Aftermath of WUI fires in Europe: problem-oriented research for structures protection

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WUIVIEW

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Outline

- **Introduction**
  - ✓ The WUI fire problem in Europe
  - ✓ Scales of observation
- **Survey of recent wildland-urban interface (WUI) fires in Europe**
  - ✓ Structure damage and population effects
  - ✓ Summary of lessons observed (factors, processes)
- **Pattern scenarios and research needs**
  - ✓ Definition and analysis approach
  - ✓ Scenarios whish list
    - ✓ Glazing systems and protections, LPG tanks fire exposure, fuel-packs, etc.
  - ✓ Expected outputs

Mati fire, Greece, July 2018
Source: The Guardian (AFP/Getty Images)

Introduction – The WUI fire problem in Europe

- **Climate change** worsening the WUI fire problem throughout Europe
  - More intense wildfires
  - Emergent WUI-fire prone zones in northern latitudes
- **Human pressure** increasing in Mediterranean forests
- **Fire-fighters capacities often exceeded** in WUI fires
  - Wildfire suppression, community evacuation, structure protection!
- **Self protection needed** → better prepared WUI scenarios

↳ **Legislation!**

Vieira de Leiria, Portugal (2017) source: H. Madeiras

Ljusdal, Sweden (2018) source: Reutrers /TT News / M. Anderson

WUIVIEW – Grant Agreement ECHO/2018/826522

Introduction – The WUI fire problem in Europe

- **Lack of regulation / codes in EU** dealing with WUI fire protection
- **Existing legislation and standards** on WUI in other wildfire-prone areas
  - Not developed for European WUI reality (building practices and fuels)
  - Showing weaknesses → not representing current fire exposures
- **Efforts on standardization and policy making are really a must in EU**
  - **RRI** (Responsible Research and Innovation) practices with better linkage between EU-policy makers, researchers and communities.

IAFSS The International Association for Fire Safety Science

Large Outdoor Fires & the Built Environment Working Group (LOF&BE)

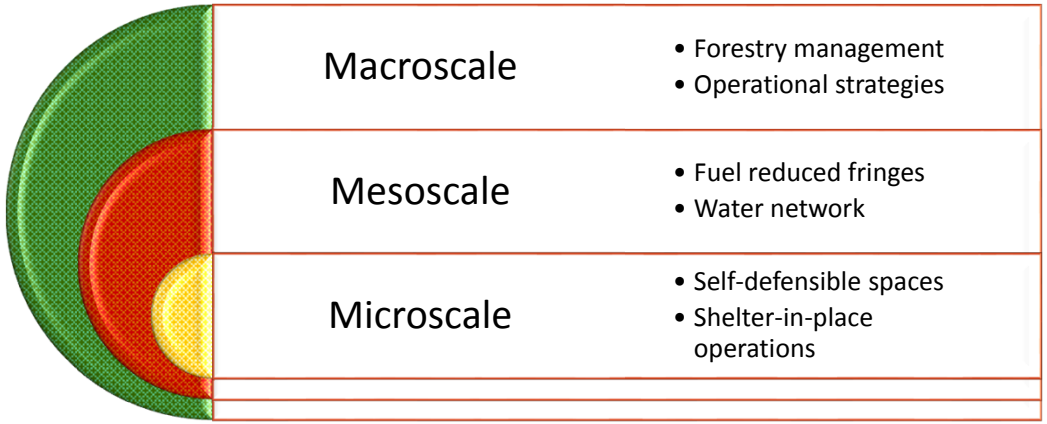
https://iafss.org/committees/large-outdoor-fires-wg/

Manzello et al, 2018

Pastor et al., 2019

Introduction – WUI fires: scales of observation

- How are we **analysing the WUI problem** in EU for better informed policy makers?



Scientific-based recommendations at all scales!

Introduction – WUI fires: scales of observation

- How are we **analysing the WUI problem at the microscale** in EU for better informed policy makers?

