Deliverable 8.2
Proceedings and conclusions of Workshop II

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<td>Actual delivery date 31/01/2021</td>
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Document coordinators: Elsa Pastor (UPC), Luis Mario Ribeiro (ADAI)
Contact Authors: elsa.pastor@upc.edu  luis.mario@adai.pt
Reviewed by: All

Abstract: This deliverable is written to be distributed as the Proceedings of the Second International Workshop of the WUIVIEW Project, entitled “Wildfire self-protection in the Wildland-Urban-Interface at home-owner level”. Being a public deliverable, its contents include an overall view of the project, the consortium and the objectives of the workshop. It also contains the abstracts and printouts of the presentations shown. The wrap-up done at the final of the workshop is also reproduced.

(1) Draft / Final
(2) Public / Restricted / Internal
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1. Introduction

The 2nd, and final, International Workshop of Project WUIVIEW (www.wuiview.org), entitled “Wildfire self-protection in the Wildland-Urban-Interface at home-owner level”, was planned to be held in Barcelona, Spain, at the end of the project. The unforeseen COVID-19 pandemic, that disrupted activities in the entire World, also affected some of the project initiatives, namely this workshop. Hence the consortium decided to transform it into a virtual workshop, or webinar. It was held on the ZOOM platform (www.zoom.com), on 15th January 2021, between 11:00 and 17:30, CET. The Webinar was organized by UPC, with the support of ADAI.

Being an online event, the limitations to the number of attendees were technological, as WUIVIEW’s Zoom account is limited to 500 simultaneous connections. In order to have a safety margin, we limited the registrations to 460 persons, and that number was achieved quite rapidly. During the event itself we could not control who was attending at every time, as participants were allowed to enter and leave the meeting room. At the peak, and multiple times, we had 213 simultaneous attendees (Figure 1). For this reason, we present here a brief description of all the registered participants, regardless if they attended the entire webinar or not.

Figure 1 – Print screen of the Webinar, during one of the audience peaks (number of participants is visible on the top right corner)

The majority of the registrations were from Portugal, but several countries, from all Continents were represented (Figure 2 and Figure 3).
Registration did not require attendees to specify a City, but we recorded 108 cities all over the world, looking at where the registrations came from (from the PC’s IP address, whenever the system could access it).

Regarding their occupation, the attendees have different backgrounds. From the 461 registered persons who provided details on their profession, the majority belonged to firefighting teams (143), either volunteers or professionals. The municipalities, with their forestry and municipal
civil protection offices accounted for 88 registrations. Research scientists, students or Academicals, accounted for 78 persons. The National Guard from Portugal (GNR) registered 34 military personnel. There were also 19 members of Forest Services in different countries and 18 individuals from Private Companies. Figure 4 presents all the professional backgrounds.

![Figure 4 – Attendees occupation](image)

1.1. The WUIVIEW Project

WUIVIEW is a project from the European Union’s Civil Protection Mechanism, ECHO, financed under the 2nd priority of the “Prevention Projects in Civil Protection” Call - “Development of disaster risk reduction strategies, taking into account climate change adaptation”. It has a duration of 2 years (01/02/2019 – 31/01/2021) and a total budget of around 760K€, distributed among the 6 participant teams.

The main aim of WUIVIEW project is to design, setup, test and operate a virtual workbench service for the performance-based analysis of fire environments in the surroundings of buildings at the wildland-urban interface. In line with the objectives of the Union’s Civil Protection Mechanism, the WUIVIEW action is developing innovative risk management tools that will help WUI communities adapting to face the new generation of forest fires that have already arisen due to climate change. Once implemented, WUIVIEW will become a powerful platform to perform essays and simulation studies dealing with structures survivability, sheltering assessment, building subsystems hazard testing and fire protection systems evaluation. The development of the system will improve knowledge base on microscale fuels fire hazards and on building systems and materials vulnerability, which will be of help to develop better policies and standards to prevent WUI disasters.

WUIVIEW service will cover important needs of current European WUI fire-prone areas (Mediterranean) and of emerging new WUI-fire realities (Northern countries), which are expected to increase in the coming years. In one hand, human pressure in the landscape is
continuously growing in Europe and wildfire potential is also increasing associated with housing developments and climate change, leading to new WUI-fire prone regions. On the other hand, innovative design solutions and new materials are certainly appearing from the building and construction sector all over Europe. WUIVIEW will definitely serve as a workbench service to test and develop more resilient emerging WUI-fire scenarios.

The project is also educational oriented. The WUIVIEW outputs and outcomes will finally lead to a higher degree of awareness between fire practitioners and more educated residents at the wildland-urban interface.

For more information, please visit the project website at [www.wuiview.org](http://www.wuiview.org).

1.2. The WUIVIEW Consortium

The project consortium is composed of 6 teams, from Spain, Portugal, France, Sweden and Italy:

**Universitat Politècnica de Catalunya (UPC)**

Barcelona, Spain

UPC is the Coordinator of WUIVIEW Project.

UPC, hosts the CERTEC, which is a research organization with large experience on technological, environmental and natural risks. This mainstreaming grants it unique characteristics to deal with fire hazard characterization, vulnerability analysis and civil protection challenges. CERTEC has engineering background and experience in all types of fire incidents. CERTEC has large computational resources, needed for the project activities.

**Association for the Development of Industrial Aerodynamics (ADAI)**

Coimbra, Portugal

The Forest Fire Research Center (CEIF) of ADAI, a non-profit Portuguese institution associated to the University of Coimbra, has a worldwide recognized expertise of 30 years of research in forest/WUI fires and hosts the largest laboratory for forest fire experimentation in Europe (LEIF). ADAI members have a wide experience on international research projects.

**Laboratory of Industrial Environment Engineering (ARMINES)**

Alès, France

ARMINES, represented by Mines d’Alès, hosts the French “Laboratory of Industrial Environment Engineering” which is a European point of reference of natural-technological risk interactions. They have experimental facilities and proven experience to study burning dynamics of non-natural fuels. They have large computational resources, needed for the project activities.
PAU COSTA FOUNDATION (PCF)

Barcelona, Spain

PCF, is non-profit organization who acts as an international platform devoted to forest fire and fire ecology management, training and dissemination. PCF has a large experience in international projects and cooperation activities. PCF has strong bonds with the fire-fighting community and agencies worldwide.

RESEARCH INSTITUTES OF SWEDEN (RISE)

Borás, Sweden

RISE, is a Swedish technical research institution with a broad focus on infrastructure as well as the built and natural environment. RISE has performed many studies on boreal forests fuels characterization, risk assessment and fire behaviour as well as characterisation of fire spread from vegetation to buildings.

UNIVERSITÀ DI BOLOGNA (UNIBO)

Bologna, Italy

UNIBO is an Italian academic institution with specific competence on safety and risk assessment. UNIBO has a worldwide recognized experience in Natech risk assessment, and has a long practice in providing technical support to Italian National and Regional Civil Protection authorities.
2. Objectives and program

The final WUIVIEW Workshop was planned to be held at the end of the project, reporting the main findings of all the work programme.

In order to get the participants familiarized with the project and its activities, the WUIVIEW consortium produced a series of videos summarizing the findings of the first year of the project. These short videos are a resume derived from the presentations given at the 1st Workshop, in Coimbra held in 17th January 2019. The presentations can be accessed in WUIVIEW YouTube Channel, at https://www.youtube.com/channel/UC_XgXfLczFvW-09mNI3slIg, or at the Dissemination Section of the WUIVIEW webpage, at https://wuiview.org/#repository.

The title of the Workshop, “Wildfire self-protection in the Wildland-Urban-Interface at home-owner level” was chosen to be broad enough to englobe all topics here addressed.

The Workshop was held in English with simultaneous translation to Spanish and Portuguese. The interaction with the public, in the questions and answers and in the Round Table was mixed, respecting the understanding and ability to speak English of the intervenients. All interventions were performed in Zoom’s Chat box and addressed by the moderators and speakers.

The program of the Workshop is presented in Table 1.

<table>
<thead>
<tr>
<th>Time (CET)</th>
<th>SESSION/ talks</th>
<th>Speaker</th>
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<tbody>
<tr>
<td>11:00 – 11:20</td>
<td>Agenda review</td>
<td>E. Pastor (UPC)</td>
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<td></td>
<td>Refreshment: the WUIVIEW research approach</td>
<td></td>
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<tr>
<td>11:20 – 11:40</td>
<td>Residential fuels: the case of LPG tanks &amp; gas canisters</td>
<td>G. Scarponi (UNIBO), T. Barbosa (ADAI)</td>
</tr>
<tr>
<td>11:40 – 12:00</td>
<td>Glazing systems: fire exposure from ornamental fuels</td>
<td>F. Heymes (ARMINES)</td>
</tr>
<tr>
<td>12:00 – 12:20</td>
<td>Semiconfined spaces: heat accumulation from non-natural fuels</td>
<td>P. Vacca (UPC)</td>
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<tr>
<td>12:20 – 12:40</td>
<td>Hedgerows: fire percolators through WUI communities</td>
<td>J. Muñoz (UPC)</td>
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<tr>
<td>12:40 – 13:00</td>
<td>Round table discussion</td>
<td>D. Caballero (PCF)</td>
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<td></td>
<td>Lunch time</td>
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<td>15:00 – 15:20</td>
<td>The Mediterranean version of VAT and SAT tools</td>
<td>A. Àgueda (UPC)</td>
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<tr>
<td>15:20 – 15:40</td>
<td>The Scandinavian version of VAT tool</td>
<td>J. Sjöström (RISE)</td>
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<tr>
<td>15:40 – 16:00</td>
<td>Questions and answers</td>
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<td>16:00 – 16:15</td>
<td>The PBD WUI method rationale</td>
<td>E. Planas (UPC)</td>
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<tr>
<td>16:15 – 16:25</td>
<td>Case study #1: Spanish property</td>
<td>P. Vacca (UPC)</td>
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</table>
16:25 – 16:35  Case study #2: Swedish property  
16:35 – 16:45  Case study #3: The community shelter at Figueirô dos Vinhos  
16:45 – 17:00  Questions and answers  

WUIVIEW PRODUCTS UPSCALING AND FUTURE CHALLENGES (Chairman: D. Caballero)  
17:00 – 17:30  Round table discussion  

Figure 5 presents a screenshot from the Zoom meeting room, with all the WUIVIEW consortium participants.

Figure 5 – Screenshot of the Zoom meeting room during one of the workshop discussions
3. Speakers

A short biographic note of each of the Speakers and Chairpersons is given here, in order of appearance.

