying this proved to be one of the most challenging elements of the project, "It immediately reduces your range of options in terms of what materials you can choose from. Even discovering the VOC content was a challenge because most manufacturers don't commonly list it."

Monitoring

Buildings and their internal environment are increasingly being monitored, as more monitoring is conducted and evidence collected, more issues will no doubt arise. The wood sector needs to be engaged and involved with monitoring to ensure that it not only knows the potentially negative impacts of its products and can react accordingly but also to highlight any positive impacts of wood based products in the built environment.

Communication

The INDEX project (2005) suggests that the capabilities of public services and experts to manage most indoor air risks, "lie crucially on their abilities to establish and maintain public confidence, to communicate the risks in a way that the public is able to comprehend," this report goes on to suggest the need for solutions to be offered which are both technically, financially and legally feasible while at the same time acknowledging the diversity of buildings, occupants, expectations and risks. The wood based industries need to work with

this in mind and provide coherent, comprehensive and evidence based, information for its end users communicating both the advantages, risks and mitigation scenarios of using their products.

CONCLUSIONS

Issues around indoor air quality, VOCs - especially formaldehyde along with source control via product selection are increasingly going to come under scrutiny as the evidence base linking air quality, health and wellbeing, productivity and performance grows. Standards and regulations are likely to tighten. Improvements in methods to measure VOCs in the home and workplace and falling costs and ease with which these tests can be carried out will mean that post occupancy performance issues can be monitored and inevitably linked, rightly or wrongly to selected heath impacts or performance.

The woodbased panels industries along with the wider wood industries and trades need to work with other industries and associations in the built environment supply chain to help "simplify the language about indoor air quality to make the issue more understandable by non-experts" (Turner 2017). To aid this process, ASBP and Loxton have prepared a range of industry briefing notes on Formaldehyde and Reducing exposure to VOCs and ASBP continues to host knowledge sharing events.

The rise in interest in the health and wellbeing agenda will mean clients and contractors will be increasingly be demanding full declaration of contents for products and systems, including their associated finishes and adhesives. Specifiers will increasingly be demanding low VOC products and more monitoring of indoor air quality will be conducted. The construction industry is developing a range of tools to assist with this transition and the industry needs to collaborate across the supply chain to ensure the delivery of healthy buildings.

ACKNOWLEDGEMENT

PLEASE SEE WWW.ASBP.ORG.UK FOR MORE INFORMATION

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