The WUIVIEW workflow

Survey of recent WUI fires

Summary of observations

Identification of pattern scenarios

Problem-oriented research needs

Problem analysis

Recommendations

Survey of recent WUI fires in Europe

- 3 killed
- 154 houses severely affected
- Impact at wildland-industrial interface

- **Funchal**, Madeira Island (Portugal, 08/2016)
  - Unprecedented heat wave → strong winds → simultaneous fires
  - Funchal: hilly city→ houses built on ravines surrounded by all types of fuel
  - Poor accessibility to firefighting
  - Small record of historic forest fires in Madeira → ill preparedness of population


Source: Associated Press


Source: D. Caballero


Source: D. Caballero

Survey of recent WUI fires in Europe

- 33 people intoxicated by smoke
- 156 houses severely affected
- Impact at critical infraestructure

- **Rognac** (France, 08/2016)
  - Long draught period (no rain since April) and high winds episode
  - Multiple fires burning simultaneously (high ROS (7 km/h), high spotting activity)
  - Highly touristic zone of the Provence-Côte d'Azur province
  - Close to Marseille critical infrastructure and services


Source: B. Hovart /AFP / Getty Images


Source: B. Hovart /AFP / Getty Images

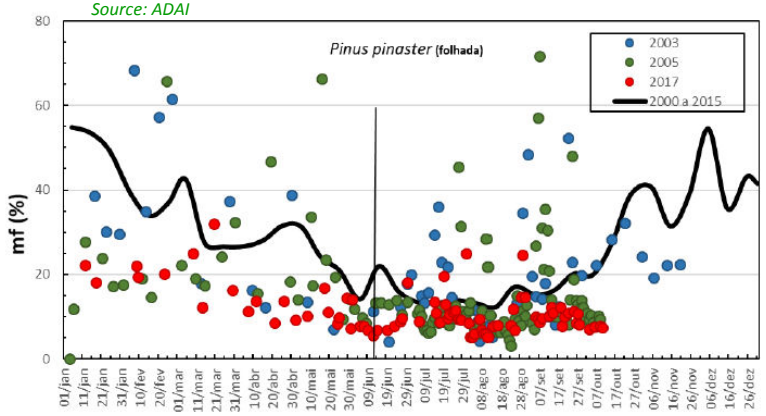

Source: D. Caballero

Survey of recent WUI fires in Europe

- 65 killed
- 1043 structures affected
- 46,000 ha burnt

- **Pedrógão Grande** (Portugal, 06/2017)
  - Long drought period → hydric stress of pine and eucalyptus and low FMC of dead fuels.
  - T =46 ºC, RH < 25%, high atmospheric instability
  - Plume dominated fire with *pyrocumulus* development, followed by a downburst.
  - Damage to structures: mostly support structures, advanced age, absence of fuel management around houses

Source: ADAI



Survey of recent WUI fires in Europe

- 102 people killed
- 2000 houses affected
- Massive car entrapment

- **Mati** (Greece, 07/2018)
  - 80-100 km/h winds unusually blowing from West, aligned with ravines
  - Extreme fire behaviour: mix pattern of houses /dense vegetation with projection of firebrands
  - No evacuation order given → several entrapments
  - Structures affected: single homes, new villas, hotels and blocks of flats

Source: D. Caballero


Source: D. Caballero


Source: The Guardian (AFP/Getty Images)

Survey of recent WUI fires in Europe

- No victims, 2500 evacuated
- 2000 houses affected

- **Llutxent** (Spain, 08/2018)
  - Atmospheric instability helped to quickly create a massive convection column
  - Simultaneity of 5 fires
  - 2,500 people were evacuated the day before the fire impact → better prepared homes
  - Fire visited 3 settlements (10 houses completely destroyed)


Source: D. Caballero


Source: D. Caballero


Source: D. Caballero


Source: D. Caballero

Survey of recent WUI fires in Europe

- 1 killed
- 71 structures affected
- 14,000 ha burnt

- **Västmanland** (Sweden , 07/2014)
  - Long and deep drought period (affecting live and dead fuels – including moss!)
  - Rapid spread and intensity of the wildfire → no chance for mitigating actions
  - Ignition of structures: direct flame impingement to the façade (combustible)
  - Better mitigation strategies could have significantly increased survivability of buildings