Elsa Pastor (UPC)

Elsa Pastor, PhD, Associate Professor at the Chemical Engineering Department of Universitat Politècnica de Catalunya · BarcelonaTech and research scientist at the Center for Technological Risk Studies at UPC. She develops teaching and research activities in diverse fields related to wildfire management and technological risk analysis. Over the last 15 years, she has studied several aspects of fire behaviour and dynamics by a multidisciplinary approach, combing both experimental and modelling techniques in a wide range of scenarios. She has profited from diverse fire environments (i.e. wildfires, wildfire research burning campaigns, outdoor large-scale industrial testing fields, compartment fires, laboratory set-ups, etc.) to observe, monitor and analyse flames and their effect to different types of assets and ecosystems. She is currently leading the European Project WUIVIEW (wuiview.org), aimed at designing, setting-up and operating a virtual workbench service for the analysis of fire risk in the surroundings of buildings at the wildland-urban interface.

Social Media user names on twitter: @elsa_pastor @CERTEC_UPC @WUIVIEW

David Caballero (PCF)

David Caballero is MSc in Forestry Engineering, specializing in forest fires, finishing PhD studies in 2003. David is a freelance consultant on forest fire risk assessment and prevention planning in wildland-urban interface areas in Europe. Currently collaborates with Pau Costa Foundation in the WUIVIEW project. He is the coordinator for the European Observatory of WUI (WUIWATCH) and gathers more than 25 years of experience in international research projects, planning and assessment. He is the author or co-author of more than 60 publications on the subject of forest fires. He accumulates more than 400 hours as instructor on risk assessment and operation, regularly collaborating with the Spanish National School of Civil Protection. He is a member of the NFPA, member of Pau Costa Foundation, Member of the European Union Civil Protection Mechanism and Member of the International Association of Fire Safety Science (IAFSS). He holds the medal to the merit of civil protection of the Ministry of Interior (2017) and the Golden Swatter Award for the best research activity (2011). He is currently working on new technologies for the risk assessment at the micro and mesoscales in the WUI, using drones, 3D models and advanced VR/AR technology.
Giordano Scarponi (UNIBO)

Giordano Emrys Scarponi has a PhD in Chemical and Process Engineering and a post-doc at the Department of Civil, Chemical, Environmental and Material Engineering at the University of Bologna (Italy). Over the last 5 years, he has studied several aspects of the behaviour of pressure vessels exposed to fire, combing both experimental and modelling techniques in a wide range of scenarios. In particular, he focused on the development of a CFD modelling approach to predict the response of LPG tanks to fire exposure.

Thiago Barbosa (ADAI)

Thiago Barbosa is bachelor and master in Chemical Engineering and post graduate in Safety Engineering. He is a PhD Student at ADAI/University of Coimbra, in Fire Safety Engineering.

Frederic Heymes (ARMINES)

Frederic Heymes is a chemical engineer and professor at the University of Technology IMT Mines Alès, France. He is leading the research axis dealing with hazardous phenomena physics in the Laboratory of Risks Sciences. His main research topics are fire safety and explosion hazards; most works are based on experiments at small or large scale.

Pascale Vacca (UPC)

Pascale Vacca is a PhD student at the Centre for Technological Risk Studies at Universitat Politècnica de Catalunya. As a fire safety engineer with experience in consultancy, she is now studying the interaction between fire, structures, and surrounding elements at the Wildland-Urban Interface microscale, focusing especially on non-natural fuels.
Juan Muñoz (UPC)

Juan Antonio Muñoz is a forest engineer focused on forest fire management. He currently works in the Centre for Technological Risk Studies of the Polytechnic University of Catalonia (CERTEC – UPC), where he is a PhD student on this topic. His research focuses on the wildland-urban interface and the interactions between their inhabitants and the vegetation, mixing computational fluid dynamic simulations and experimental data.

Luís Mário Ribeiro (ADAI)

Luís Mário Ribeiro is a senior researcher at ADAI. He has a degree in Forestry from the University of Trás-os-Montes and Alto Douro (1998) in Vila Real (Portugal), where in 2002 finished a post-graduate degree in Forest Resources Engineering. In 2016 he finished his Masters in Social dynamics, natural and technological risks, in the University of Coimbra (Portugal), in which he received a recognition from the Faculty of Economics regarding his outstanding curricular performance. Since he joined the Forest Fire Research Centre (CEIF) of ADAI, in 1998, he has been actively involved in the realization of various scientific research projects, national and international, in the field of forest fires. He teaches regularly in specialized courses in forest fires promoted by ADAI and is responsible for the lessons related to forest fuels, decision support systems, wildland-urban interface, regulations and safety rules in firefighting and fire behavior prediction systems. Since the beginning of his collaboration with CEIF he has published several papers as author or co-author and presented numerous communications at conferences and seminars, both scientific and operational, in Portugal and abroad.

Alba Àgueda (UPC)

Alba Àgueda, is assistant professor and researcher at the Chemical Engineering Department of the Universitat Politècnica de Catalunya (UPC). She has a degree (2003) and a PhD (2009) in Chemical Engineering. She is involved in several research activities related to risk assessment, fire engineering and fire behaviour modelling. She is currently developing tools to check houses vulnerability. Also, she is testing new approaches to evaluate shelter-in-place and evacuation strategies feasibility during WUI fires using a Computational Fluid Dynamics (CFD) tool (Fire Dynamics Simulator –FDS–). She is also involved in projects devoted to fire protection in equipment, buildings and industrial facilities using a Performance Based Design (PBD) approach.
Johan Sjöström (RISE)

Johan Sjöström and Frida Vermina Plathner are researchers at RISE Research institutes of Sweden, which is a state-owned research institute. They work on fire behaviour, ignition as well as trends and development of fuel characteristics, suppression and fire danger.

Valerio Cozzani (UNIBO)

Valerio Cozzani is Professor and Director of the M.Sc. in Offshore Engineering at University of Bologna, Italy. He received a PhD in Chemical Engineering from University of Pisa, Italy. At University of Bologna he leads the laboratory of industrial safety and environmental sustainability, associated to the IChemE Safety Centre, and coordinates several courses for professionals in the fields of industrial safety and design of Oil&Gas facilities. He has about 20 years of research experience in the fields of risk analysis and safety assessment, sustainable design and technology innovation in chemical processes. His specific research topics are: the assessment of major accidents involving dangerous substances caused by external hazard factors, cascading events and domino effects; the safety and sustainability assessment of innovative chemical processes; the safety assessment of alternative fuel systems and synthetic fuel supply chains. Prof. Cozzani chairs the ESRA Technical Committee on Chemical and Process Industry, and is the Italian Delegate in the EFCE Working Party on Loss Prevention in the Process Industry. He serves as Associate Editor for Safety Science, and as member of the Editorial Board for Elsevier publications on Chemical Engineering, for the Journal of Hazardous Materials and for the Journal of Loss Prevention in the Process Industry. He serves as member of the scientific committees of ESREL conferences since 2008, and chairs the scientific committee of CISAP conference since 2012.

Eulàlia Planas (UPC)

Eulàlia Planas, is Associate Professor at the chemical engineering Department of the Universitat Politècnica de Catalunya (UPC). Head of the Centre for Technological Risk Studies (CERC). She has a degree in Industrial Engineering (1993) and a PhD in Chemical Engineering (1996). Her main research lines are the study of hydrocarbon pool-fires; the mathematical modelling of major accidents; risk analysis in the transportation of hazardous materials; and the study of wildfires. In the field of wildfire research, she has developed infrared image processing systems to quantify fire progression (rate of spread, fire intensity, and flame geometry) and aerial fire attack effectiveness. Currently she is working on providing systems to deliver fire behaviour forecasts for decision-making, based on data assimilation and inverse modelling. She
also develops methodologies based on CFD modelling to study the effects of burning residential fuels on structures, relying on performance-based criteria to assess houses vulnerability and sheltering capacity. Prof. Planas also got involved extensively on experimental fire research.

She has directed 12 PhD thesis and worked on 33 competitive projects. Is author of 6 books and 10 book chapters. She has 80 papers in indexed peer-reviewed journals and 125 contributions to conferences. According to Scopus, she has a total amount of 1662 citations with a mean value of citations per year (2016-2020) of 154 and h-index of 22.

Miguel Almeida (ADAI)

**Miguel Almeida** is a senior researcher in ADAI, working since 2003 on fire behaviour and safety in wildland and in wildland urban interface. He finished his MSc and PhD on wildfires in 2004 and 2011, respectively. In his professional career, he co-supervised several master's and doctoral theses and co-published several papers in this thematic. He participated in more than 20 scientific projects, National and European, many of them in the context of the fire risk in the WUI.
4. Presentations

An abstract of each of the presentations, as well as the printout of the slides shown during the workshop are reproduced here.

4.1. Agenda Review

4.1.1. Refreshment: the WUIVIEW research approach, by Elsa Pastor

4.1.1.1. Screenshots taken during the webinar
4.1.1.2. Abstract

WUIVIEW is a European project funded by the DG-ECHO agency, whose main aim has been to reinforce WUI fires risk reduction strategies by designing, setting up, testing and operating a virtual workbench service for the performance-based analysis of fire environments in the surroundings of buildings at the wildland-urban interface. The agenda of this Final Workshop has been structured following the workflow that the WUIVIEW consortium has gone through during these last two years. In the first session, the main vulnerabilities at property level will be presented and discussed, the following two sessions are devoted to the demonstration of the two main products coming out of the WUIVIEW project: the VAT (Vulnerability Assessment Tool) and SAT (Sheltering Assessment Tool) check-lists, which are basic tools for vulnerability and sheltering capacity self-assessment and the PBD (performance based design) engineering framework for an in-depth analysis of fire impact in properties. Finally, the last session is devoted to a round table discussion in which WUIVIEW products upscaling and future challenges on this matter will be debated.

It has been a very exciting journey of research, innovation and demonstration that the WUIVIEW consortium has undertaken during these last two years, counting always with the engagement and feedback of final users and stakeholders, and doing different types of activities: analysing the aftermath of fire incidents, looking very carefully at flames in real fires, in laboratory fires, and FDS simulated fires, analysing the hazard of residential fuels and, finally, putting all the findings and knowledge together in such a way to generate tools that may be of help to mitigate fire risk at the wildland-urban interface.

4.1.1.3. Presentation printout

WUIVIEW International Workshop

Wildfire self-protection in the WUI at home-owner level

Opening and Welcome
The WUIVIEW research Approach

Elsa Pastor
elsa.pastor@upc.edu
CERTEC/Universitat Politècnica de Catalunya - Spain

FINAL Workshop of the WUIVIEW Project 15/07/2021
WUIVIEW – GA #826544  D8.2 Proceedings and conclusions of Workshop II

Agenda

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<tr>
<th>Time</th>
<th>Session/ Talks</th>
<th>Speaker</th>
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<tr>
<td>11:00</td>
<td>WELCOME</td>
<td>E. Pastor (IPPC)</td>
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<tr>
<td>11:30</td>
<td>Workshop review</td>
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<tr>
<td>11:35</td>
<td>Introduction to the WUIVIEW approach</td>
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<tr>
<td>11:45</td>
<td>1. IDENTIFIED VULNERABILITIES IN WILDLAND-URBAN INTERFACE PROPERTIES (Chairman: D. Caballero)</td>
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<tr>
<td>11:50</td>
<td>Residential fuels: the case of LPG tanks &amp; gas canisters</td>
<td>G. Scanapio (UPC)</td>
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<tr>
<td>12:00</td>
<td>Glazing systems: fire exposure from ornamental fuels</td>
<td>F. Ramus (ARIEMINE)</td>
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<td>12:05</td>
<td>Semi-confined spaces: heat accumulation from non-natural fuels</td>
<td>P. Vazquez (UPC)</td>
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<td>12:15</td>
<td>Hedge rows: fire percolation through WUI communities</td>
<td>J. Muñoz (UPC)</td>
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<td>12:45</td>
<td>Lunch time</td>
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</tr>
<tr>
<td>13:00</td>
<td>Round table discussion</td>
<td>D. Caballero (IPC)</td>
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</tbody>
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2. VAT (VULNERABILITY ASSESSMENT TOOL) AND SAT (SHELTER ASSOCIATION TOOL) FOR SELF-PROTECTION AND FIRE RISK AWARENESS (Chairman: L.M. Ribeiro) |
| 13:00  | The Mediterranean version of VAT and SAT tools | A. Álvarez (UPC) |
| 13:30  | The Mediterranean version of VAT tool | A. Skåtedalen (IRIF) |
| 13:45  | Questions and answers                 |                          |

3. PRO (PERFORMANCE-BASED DESIGN) METHODOLOGY FOR AN IN-DEPTH VULNERABILITY ANALYSIS (Chairman: V. Cezard) |
| 14:30  | The PRO WUI method rationale | F. Planas (UPC) |
| 14:45  | Case study #1: Spanish property | P. Vazquez (UPC) |
| 15:00  | Case study #2: Swedish property | J. Skåtedalen (IRIF) |
| 15:15  | Case study #3: The community shelter at Figueres (PV) | M. Arreola (IRIF) |
| 15:30  | Questions and answers                 |                          |

4. WUIVIEW PRODUCTS UPSCALING AND FUTURE CHALLENGES (Chairman: D. Caballero) |
| 15:45  | Round table discussion                | D. Caballero (IPC)       |

The WUIVIEW Project – Basic information

Duration: 2 years (01/02/2019 – 31/01/2021)

Funding agency: DG - ECHO (European Civil Protection and Humanitarian Aid Operations)

- Consortium:
  - UPC (Coord.) – Spain
  - ADAI – Portugal
  - PCF – Spain
  - ARMINES – France
  - UNIBO – Italy
  - RISE – Sweden

The WUIVIEW Project – Basic information

Duration: 2 years (01/02/2019 – 31/01/2021)

Funding agency: DG - ECHO (European Civil Protection and Humanitarian Aid Operations)

- Final users:
  - Bombers
  - Corpo Nazionale de Vigili del Fuoco
  - MSB (Swedish Civil Contingency Agency)
  - ANEPC Autoridade Nacional Emergência e Proteção Civil
  - Dirección General de Protección Civil y Emergencias
  - Instituto da Conservação da Natureza e das Florestas
  - Tecnifuego
The WUIVIEW Project – Main Activities

WUIVIEW first half: refreshment of activities  
https://wuiview.org

The WUIVIEW Project – Milestones

- WUIVIEW main aim has been to develop a Fire Risk Analysis framework to be applied at the WUI microscale
  - To understand factors and processes occurring at WUI microscale
  - To list a set of pattern scenarios responsible of home damage

Fault tree: fire entrance paths

WUIVIEW milestones 1st Phase

Vacca et al., 2020, JSSR
Wuiview.org
The WUIVIEW Project – Milestones

- WUIVIEW main aim has been to develop a **Fire Risk Analysis framework to be applied at the WUI microscale**
  - Analysis of residential fuels as fire sources
  - Non-natural fuels: LPG tanks and gas canisters
  - Hedgerows as fire percolators
  - Fire impact in glazing systems
  - Semiconfined spaces: heat accumulation from non-natural fuels

The WUIVIEW Project – Milestones

- WUIVIEW main aim has been to develop a **Fire Risk Analysis framework to be applied at the WUI microscale**
  - Development of user-friendly tools for self-protection and risk awareness
  - Vulnerability Assessment Tool (VAT) – Mediterranean Version
  - Vulnerability Assessment Tool (VAT) – Scandinavian Version
  - Sheltering Assessment Tool (SAT)
The WUIVIEW Project – Milestones

- WUIVIEW main aim has been to develop a Fire Risk Analysis framework to be applied at the WUI microscale

  - Development of Performance Based Design (PBD) methodology for in-depth vulnerability analysis, using FDS software
    - Case study #1: Spanish property
    - Case study #2: Swedish property
    - Case study #3: Community shelter

The WUIVIEW Project – What’s next?

- WUIVIEW products upgrading and future challenges

  - Enlarge WUI type coverage
  - Adapt tools to all types of assets and infrastructure
  - Cope with a general lack of risk awareness in EU
  - Cope with unprecedented extreme fire behaviour scenarios
  - Etc.
4.2. Session 1: identified vulnerabilities in wildland-urban-interface properties

– Chairman: D. Caballero –

4.2.1. Residential fuels: the case of LPG tanks & gas canisters, by Giordano Scarponi and Thiago Barbosa

4.2.1.1. Screenshots taken during the webinar

4.2.1.2. Abstract

The hazards associated to ground fuels, ornamental vegetation and stored material are poorly characterized and remarkably disregarded by residents. In this framework, hazard associated with domestic LPG (liquefied petroleum gas) storage tanks, used as energy source for heating, hot water production or cooking in WUI developments, stands out. This kind of tanks are usually located above-ground, often in the proximity of vegetation and/or any kind of combustible material. In case of fire exposure of burning elements in the vicinity LPG tanks heat-up and pressurize. This may result in the Pressure Relief Valve (PRV) opening followed by a jet fire. In particular conditions, the catastrophic failure of the tank itself may also occur. If the fire exposure is long and intense enough making insufficient the pressure release, the catastrophic failure of the tank can occur, leading to extremely dangerous events, such as boiling liquid expanding vapour explosion (BLEVE), fireball and missiles projection, which can severely worsen the effects of the WUI fire event. Recent accidents involving this type of infrastructure have been observed in Benitatxell, Spain (2016), Madeira, Portugal (2016), Calabassas, California (2016) and Attica, Greece (2017).

The main cause of occurrence of such events is twofold: in one hand, the regulation framework presents serious deficiencies and gaps. Current set-up and maintenance standards have not been developed considering real WUI fire exposures and as such, safety distances from the LPG supply unit to vulnerable elements have been revealed insufficient. Moreover, conditions of this type of infrastructure have been found inappropriate in reported cases. Self-protection and risk
culture of WUI residents is also lacking being population negligence also responsible of the problem.

During the WUIVIEW project, we have developed a methodology based on CFD (Computational Fluid Dynamics) modelling to analyse risk associated to LPG infrastructure at the WUI microscale. The performance of the method was tested using several study cases which are set-up inspired in real accidents and according to current legislation provisions. The CFD modelling outcomes deliver scientific evidence of this type of risk and can help defining improved provisions in terms of safety distances and maintenance actions.

The second part of the presentation focused on analysing gas canisters’ accidents that happened in Funchal, Miranda do Corvo, and Freamunde, in Portugal, and its impact on the surrounding structures and citizens, due to the release of stored energy. The preliminary results inform how the metallic and composite bottles and the safety system were affected by the fire.

4.2.1.3. Presentation printout
## Domestic LPG tanks at the WUI

Among artificial fuels:

- Affordable way to provide fuel for house services
- Often placed in the proximity of buildings and ornamental vegetation

### In case of fire exposure:

- Benetxell, Spain (2016)
- Calabassas, California (2016)

The tank may fail causing catastrophic consequences!

---

## Regulation framework in EU

Separation distances are defined according to the volume of the tank:

<table>
<thead>
<tr>
<th>Country</th>
<th>V (m$^3$)</th>
<th>0.15 V &lt; 5</th>
<th>0.5 V &lt; 5</th>
<th>5 V &lt; 12</th>
<th>5 V &lt; 25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greece</td>
<td>V &lt; 0.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>V &lt; 8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>V &lt; 0.8</td>
<td>0.15 V &lt; 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td>V &lt; 0.5</td>
<td>0.5 V &lt; 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td>0.15 V &lt; 1</td>
<td>1 V &lt; 5</td>
<td>5 V &lt; 12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UK</td>
<td>0.15 V &lt; 0.5</td>
<td>0.5 V &lt; 5</td>
<td>0.75 V &lt; 12</td>
<td>2.5 V &lt; 9</td>
<td></td>
</tr>
</tbody>
</table>

Minimum safety distance (m)

For example:
- V = 5 m$^3$
- d = 3 m

Lack of harmonization!

---

## How to assess if a tank is safe?

### Methodological approach

1. **Step 1: Fire source characterization**
2. **Step 2: Tank response simulation**
3. **Step 3: Assessment of tank integrity**

Analysis of the impact of wildland-urban-interface fires on LPG domestic tanks:

Giordano Enrico Scarpioni, Elia Pantea, Fujilla Piazza, Valerio Cozzani

[Contact info available at WUIVIEW] Safety Science
journal homepage: www.wuiview.com/safety

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**WUIVIEW – GA #826544**

**D8.2 Proceedings and conclusions of Workshop II**
How to assess if a tank is safe?

Let us consider a realistic scenario: A 3 m³ LPG tank at the WUI during a wildfire

**FDS simulation:**

Example of results: Dynamic maps of thermal radiation

How to assess if a tank is safe?

**Computational domain**

Material properties (density, viscosity, heat capacity ...)

**CFD solver**

**CFD results**

How to assess if a tank is safe?

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Definition</th>
<th>Notes</th>
</tr>
</thead>
</table>
| **WSI - Weakened Surface Index** | $\text{WSI} = \frac{S_{\text{max}}}{S_C}$ | maximum (over simulation time) surface area where the temperature is higher than 400°C  
  $S_C$: critical surface area (0.46 m²) |
| **PRVI - Pressure Relief Valve Index** | $\text{PRVI} = \frac{P_{\text{max}}}{P_{\text{PRV}}}$ | $P_{\text{max}}$: maximum pressure reached in the tank  
  $P_{\text{PRV}}$: PRV set point |

If WSI and/or PRVI > 0.9 → NOT SAFE!
Important remarks on LPG domestic tanks

• Domestic LPG tanks at the WUI represent a critical safety issue
• The legislation in terms of LPG tanks set-up is not harmonized and does not provide enough provisions to ensure tank integrity
• The proposed methodology is a promising tool to assess tank vulnerability in WUI fire scenarios

• During the WUIVIEW project, industrial tanks were also considered:
  • Smaller gas containers may also present relevant hazard...