Source: unknown


Source: RISE

Survey of recent WUI fires in Europe

Summary of recent WUI fires in Europe

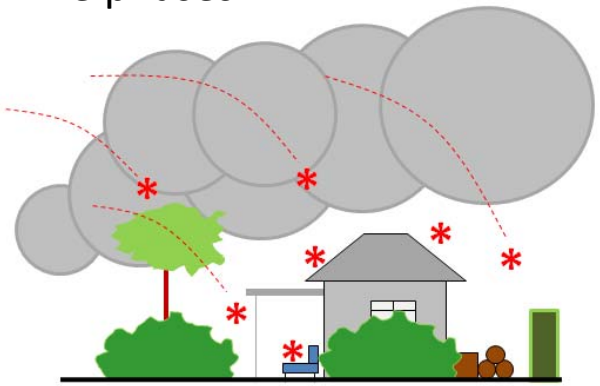
Fire / Date	Structure damage	Effects on population
Funchal, Portugal (09/08/2016)	37 structures destroyed 154 houses affected	3 fatalities 200 injuried
Rognac, France (10/08/2016)	24 houses destroyed 156 structures affected	No fatalities
Pedrógão Grande, Portugal (17/06/2017)	1000 structures affected	65 fatalities 200 injured
Mati, Greece (23/07/2018)	2000 houses affected 700 severely damaged or destroyed	102 fatalities 200 injured 4000 affected
Llutxent, Spain (07/08/2018)	50 structures affected	No fatalities
Västmanland, Sweden (31/07/2014)	71 structures affected	1 fatality 1 seriously injured

- Climate change
- Human pressure
- Exceeded fire-fighting capacity
- Large impact on structures and population

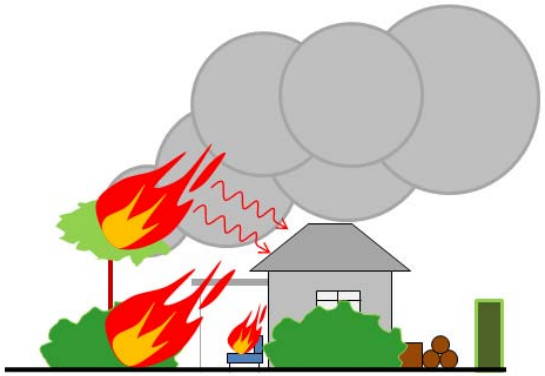
Lessons learnt?

WUI fires in Europe – lessons learnt at microscale

- WUI fire phases



1. Pre-arrival of the wildfire front



2. Fire front impact

1

- Smoke, firebrands → ignition of residential fuels
- Hot air → desiccating effect of fuels

2

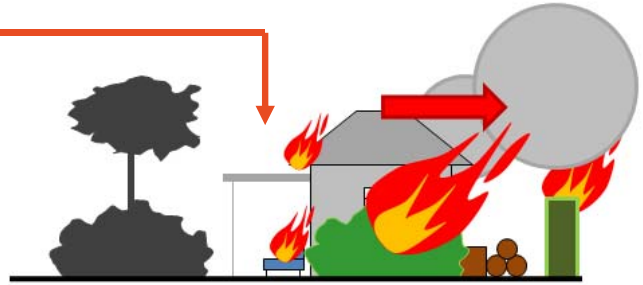
- Flame radiation / direct flame contact
- Ignition of residential fuels and structures

3

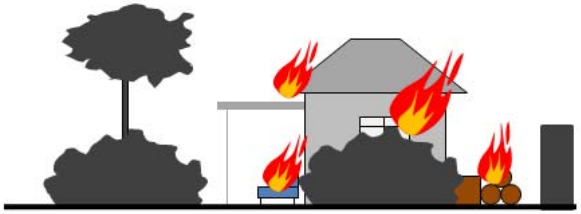
- Fire propagation into neighbouring lots
- Firebrands and corridors of natural fuels

4

- Flaming / smouldering



3. Fire percolation



4. Postfrontal combustion

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WUI fires in Europe – lessons learnt at microscale

➢ Why do actually our houses **burn** if they are generally made of **non combustible** materials?