LPG canisters

Recent accidents with canisters in Portugal

• Funchal 2016

LPG canisters

Recent accidents with canisters in Portugal

• Miranda do Corvo 2020
• Freamunde 2020
LPG canisters

Effects

Overpressure x Distance

- Propane
- Butane

Preliminary tests and partial results

- Two types: steel and composite
- Forest fuels: wood and bush

Preliminary tests and partial results

- Protection
  - Decrease temperature
  - Stop missiles
  - Canister safe
  - Pressure doesn’t rise
  - Decrease heat flux

T [°C]
- T Lab: 9 to 14
- T IN: 13 to 16
- T OUT: 13 to 300
4.2.2. Glazing systems: fire exposure from ornamental fuels, by Frederic Heymes

4.2.2.1. Screenshots taken during the webinar

4.2.2.2. Abstract

Windows often break when exposed to a nearby fire. Safety of dwellings located in the WUI involves the fracture and subsequent collapse of windows, since firebrands that may enter the house are a very important structure ignition source.

This work aimed at understanding the conditions under which pieces actually fall out, in order to define safety distance when windows are exposed to ornamental vegetation fire. Experiments were performed and considered single and double panes windows, various thicknesses and incident heat fluxes in order to provide safety criteria for CFD. Different indicators are relevant to predict failure of a glazing system: maximum glass temperature of the first pane, maximum gradient of the first pane, maximum heat flux and thermal dose impacting the window.

Simulations were performed by FDS and considered various scenarios of 1, 2 or 3 Douglas fir trees located at various distances from window. The main conclusions are that large windows are most vulnerable to fire. Double glazing systems with glass thickness of 6 mm or more are recommended. PVC frames and shutters should be avoided. Aluminium and wooden shutters can protect windows, if tightly closed, from fires located in their proximity.
4.2.2.3. Presentation printout

Windows destruction

- Windows often break when exposed to a nearby exterior fire
- Feedback and experiences indicate that any opening to the interior of the structure increases the potential for ignition
- Ensuring safety of glazing during a wildfire event is therefore very important

Introduction

Two different impacts of a wildfire on a house:

- Direct impact
  - Wildfire front
  - Natural fuel (ornamental vegetation)
  - Artificial fuel (plastic, wood, complex)

- Indirect impact
  - Increased exposure to heat

Fuels located close to the house are expected to impact at high heat flux level
Why does a window exposed to fire break?

- Parameters:
  - Thickness, simple, double, triple pane
  - Type of glass (Float, wired, tempered)
  - Type of frame (PVC, aluminum, wood)
  - Insect screens or wider protection
  - Shutter

- Thermal response of the window:
  - Radiation (reflection, transmission, absorption, emission)
  - Convection (internal, external)
  - Condensation in the glass
  - Insulating layer
  - Frame effect

- Stress in the window:
  - Transverse and tangential
  - Depends on previously existing stress

- Failure:
  - Cracks
  - Fallout

Objective of this work

This work aims to provide guidelines for windows prevention during wildfire event, when exposed to ornamental trees fire.

Douglas fir trees are large and provide a conservative approach. Three scenarios:
- one Douglas fir tree
- two Douglas fir trees
- three Douglas fir trees

Windows:
- medium (0.5x0.5 m) and large (1.2x1.2 m)
- Single or double pane
- 3 mm or 6 mm thick float glass
- Aluminum or PVC frame

Literature review

Fire resistance of windows was studied previously, and several safety criteria were proposed:
- Maximum temperature of glass (150°C / 200°C / 447°C)
- Maximum temperature gradient on the window (58°C / 60°C / 80°C / 100°C / 125°C / 146°C)
- Heat flux on the window (4 / 6 / 9 / 16 / 20 / 28 / 35 kW/m²)
- Thermal dose received by the window (1840 [kW/m²]²h)

It depends on dynamic phenomena (fire, heat-up) and characteristics of windows

Experiments and CFD simulations (FDX) were performed to analyse a series of given scenarios

References:
Kasiki, Ramesh, et al., 1998
Johli, A., 1994
Balasubramaniam, 2005
Harada, Y., 2000
Hussain et al., 1995
Pagli, G., 1991
Cohen, A., 1994
Zhang, J., 2011
Experimental work

- Tests were performed to determine safety rules for windows
- A radiant panel was designed to heat by radiation several windows
- The incident flux was in the range [7-20] kW/m²
- Glass temperature, heat fluxes, IR pictures were monitored

Experimental setup

- Radiant panels are made by ceramic porous plates and are heated up to 900°C with propane flame
- The emission spectra is close to hydrocarbons fire (wood, plastic), mostly in visible and infrared spectrum
- Glass has a high absorbance in infrared range and will heat up
- No heat convection in the experiments
The criteria to determine whether a window breaks (or not) may be related:

- To the highest temperature on the exposed face: \( T_{\text{max}} \) °C
- The highest temperature gradient on the exposed face: \( \Delta T_{\text{HL}} \) °C
- The temperature gradient through the thickness of the window: \( \Delta T_{\text{TH}} \) °C

These data are easy to measure during experiments, but time consuming for engineering.

It is more easy to use data of incident heat flux:

- The incident heat flux: \( \Phi \) kW/m²
- The thermal dose: \( \Phi t \) (kW/m²)²

---

Windows breaks and fall out

3mm single glass exposed to 10 kW/m²

Second pane remains cold

6mm double pane exposed to 10 kW/m²
**Results**

- The more the glass is thick, the more time is needed but the rupture temperature remains the same.
- The heat dose limit is higher for thick windows.
- Double pane windows require more heat/time to be broken, the second window is protected by the first one until it breaks.
- The second glass provides mechanical resistance to the first glass (cracks but no fallout).

**Simulations**

FDS simulations (Vacca et al.) computes Heat Release Rate (HRR), radiative and convective heat flux to the windows.

Distance between fire and window is varied by steps of 0.5 m.
### Results

<table>
<thead>
<tr>
<th>Fire scenario</th>
<th>Window size [m]</th>
<th>Glass thickness [mm]</th>
<th>Safety distance glass NO WIND [m]</th>
<th>Safety distance WITH WIND [m]¹</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Single pane</td>
<td>Double pane</td>
</tr>
<tr>
<td>One Douglas</td>
<td>0.5x0.5</td>
<td>3</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>0.5x0.5</td>
<td>6</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>1.2x1.2</td>
<td>3</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>1.2x1.2</td>
<td>6</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Two Douglas</td>
<td>0.5x0.5</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>0.5x0.5</td>
<td>6</td>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>1.2x1.2</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1.2x1.2</td>
<td>6</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Three Douglas</td>
<td>0.5x0.5</td>
<td>3</td>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>0.5x0.5</td>
<td>6</td>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>1.2x1.2</td>
<td>3</td>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>1.2x1.2</td>
<td>6</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

¹ wind < 30 km/h at 10m high

### Main conclusions

- The larger the window, the less resistant it is to fire. Items must thus be placed further from a large window than from a small one.
- Probability for a flying ember to cross large broken windows is also increased.

- Double pane windows are more resistant than single pane windows, and a glass thickness of 6 mm is more favorable.
- Aluminium frames are more resistant than PVC frames, given that the melting point of aluminium is much higher than the one of PVC.
- Wind will push flames and heat coming from a burning item towards a window, and a greater distance is thus needed between the two in order to achieve safe conditions.
- Aluminium and wooden shutters can protect windows, if tightly closed, from fires located in their proximity.
- PVC shutters are not recommended, since they will melt and expose the window to the fire.

In the worse case (wind, large window, PVC frame), vegetation should remain at a safety distance of 4 meters minimum.
4.2.3. Semiconfined spaces: heat accumulation from non-natural fuels, by Pascale Vacca

4.2.3.1. Screenshots taken during the webinar

Analysis of fuel packs in semi-confined spaces

- Structural survivability of a concrete semi-confined space
- Load bearing capacity of walls with different thickness
  - 15 – 20 – 25 cm
  - Temperature profile

Conclusions

- In all of the four analysed fires, the walls of the simulated semi-enclosed space will fail, with the exception of those spaces which have very thick walls subjected to a fire with low HRR values.
- Semi-confined spaces used as storage areas should be independent from the frame of the main building, in order to avoid causing its structural failure. No items should be stored under overhangs of the main building.
- The area of the space influences the temperatures inside the semi-confined space: the bigger the area, the lower the temperatures. However, the bigger the area, the more space to store items.

4.2.3.2. Abstract

Investigation of past fires has highlighted the issue of fuels located in semi-confined spaces. These are places on a property that can be adjacent to the main building or located independently from it, where owners tend to store objects and materials. These spaces commonly cause heat accumulation in case of the ignition and combustion of the stored materials. An analysis of the structural survivability of concrete semi-confined spaces has been performed with the aid of FDS. Three different fire scenarios are analysed in combination with different wall thicknesses (15-20-25 cm). Results show that the load bearing capacity of the walls is reduced below 74% for all cases, with the exception of the scenario with a wall thickness of 25 cm and a short and low Heat Release Rate curve. The results suggest that semi-confined
spaces used as storage areas should be independent from the frame of the main building, in order to avoid its structural failure.

4.2.3.3. Presentation printout
Risk scenario

- Non-natural fuels → combustion period > 10 min
- Heat accumulation

Analysis of fuel packs in semi-confined spaces

- Structural survivability of a concrete semi-confined space
- Load bearing capacity of walls with different thickness
  - 15 – 20 - 25 cm
  - Temperature profile
Analysis of fuel packs in semi-confined spaces

Fire design
- Location
- Type of fuel
- Heat Release Rate Curve: rate at which a fire releases energy (power)

Scenario 1: wood (oak and chestnut)
- Highest temperatures recorded on the back wall at 2 m

Scenario 2: plywood wardrobe, pillows, plastic tree
- Highest temperatures recorded on the back wall at 2 m
Analysis of fuel packs in semi-confined spaces

Scenario 3: pallets, cardboard, paint, foam mats
- Highest temperatures recorded on the left wall at 50 cm

Scenario 4: pallets, cardboard, paint, foam mats
Area of semi-confined space is doubled
Highest temperatures recorded on the left wall at 50 cm

Conclusions

- In all of the four analysed fires, the walls of the simulated semi-enclosed space will fail, with the exception of those spaces which have very thick walls subjected to a fire with low HRR values.
- Semi-confined spaces used as storage areas should be independent from the frame of the main building, in order to avoid causing its structural failure. No items should be stored under overhangs of the main building.
- The area of the space influences the temperatures inside the semi-confined space: the bigger the area, the lower the temperatures. However, the bigger the area, the more space to store items.
4.2.4. Hedgerows: fire percolators through WUI communities, by Juan Muñoz

4.2.4.1. Screenshots taken during the webinar

4.2.4.2. Abstract

Ornamental vegetation management is key to prevent home ignitions when forest fires reach the wildland-urban interface. With this regard, hedgerows hold a double role acting as a source of heat during combustion and linking distant places of this wildland-urban interface.

We investigated whether it was possible to reduce fire risk from hedgerows through species selection and gardening. We performed burning tests and fuel samplings of hedgerows from different species, physiological status and shapes to analyse fire risk and run computational fluid dynamic simulations. We found that:
- Species selection is key to reduce fire risk, but for most species used in Mediterranean environments to shape hedgerows, the amount of biomass is more important than the species.
- When the species trend to accumulate fine dead fuels in the inside, gardening must focus on shaping thin hedgerows and allowing sunlight to enter the plant.
- Hedgerows with fine dead fuels are highly sensitive to convection, and maintenance must focus on reducing these fuels.
- Burning behaviour predictions from computational fluid dynamic simulators are possible, but there is still a room for improvement.

These results advance fire risk comprehension in the wildland-urban interface and support species and specific gardening techniques, helping landscape managers to build safer neighbourhoods.

4.2.4.3. Presentation printout
Hedgerows: fire percolators through WUI communities

Hedgerows: fire percolators through WUI communities

Hedgerows: fire percolators through WUI communities
Hedgerows: fire percolators through WUI communities

- SPECIES
- PHYSIOLOGICAL STATUS
- SHAPE

FINAL Workshop of the WUIVIEW Project 15/01/2021
Hedgerows: fire percolators through WUI communities

Cherry laurel
(P. laurocerasus)

Arizona cypress
(C. arizonica)

Northern white cedar
(T. occidentalis)

Leyland cypress
(C. leylandii)
Hedgerows: fire percolators through WUI communities

- Homogeneous
- Same hazard than other ornamental plants
- Canopy bulk density ≈ 3 kg/m³
Hedgerows: fire percolators through WUI communities

- ¼ Foliage
- ¼ Fine dead fuels
- ¼ Branches

- Foliage ≈ 5-15 kg/m³
- Fine dead fuels ≈ 1-20 kg/m³ (↑↓)
- 90% of fuel availability
**Hedgerows: fire percolators through WUI communities**

---

**Conclusions**

- Since the moment we plant the trees to shape a hedgerow, the fire risk will be constantly increasing. Never decreasing.
- Gardening matters: much better to shape thin hedgerows (with sunlight and little space to store dead fuels) than thick ones.
- Maintenance is paramount: periodically remove the fine dead fuels stored in the inside as well as the mulch on the ground.
- Between the species that we have studied, Cherry laurel is the best for our garden, while Arizona cypress is the worst.
- It is possible to simulate hedgerows, but there is still room for improvement.
4.3. Session 2: VAT (Vulnerability Assessment Tool) and SAT (Sheltering Assessment Tool) for self-protection and fire risk awareness

– Chairman: L.M. Ribeiro –

4.3.1. The Mediterranean version of VAT and SAT tools, by Alba Àgueda

4.3.1.1. Screenshots taken during the webinar

4.3.1.2. Abstract

We have developed user-friendly tools for self-assessment of structures vulnerability (VAT tool) and sheltering suitability (SAT tool). The questions formulated in the quizzes integrate all the knowledge obtained during the WUIVIEW project thanks to literature reviews, lessons learnt from other WUI programs and real case studies, and also thanks to the results of our own simulations and experiments. We have implemented these tools using Google Forms and a
detailed description of the questions posed is shown in this work. Finally, a real case example is set for a property located in Cagliari, Sardinia (Italy). The scores obtained and the vulnerabilities of the property are highlighted.

4.3.1.3. Presentation printout

**WUIVIEW International Workshop**

*Wildfire self-protection in the WUI at home-owner level*

The Mediterranean version of VAT and SAT tools

Alba Águeda
alba.agueda@upc.edu
CERTEC/Universitat Politècnica de Catalunya - Spain

**Introduction**

- Structures vulnerabilities understanding:
  - Literature available (recommendations, scientific studies, international legislation)
  - Lessons learnt from other WUI fire risk mitigation programs/real case studies
  - Own simulations and experiments
- VAT and SAT tools integrate all this knowledge.
VAT tool - Rationale

- Questionnaire format (YES/NO)
- Based on a “fault tree” about the elements that may trigger fire inside the structure
- Fire Vulnerability Index (FVI):
  - Likelihood of fire entrance inside the structure in case of forest fire
  - Ranking from 0 to 100
- To take into account:
  - This index is adequate only for structures made of concrete, bricks, etc., but not for structures made of wood (or other combustible materials).


VAT tool - Implementation

- Tool: Google Forms
- In English
- General structure:
  - Introduction: Rationale description
  - General data: Address, Emails, Coordinates (Google Maps), Comments
  - Questions: DETAILS NEXT
  - Images: Upload of different views/details
### VAT tool - Implementation

#### B1. Vents
- Ventilation openings are potential entry points for flying embers that could ignite the building.

| B1.1 Do you have unprotected ventilation openings (i.e., vents without any type of screening)? |
|---|---|
| YES | NO |
| 20 | 0 |

| B1.2 Are your vents protected with non-combustible corrosion-resistant materials/meshes (e.g., aluminium, galvanized steel, stainless steel, copper, intumescent coating)? |
|---|---|
| YES | NO |
| 0 | 10 |

| B1.3 Are your fire-resistant mesh openings less than 2 mm in characteristic length? |
|---|---|
| YES | NO |
| 0 | 5 |

#### B2. Roof-gutters system
- The roof is one of the parts most exposed to fire front radiation and eventually to the landing of firebrands.
- Accumulation of fine fuel that can be ignited by firebrands is not desirable. Roof and gutters maintenance and cleaning are key aspects.

| B2.1 Is your roof covering or your roof assembly made of fire-rated material (e.g., clay tiles, concrete tiles, asphalt glass fibre composition singles, slate, etc.)? |
|---|---|
| YES | NO |
| 0 | 20 |

| B2.2. Is your fire-rated roof covering in good state? |
|---|---|
| YES | NO |
| 0 | 4 |

| B2.3 Are your roof and gutters not exposed to overhanging tree branches? |
|---|---|
| YES | NO |
| 0 | 4 |

#### B2.4 Do you perform periodic roof maintenance?

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4</td>
</tr>
</tbody>
</table>

#### B2.5 Does your roof present geometry favourable for the deposition of fuels and firebrands? (Is your roof flat? Are there roof valleys? Are there intersections between roofs and external vertical walls/sidings?)

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>

#### B2.6 Do you perform regular cleaning of debris pilling up on roof or gutters?

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4</td>
</tr>
</tbody>
</table>
### VAT tool - Implementation

#### B3. Glazing systems

- One of the most exposed elements in a house.
- Shutters should be made of non-combustible material (solid core wood or metal, no PVC).

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5</td>
</tr>
</tbody>
</table>

**B3.1** Do you have protection for all your windows/glazing systems (i.e. shutters, blinds) made of non-combustible materials (solid core wood fire-resistant, metal like aluminium)?

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5</td>
</tr>
</tbody>
</table>

**B3.2** Are your glazing systems double or made of fire-resistant tested material (e.g. tempered glass) or have a thickness ≥ 6 mm?

#### B4. Wildfuels surrounding the structure

- Location of the lot where the house is installed in the landscape plays a key role in the type, extension and intensity of exposure to wildfire.

**B4.1** Do you have a fuel-managed area around your settlement (in case of WU-interface) or your property (in case of WU-intermix) well maintained?

To answer affirmatively this question take into consideration the following criteria:

<table>
<thead>
<tr>
<th>Midslope, ridges or hilltops</th>
<th>Flat terrain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel-managed ring</td>
<td>≥ 50 m</td>
</tr>
<tr>
<td>Separation between crown trees/high shrubs</td>
<td>≥ 8 m</td>
</tr>
<tr>
<td>Lower tree branches pruned at</td>
<td>½ of tree height</td>
</tr>
<tr>
<td>Low surface fuel load</td>
<td>≤ 10 cm depth</td>
</tr>
</tbody>
</table>

#### B5. Natural fuels

- Ornamental vegetation must be properly selected, placed and managed to minimize impact.

**B5.1** Do you have a 10-m wide area around your structure with ornamental vegetation properly managed? To answer affirmatively this question, the following conditions have to be met:
  - Fire-resistant species (for trees or shrubs) or separated 6 m
  - Small trees/hedges separated at least 4 m from any glazing system
  - Non-continuous litter layer
  - Hedges not aligned with wind or main slopes
  - No presence of dead fuels

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10</td>
</tr>
</tbody>
</table>
VAT tool - Implementation

**B6. Non-natural fuels**
- Non-natural fuels are all type of materials and objects located around the house which may eventually entail combustion.

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>

B6.1 Are there any non-natural fuels (e.g. outdoor furniture, stored materials, gas canisters, small sheds, wood piles) located within 5 m from vulnerable structure elements (e.g. doors or windows, gutters)?

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>

B6.2 Are there any combustible materials (including ornamental vegetation, storage spaces, or combustible eaves) located within 2 m from LPG tanks? (*) Answer this question only if you have LPG tanks.

**B7. Semi-confined spaces**
- The presence of combustible material in semi-confined spaces entails large heat accumulation should these materials be ignited.

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>0</td>
</tr>
</tbody>
</table>

B7.1 Is there combustible material in any semi-confined space adjacent to your house?

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>

B7.2 Are there openings (e.g. windows, doors) connecting the house to any semi-confined space with combustible material?

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5</td>
</tr>
</tbody>
</table>

B7.3 Are the walls of the house connecting to the semi-confined space with combustible material made out of concrete or bricks (20 cm thick minimum)?

**B8. Preparation for evacuation**

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>20</td>
</tr>
</tbody>
</table>

B8.1 Would you be capable of shutting all the doors and windows before leaving, tape your windows from the inside so that they remain in place if broken?
VAT tool - Implementation

- Preliminary processing of answers:
  - Function programmed in Google Apps Script, a JavaScript platform in the cloud.
  - On form submission, a trigger is set:
    - To do simple processing steps
    - To send an email to the respondent and the surveyor showing the main results

SAT tool - Rationale

- Questionnaire format (YES/NO)
- Based on three requirements
- Binary result:
  - < 45 scores → some questions NO → sheltering unreliable option
  - ≥ 45 scores → all questions YES → sheltering reliable option

Similar to action checklists from South Australian Country Fire Service:
https://www.cfs.sa.gov.au/site/resources.jsp

VAT questionnaire FVI ≤ 20

SAT tool - Implementation

- B1. Physical and mental fitness

<table>
<thead>
<tr>
<th></th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1.1 Are you <strong>mentally, physically and emotionally</strong> able to cope with the intense smoke, heat, stress and noise of a wildfire while defending your home?</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>B1.2 Are you <strong>physically fit</strong> to fight spot fires in and around your home?</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>B1.3 Will you be able to <strong>protect your home</strong> while also caring for members of your <strong>family, pets</strong>, etc.?</td>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>
**SAT tool - Implementation**

**B2. Immediate preparedness and response**

<table>
<thead>
<tr>
<th><strong>B2.1</strong> Can you patrol the inside of the home as well as the outside for embers or small fires?</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>B2.2</strong> Can you prepare the inside of your home (e.g. remove curtains, move furniture away from windows, tape windows from inside so they remain in place if broken)?</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>B2.3</strong> Do you have a supply of fresh water available to keep hydrated?</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>B2.4</strong> Are you able to estimate which openings (windows, doors) may influence at most hot gases propagation pathways inside the house depending on fire front position?</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>B2.5</strong> Do you have the necessary clothes and properly maintained equipment to effectively fight a fire?</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

---

**SAT tool - Implementation**

**B3. Structure endurance**

<table>
<thead>
<tr>
<th><strong>B3.1</strong> Does your structure have a high chance of survivability according to VAT (vulnerability assessment tool) checklist (FVI ≤ 20)? (*)</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

(*) A threshold value of Fire Vulnerability Index (FVI) ≤ 20 is considered here for an affirmative answer. An FVI of 20 means that there is at least 1 out of 5 possibilities of fire entrance inside the structure due to possible gaps. If Blocks 1 and 3 are affirmative, a value of FVI = 20 is considered manageable.

---

**Real case**

**House in Cagliari (Sardinia, Italy)**

---

![Image of Cagliari area]
Real case

- VAT Final score = 30/100

<table>
<thead>
<tr>
<th>Block</th>
<th>Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1 (Gaps through vents):</td>
<td>0/20</td>
</tr>
<tr>
<td>B2 (Gaps through the attic):</td>
<td>0/20</td>
</tr>
<tr>
<td>B3-86 (Broken window):</td>
<td>15/20</td>
</tr>
<tr>
<td>B3 (Unprotected glasses):</td>
<td>5/10</td>
</tr>
<tr>
<td>B4-86 (Fuels management):</td>
<td>10/10</td>
</tr>
<tr>
<td>B7 (Large structural damage in house envelope):</td>
<td>15/20</td>
</tr>
<tr>
<td>B8 (Windows/doors left open):</td>
<td>0/20</td>
</tr>
</tbody>
</table>

Real case

- VAT Final score = 30/100

<table>
<thead>
<tr>
<th>Block</th>
<th>Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1 (Gaps through vents):</td>
<td>0/20</td>
</tr>
<tr>
<td>B2 (Gaps through the attic):</td>
<td>0/20</td>
</tr>
<tr>
<td>B3-86 (Broken window):</td>
<td>15/20</td>
</tr>
<tr>
<td>B3 (Unprotected glasses):</td>
<td>5/10</td>
</tr>
<tr>
<td>B4-86 (Fuels management):</td>
<td>10/10</td>
</tr>
<tr>
<td>B7 (Large structural damage in house envelope):</td>
<td>15/20</td>
</tr>
<tr>
<td>B8 (Windows/doors left open):</td>
<td>0/20</td>
</tr>
</tbody>
</table>

Real case

- VAT Final score = 30/100

<table>
<thead>
<tr>
<th>Q</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>B3.1 (5)</td>
<td>No protection for all glazing systems</td>
</tr>
<tr>
<td>B3.2 (9)</td>
<td>Glazing systems thick enough</td>
</tr>
<tr>
<td>B4.1 (10)</td>
<td>Fuel-managed area around the settlement not well maintained</td>
</tr>
<tr>
<td>B5.1 (10)</td>
<td>Ornamental vegetation improperly managed</td>
</tr>
<tr>
<td>B6.1 (5)</td>
<td>Non-natural fuels (outdoor furniture, wood piles) located within 5 m from vulnerable structure (glazing system)</td>
</tr>
<tr>
<td>B6.2 (5)</td>
<td>Ornamental vegetation located within 2 m from an LPG tank</td>
</tr>
</tbody>
</table>
Real case

- House in Cagliari (Sardinia, Italy). VAT Final score = 30/100

<table>
<thead>
<tr>
<th>Q(10)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q7.1</td>
<td>Combustible material in a semi-confined space adjacent to the house.</td>
</tr>
<tr>
<td>Q7.2</td>
<td>Openings connecting the house to the semi-confined space, with combustible material.</td>
</tr>
</tbody>
</table>

Real case

- SAT Final score: unreliable option (25 < 45)

<table>
<thead>
<tr>
<th>Q</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1.1</td>
<td>Not mentally, physically and emotionally prepared</td>
</tr>
<tr>
<td>Q2.2</td>
<td>Cannot prepare the inside of their home</td>
</tr>
<tr>
<td>Q2.5</td>
<td>Do not have the necessary clothes to effectively fight a fire</td>
</tr>
<tr>
<td>Q3.1</td>
<td>FVI = 30 (&gt; 20)</td>
</tr>
</tbody>
</table>

Further work

- To test the questionnaires at a community level, doing campaigns to characterize as much structures as possible.
- To analyse the effect of communities on vulnerability management (what my neighbour does, affects my own house vulnerability).
- To verify some of the values used in the forms (e.g. weight given to each block, distances).
4.3.2. The Scandinavian version of VAT tool, by Johan Sjöström

4.3.2.1. Screenshots taken during the webinar

![Webinar Screenshots]

4.3.2.2. Abstract

Scandinavia and southern Europe share many similarities related to the fire in the WUI. However, the situation also differs in many ways concerning differences in building material, frequency of high intensity fires and fuel distributions. Therefore, the Vulnerability Assessment Tool (VAT), developed for a south European reality, is not applicable to Scandinavia without adaptation. This presentation described the background to the adaptations and exemplifies the questionnaire on two Swedish properties, both previously subject to wildfires.
4.3.2.3. Presentation printout

**WUIVIEW International Workshop**

*Wildfire self-protection in the WUI at home-owner level*

**Vulnerability Assessment Tool – Scandinavian version**

**Johan Sjöström & Frida Vermina Plathner**

Johan.sjostrom@ri.se

RISE Research institutes of Sweden

---

**Scandinavian version of the VAT tool**

- Fires occur where people live. Large areas burn where people do not live

---

**Scandinavian version of the VAT tool**

- More houses are burnt in low intensity fires than in high intensity
Scandinavian version of the VAT tool

- Traditional and modern buildings in Sweden – Timber facades

We have studied buildings damaged/surviving large scale fires
- We have read incidents reports of small low intensity fires igniting/threatening buildings
- Key to structural survival – managed lean

Scandinavian version of the VAT tool

Incombustible foundation protects from low intensity fires
### Scandinavian version of the VAT tool

- Wooden decks and semicofined spaces
- Can have high fuel load
- Highly susceptible to ignitions
- Rapid fire growth and high intensity

---

### Seven questions, 2 related to garden vegetation

<table>
<thead>
<tr>
<th>ID</th>
<th>Question</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>VR-1</td>
<td>Do you have environmental barriers close to your buildings?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VR-2</td>
<td>Do you have a high degree of vegetation within 15 m of your building?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

### Seven questions

- Seven questions
- 3 related to structure

---

### Seven questions, 2 related to garden vegetation

- Seven questions, 2 related to garden vegetation
- Do you have environmental barriers close to your buildings?
- Do you have a high degree of vegetation within 15 m of your building?

---

### 10. How high should a technical ventilation system have if it is related to the respiratory health of people?

- Depends on the type of ventilation system and the ventilation system's size.
- The ventilation system must be able to supply enough fresh air to maintain a healthy indoor environment.

---

### 11. Is your land managed in a sustainable way?

- Land management practices such as sustainable land use, agroforestry, and water management.
- The goal is to maintain the land's health and productivity while also providing for human needs.

---

### 12. Is your garden flor property managed?

- Practices include lawn care, irrigation, pest control, and waste management.
- The goal is to maintain the garden's health and appearance while also reducing waste.

---

### 13. Do you have a managed lawn or another low-combustible surface such as pavement in the garden?

- Managed lawn or other low-combustible surface within the garden.
- The goal is to reduce the risk of fire spread.
Scandinavian version of the VAT tool

- Seven questions, 1 other fuels

<table>
<thead>
<tr>
<th>ID</th>
<th>Question</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>96.1</td>
<td>Do you have stacked fuels (&gt;20 kg) directly to the facade?</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>96.2</td>
<td>Do you have additional combustible material (&gt;100 kg) or a shed within 10 m from the building?</td>
<td>7</td>
<td>0</td>
</tr>
</tbody>
</table>

Scandinavian version of the VAT tool

- Seven questions, surrounding
  - Conifers
  - Grassland / shrubs
  - Deciduous trees (leaves)
  - Arable land (fields)

<table>
<thead>
<tr>
<th>ID</th>
<th>Question</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>97.1</td>
<td>To what percentage is the garden surrounded by:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Conifer?</td>
<td>5%</td>
<td>50%</td>
</tr>
<tr>
<td></td>
<td>- Grassland / shrubs?</td>
<td>10%</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>- Deciduous trees?</td>
<td>15%</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>- Arable land?</td>
<td>5%</td>
<td>5%</td>
</tr>
</tbody>
</table>

The score for this question is the sum of each percentage of fuel type multiplied with the corresponding multiplier in the right column. A structure surrounded by 50% conifers, 20% deciduous trees and 20% none of these above (e.g., +10 points) results in a score of: \(0.5 \times 10 + 0.2 \times 15 + 0.2 \times 20 = 11.5\) points.

Scandinavian version of the VAT tool

- Testing - 1

House surviving high intensity fire
Scandinavian version of the VAT tool

- Façade, timber with stone foundation 16/20p
- Clean roof and gutters, 0/5p
- No wooden porch or deck, 0/10p

Scandinavian version of the VAT tool

- Managed lawn (or pebbled ground) around all house, 0/25p
- Low degree of ornamental plants, 0/5p
- Little other fuel but close distance to shed, 7/15p

Scandinavian version of the VAT tool

- Garden surrounded by
  - 70% conifers
  - 0% grassland
  - 30% deciduous trees
  - 0% arable land

15.5/20 p
Scandinavian version of the VAT tool

Total score: 38.5 / 100p
+ managed garden, no semiconfined space
- Surrounding and façade

Scandinavian version of the VAT tool

• Testing - 2
Burnt down in spring fire
• April, 2019
• Strong winds
• Embers

Scandinavian version of the VAT tool

• Testing - 2
Burnt down in spring fire
• April, 2019
• Strong winds
• Embers
Scandinavian version of the VAT tool

- Testing - 2
- Burnt down in spring fire
  - April, 2019
  - Strong winds
  - Embers

<table>
<thead>
<tr>
<th>Factor</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Façade</td>
<td>20/20p</td>
</tr>
<tr>
<td>Cleaning of roof or gutters</td>
<td>5/5p</td>
</tr>
<tr>
<td>Deck or porch</td>
<td>0/10p</td>
</tr>
<tr>
<td>Lawn or pebbled ground</td>
<td>15/25p</td>
</tr>
<tr>
<td>Ornamental fuels</td>
<td>2/5p</td>
</tr>
<tr>
<td>Other fuels</td>
<td>15/15p</td>
</tr>
<tr>
<td>Surrounding (arable, deciduous, grass)</td>
<td>9.25/20p</td>
</tr>
<tr>
<td>Total</td>
<td>66.25/100p</td>
</tr>
</tbody>
</table>

Read more about the Scandinavian conditions

- Vermina Platnér F. & Sjöström J. (2021a) *The wildland-urban interface in Sweden*, Technical Note 7.1 from the WUIVIEW project.
4.4. Session 3: PBD (Performance-Based Design) methodology for an in-depth vulnerability analysis

– Chairman: V. Cozzani –

4.4.1. The PBD WUI method rationale, by Eulalia Planas

4.4.1.1. Screenshots taken during the webinar

A deep analysis of past accidents can help to identify the most important vulnerabilities of houses at the WUI. In the WUIVIEW project, this has allowed developing a simple tool, the VAT tool, which home-owners and practitioners can use to quickly assess the vulnerability of properties. This tool has been developed not only from observations but also from quantitative...
data that has been extracted through experiments and CFD simulations. Sometimes a more
detailed and deeper analysis of the interactions that can occur between fire, structures and
residents may be required. For that purpose, the Performance Based Design (PBD) approach,
commonly used in the field of fire safety engineering, which is based on the definition of
performance criteria, the design of fire scenarios and the evaluation of the trial designs, can be
used with some modifications and adaptations in the WUI context.

This presentation shows how, in the frame of the WUIVIEW project, we have adapted the
classical PBD methodology to evaluate wildland-urban interface fire safety at homeowner level.
First, we explain what PBD is and then how we have adapted it to the WUI context, starting with
the definition of scope, goals and objectives, and then setting the performance criteria to be
used, the definition of the design fire scenarios and finally the evaluation of the trial designs.

4.4.1.3. Presentation printout
Performance-Based Design (PBD) framework

Performance-Based fire safety Design is a methodology for the engineering of fire safe building solutions.

1. The definition of the level and type of performance that the final solution has to guarantee Fire safety objectives
2. The definition of the potential fire events that may occur. Design fire scenarios
3. The quantitative assessment of the proposed design against the defined goals CFD

Performance-based fire protection is usually carried out when the building unique characteristics makes very difficult or impossible to comply with prescriptive-based codes

WUI-PBD: Scope

Identifies the needs of the project

- The parts of the building or plot facilities that will be considered by the design
- The intended characteristics of the building or plot facilities
- The regulations applicable
- The identification of the project stakeholders

To quantify hazards and vulnerabilities of buildings taking in mind their sheltering capacity or just their ability to withstand the passing of a wildfire
WUI-PBD: Goals and objectives

Goals:
- Life safety
- Property protection
- Mission continuity
- Environmental protection

Objectives:
- Occupant protection
- Structural integrity
- ...
WUI-PBD: Design fire scenarios

Scenarios considered

- **High-frequency, low-consequences (typical)**
  - Residential fuels igniting at different times
  - Seasonal average temperature and humidity
  - Average wind speed and usual direction
  - Normal/typical building conditions (e.g. closed shutters and windows/doors, etc.)

- **Low-frequency, high consequence (high challenge)**
  - Residential fuels igniting at once
  - Seasonal peak temperature and humidity
  - Peak wind speed and worst-case direction
  - Unusual building conditions (e.g. open shutters, open window/door, etc.)

- **Special problems scenario**
  - LPG tank
  - Semi-confined spaces with stored materials

- **Property characteristics:** physical features, contents, and internal and external building’s environment
- **Occupant characteristics:** when life safety or occupants response is considered in the scope
- **Fire characteristics:** quantitative fire curves (i.e., HRR or MLR vs time)

WUI-PBD: Trial designs and evaluation

- **Trial designs**
  - Existing properties vulnerabilities
  - Fire protection strategies

If the trial designs do not achieve the set performance criteria, they should be redefined and re-evaluated.
WUI-PBD: Trial designs and evaluation

- Trial designs
  - Existing properties vulnerabilities
  - Fire protection strategies

- Evaluation of the design
  - Fire models – CFD tools
  - Fire Dynamics Simulator
    - CFD model of fire-driven fluid flow
    - Emphasis on smoke and heat transport from fires

Conclusions

- Classical PBD approach can be used at the WUI with modifications

- WUI-PBD approach requires different objectives and design fire scenarios

- Trial evaluation with CFD tools require information sometimes not yet available

- WUI-PBD approach with CFD modelling tools can provide useful information on interactions that can occur between fire, structures and residents
4.4.2. Case study #1: Spanish property, by Pascale Vacca

4.4.2.1. Screenshots taken during the webinar

4.4.2.2. Abstract

We present a case study for a property located in the settlement of Entrepinos (Community of Madrid, Spain). The goal of the study is property protection, with the objective of maintaining the building’s structural integrity in case of fire. Four fire scenarios are analyzed in order to test the property’s performance, which is set by selecting criteria for the glazing systems and the concrete walls of the building, and the LPG tank located on the property. The evaluation of the scenarios showed critical issues for the glazing systems and the LPG tank. Suggestions are made for the modification of the design for the subsequent re-evaluation of the property.
4.4.2.3. Presentation printout

WUIVIEW International Workshop

Wildfire self-protection in the WUI at home-owner level

Case study #1: Spanish property

Pascale Vacca
pascale.vacca@upc.edu
CERTEC/Universitat Politècnica de Catalunya - Spain

Spanish property

Community of Madrid
VAT score = 61/100

Performance-Based Design

Entire property
Property protection
Maintain the building’s structural integrity
Non-life safety
4 scenarios

Performance-based design

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Criteria Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Windbreakage</td>
<td>50 mph</td>
</tr>
<tr>
<td>Uni tank integrity</td>
<td></td>
</tr>
<tr>
<td>Concrete wall self-hosting capacity</td>
<td></td>
</tr>
</tbody>
</table>

Final Workshop of the WUIVIEW Project 15/01/2021
Fire scenarios

- **High frequency, low consequences**
  - Wind direction
  - Rate of spread = 0.55 m/s
- **Low frequency, high consequences**
  - Wind direction
  - Rate of spread = 0.55 m/s
- **Special issues**
  - Porch (semi-confined space) with garden furniture
  - LPG tank

Trial designs and evaluation

- **Trial design**: building and property as they are at the moment
- **Evaluation** of the scenarios

**S1: High frequency, low consequences**

<table>
<thead>
<tr>
<th>Window</th>
<th>Time to Injection (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>59</td>
</tr>
<tr>
<td>S2</td>
<td>103</td>
</tr>
<tr>
<td>Doors</td>
<td>127</td>
</tr>
</tbody>
</table>

**S2: Low frequency, high consequences**

<table>
<thead>
<tr>
<th>Window</th>
<th>Time to Injection (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LS</td>
<td>6</td>
</tr>
<tr>
<td>S</td>
<td>63</td>
</tr>
<tr>
<td>Doors</td>
<td>64</td>
</tr>
</tbody>
</table>

Scenario evaluation

- **S3: Special problem – porch**
- **S4: Special problem – LPG tank**

**Pressure Relief Valve Index > 0.9**
4.4.3. Case study #2: Swedish property, by Johan Sjöström

4.4.3.1. Screenshots taken during the webinar
4.4.3.2. Abstract

The PDB methodology is applied to a Swedish property in southwest Sweden. The property has a typical Swedish style single dwelling, wooden with a wooden garage. It is vulnerable due to the long and tall coniferous hedge separating the garden to two neighbouring properties.

4.4.3.3. Presentation printout

Case study #2 – Swedish single dwelling

- Building the geometry in Pyrosim
- Mesh size 6.25 cm around details, 250 cm in large volumes
Case study #2 – Swedish single dwelling

- Hedge, *Thuja Occidentalis*
- Double row
- Partly dead
- 4 m tall, close to garage
Case study #2 – Swedish single dwelling

- Hedge, *Thuja Occidentalis*
- Extends to neighbours

Case study #2 – Swedish single dwelling

- Performing the VAT

<table>
<thead>
<tr>
<th>Factor</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Façade</td>
<td>16/20p</td>
</tr>
<tr>
<td>Cleaning of roof or gutters</td>
<td>5/5p</td>
</tr>
<tr>
<td>Deck or porch</td>
<td>10/10p</td>
</tr>
<tr>
<td>Lawn or pebbled ground</td>
<td>0/25p</td>
</tr>
<tr>
<td>Ornamental fuels</td>
<td>5/5p</td>
</tr>
<tr>
<td>Other fuels</td>
<td>7/15p</td>
</tr>
<tr>
<td>Surrounding (arable, deciduous, grass)</td>
<td>5/20p</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>48/100p</strong></td>
</tr>
</tbody>
</table>

Case study #2 – Swedish single dwelling

- Building the geometry in Pyrosim
- Mesh size 6.25 cm around details, 250 cm in large volumes
Case study #2 – Swedish single dwelling

• Checking if detailed geometry influences result

Case study #2 – Swedish single dwelling

• Scenario: previous weather
  Relevant but high end of the situation for large fires in Sweden
  • FFMC = 92
  • DMC = 70
  • DC = 250
  • Present day: 40% RH, 26°C
  • Wind: 6 and 4 m/s (0 and 45°)

Case study #2 – Swedish single dwelling

• Design fire
  • Spread: Use conifer plantation from Canadian Forest Fire Behavior Prediction System
  • Heat Release Rate: Use experimental data for Douglas Fir trees

1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
Case study #2 – Swedish single dwelling

- Design fire
  - Spread: Use conifer plantation from Canadian Forest Fire Behavior Prediction System
  - Approximate burning with a triangular HRR
  - Assume one tree per meter

![Graph showing HRR/m vs. t (s)]

Case study #2 – Swedish single dwelling

- Results. Temperature slices
- Note, embers are not considered

![Images showing temperature slices]

Case study #2 – Swedish single dwelling

- Results: Heat Release Rate

![Graph showing heat release rate over time]
Case study #2 – Swedish single dwelling

• Results: Temperatures

1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020

Case study #2 – Swedish single dwelling

• Results: Temperatures

1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020

Case study #2 – Swedish single dwelling

• Summary
  • Dwelling facade
  • Porch
  • Wooden fence

1st WUIVIEW International Workshop – Coimbra (PT); 17/01/2020
4.4.4. Case study #3: The community shelter at Figueiró dos Vinhos, by Miguel Almeida and Alba Águeda

4.4.4.1. Screenshots taken during the webinar
4.4.4.2. Abstract

This case study is based on a community shelter that will be built in the village of Moninhos Cimeiros, in the Municipality of Figueiró dos Vinhos, Portugal. This community shelter will enable people to take refuge during a large fire event or any other threat that force them to search for a refuge.

It was not intended here to assess the vulnerability of the construction itself, since it has been designed using materials and practices that confer a good resistance to fire. The main intention was to estimate the time at which tenability criteria are exceeded in the surroundings of the shelter. Specifically, the objective was to test a new toolchain where GIS tools and wildfire functionalities from FDS are integrated. To do so, a simple scenario was firstly run to confirm that all the elements of interest (sloped surface, fuel models, a generic building, wind and fire propagation) were correctly integrated into the simulation. Afterwards, a new simulation involving a large scenario was carried out where the shelter, wind, and elevation and land use data were considered. For this large scenario, the fire propagation could only be modelled through the fire front arrival. No burning could be considered so far due to numerical instabilities. These numerical instabilities are being currently checked by FDS developers.

The estimated “Available Safe Escape Time” (based on the fire front arrival) was of 25-33min assuming the following conditions: north-westerly wind blowing at 10m/s, the ignition point was located 1km far from the shelter at the NW area of the domain.
4.4.4.3. Presentation printout

WUIVIEW International Workshop

Wildfire self-protection in the WUI at home-owner level

Case study #3: The community shelter at Figueiró dos Vinhos

Outline

- Aldeias Resilientes Project
- Shelter description
- Simulation approach
- Scenarios tested

Aldeias Resilientes project

- The development of this case study could be carried out thanks to:

Aldeias Resilientes / Abrigo Coletivo:
Cooperation agreement between the WUIVIEW project and this AVIPG (Association of Victims of the Fire in Pedrógão Grande).
Study site – Moninhos Cimeiros

- Historical analysis of fires nearby:
  - Burned area (ha): 243, 44, 484, 908, 357, 9
- Wildfire in Pedrogão Grande (June 2017)
- About 70 properties, many in poor condition
- 13 inhabitants → ~ 80 people in August

Study site – Community shelter implantation

- Community Shelter of Nossa Senhora da Piedade (Moninhos Cimeiros)
- Fire risk area
- Used during the festivities of the village.
- Possible use by Moninhos Fundeirinos and by tourists

Study site – Community shelter structure

- Self protection systems
- Water and energy autonomy
- Communication (radios)
- Special needs area
- Food/water supplies
- Place for prayer
- ...

Challenges
- Fuel management: surroundings and access
- Car parking
- Panic management
PBD analysis

- The PBD analysis performed in this case study is different from the previous ones.
- The property of this case study is already designed to be fire resistant.

Research question:
Time at which tenability criteria around the structure are exceeded

Main goal:
To improve WUI evacuation decision-making processes

PBD analysis

- Fire
  - Topography
  - Meteorology
  - Vegetation
  - Fire fighters intervention

- Pedestrian
  - Training
  - Notification
  - Emergency services
  - Socioeconomic

- Traffic
  - Network condition
  - Transport modes
  - Traffic management

Modelling domains of WUI evacuation

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PBD analysis

- Level of safety
  - ASET (Available Safe Escape Time): the time at which tenability criteria are exceeded by environmental conditions.
  - RSET (Required Safe Escape Time): the time taken by the evacuees to reach the shelter.

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Figure 4. Schematic representation of the WUI modelling layers representing three distinct aspects (fire, pedestrian, and traffic) of WUI.

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Figure 10. WASET/RSET proposed timeline for a wildfire incident at WUI.
Objectives and Methodology

**Objective:**

O.1 To estimate a simplified ASET using FDS and associated tools:

- Preliminary ASET criterion: Elapsed time between ignition and the arrival time of the fire front

O.1.1. To test the NEW toolchain: qgis > qgis2fds > blenderfds > fds > smv

### Simple scenario

- Sloped surface boundary
- 4 meshes
- Structure included
- Wind (several directions were tested)
- Fire propagation: Level Set Method
  - Empirical model; reproduces FARSITE model
    - Wind and fire are coupled.
    - When fire front arrives at a given surface cell, it burns for a finite duration and with a HRRPUA provided as part of the fuel model.

http://www.blenderfds.org
https://github.com/firecode/qgis2fds
Large scenario

- Digital Terrain Model and Landuse Layer:
  - Resolution: 5 m; Domain: 2 km x 2 km
- Landuse Layer:
  - 13 Anderson (1982) fuel models
- Structure:
  - Volume included; Inert surface set
- Wind:
  - 10 m/s (36 km/h); NW direction
- Fire propagation: Level Set Method
  - Level Set Mode = 1 (no fire, wind not affected by terrain)
- Meshes:
  - 16 meshes; Coarse cells (10 m cell size); 972,000 total cells

Large scenario

- $ASET_{fire\ front\ arrival}$
  - $\sim 1500-2000$ s = 25-33 min

Further work

- This is a work-in-progress. FDS developers are now using this scenario to handle geometries issues.
- Once they are solved, the toolchain proposed seems promising to establish WUI ASET values based on different performance criteria (fire front arrival, radiant heat flux, visibility).
- We need to analyse the influence of ignition point location and meteorological conditions (wind).
- We need to establish a methodology for the definition of rellevant scenarios according to stakeholders experience.
4.5. Session 4: WUIVIEW PRODUCTS UPSCALING AND FUTURE CHALLENGES (Chairman: D. Caballero)

4.5.1.1. Screenshots taken during the webinar

Future challenges and upscaling

• **Challenge 1.** Megafires and extreme fire behaviour. Unprecedented scenarios (wind direction and intensity, drought periods, atmospheric instability. First responders overwhelmed.


• **Challenge 3.** Prevention as community. Collective vulnerability. Strategies and designs. Fragmentation of communities. New urban designs (avoid lineations). (MESOSCALE)

4.5.1.2. Abstract

As the WUIVIEW project is ending, a set of new challenges for the management of risk under the upcoming threat of megafires and extreme fire behaviour is presented. These include aspects to be properly addressed, researched and solved for the three spatial scales considered in the wildland-urban interface areas. Particularly, the upscaling of fire behaviour modelling from the micro-scale (property level) to the meso-scale (community level) and the role of vegetation patches inside the urban pattern in the propagation. Several other aspects focus on the community vulnerability, the risk perception and the transformation of the surrounding
environments. Finally, some messages are put across in regard to self-protection and using houses as shelters and the technical and sometimes social challenges that these represent.

4.5.1.3. Presentation printout
Future challenges and upscaling

• **Challenge 1.** Megafires and **extreme fire behaviour.** Unprecedented scenarios (wind direction and intensity, drought periods, atmospheric instability. First responders overwhelmed.


• **Challenge 3.** Prevention as community. Collective vulnerability. Strategies and designs. Fragmentation of communities. New urban designs (avoid lineations). (MESOSCALE)

Future challenges and upscaling

• **Challenge 4.** Understanding fire behaviour in WUI communities. Fire percolation. Fragmented propagation and front interaction. (MESOSCALE)

• **Challenge 5.** Surrounding environment. Transforming transition areas. Naturalised landscapes. (MESOSCALE)

• **Challenge 6.** Early and **safe evacuation** processes. Contextual awareness. Supporting technology. (MESOSCALE)

Future challenges and upscaling

• **Challenge 7.** Water availability. Water management. Vegetation moisture. Gardens, transition areas. Soil protection. (MESOSCALE /MICROSCALE)

• **Challenge 8.** Prevention and risk mitigation. Self protection. Vulnerability as individuals. My house, my garden. Post-frontal combustion. (MICROSCALE)

• **Challenge 9.** Houses as shelters. Shelter in place. Perceive houses as shelters. Self-protection. Active sheltering. Reinforced houses. (MICROSCALE)
5. Workshop wrap-up

The FINAL workshop of the WUIVIEW project “Wildfire self-protection in the Wildland Urban Interface at home-owner level” has been amazingly welcomed by the wildfire community, with 460 people registered from many different places around the world. Actually we have covered all continents. We have had people registered from North America, South America, Australia, Asia, Africa and of course Europe. This could never have happened in a classic workshop, in the face-to-face workshop that was initially planned in the project to be held at UPC premises in Barcelona. Feelings are mixed in this sense, since we have not being able to greet us all, to benefit from coffee breaks, to catch-up with old friends and new colleagues as well, but, on the other side, we have had the opportunity to reach a wide audience, to share with all types of worldwide WUI fire actors (researchers, practitioners, fire managers, etc.) the work that we have been doing during these last couple of years.

In the FINAL Workshop we have shared and demonstrated the findings and products developed to mitigate fire risk at home-owner level within the framework of WUIVIEW. We have first analysed and discussed the main vulnerabilities at property level; following, we have provided with details on the VAT and SAT check-lists for self-assessment of vulnerability and sheltering capacity and, finally, we have dug into the PBD methodology developed to perform fire safety in-depth analysis at the WUI home-owner level.

Our wish is that, after two years of hard work, we generate real impact in our WUI communities in the not-too-distant future. To achieve so, there is further work to do to upgrade our tools so that they can cover all types of WUI communities (rural, touristic, and even metropolitan communities) and all types of assets and infrastructure (particularly focussing on critical infrastructure). We will have to make a step forward and do demonstrations of improved tools integrated into wider fire risk prevention and preparedness programs with the help and engagement of different fire actors: local civil protection and fire prevention authorities, fire risk managers, municipalities and, of course, residents at the WUI.

Indeed, Europe needs a common framework to empower all stakeholders and foster WUI community resilience in the face of wildland fires. All together we need to build the bespoke EU platform for fire-wise fire-adapted communities to join collaborative efforts across WUI residents, fire agencies, fire practitioners and fire researchers. We need a common framework to develop science-based programs and resources to mitigate fire risk in WUI communities and we modestly believe that, with the WUIVIEW effort, we have contributed to sow the seeds to make this happen.

Finally, we cannot fail to express again our gratitude to the European Commission to believe in our proposal and allow us to have the opportunity to develop WUIVIEW, a challenging but rewarding joint endeavor to reinforce wildfire fire prevention and preparedness across Europe. To the DG-ECHO agency and in particular to Project Officers, thank you all for your support.