Source: D. Caballero


Source: D. Caballero


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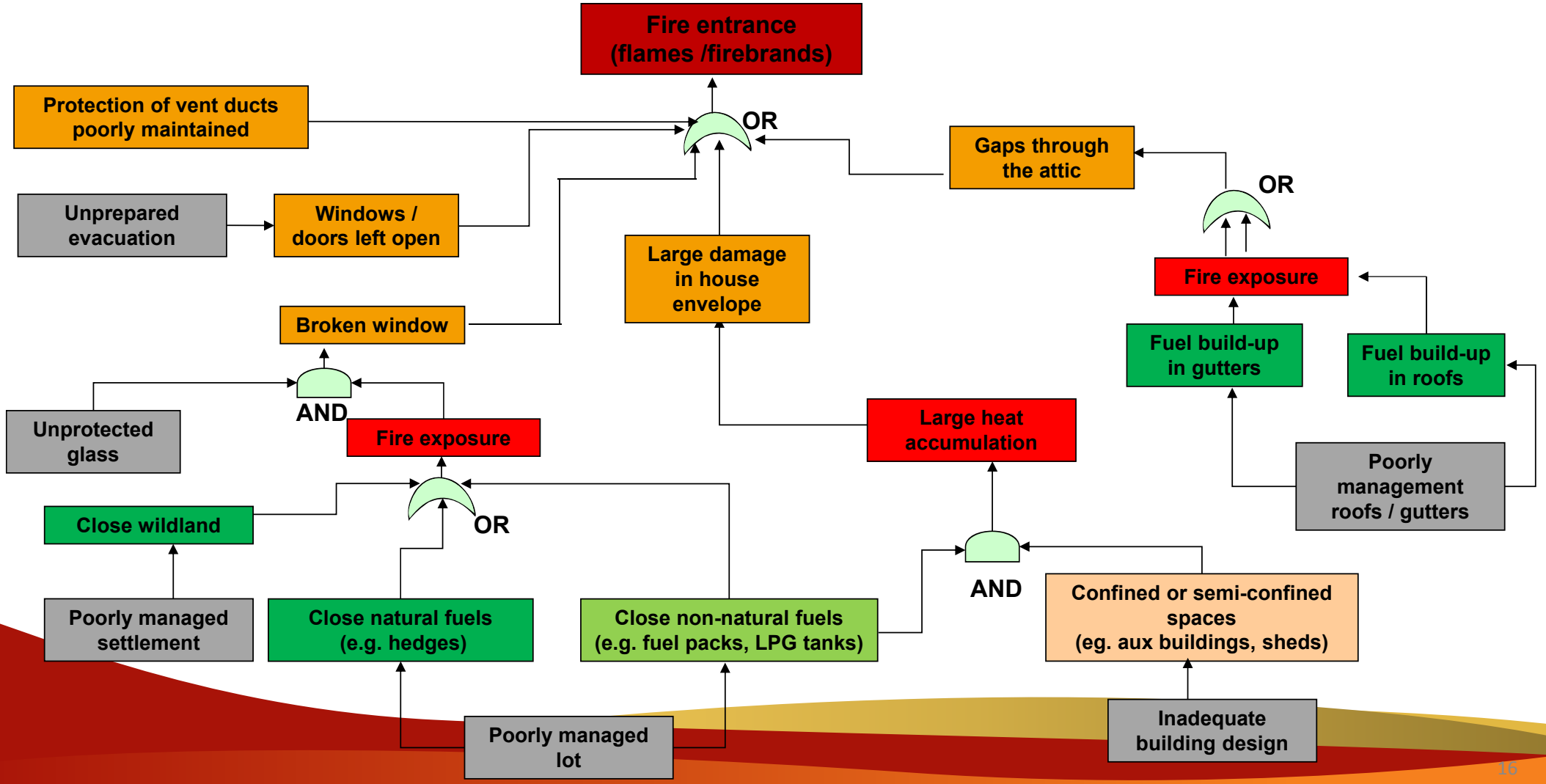
Source: D. Caballero

Little details matter!

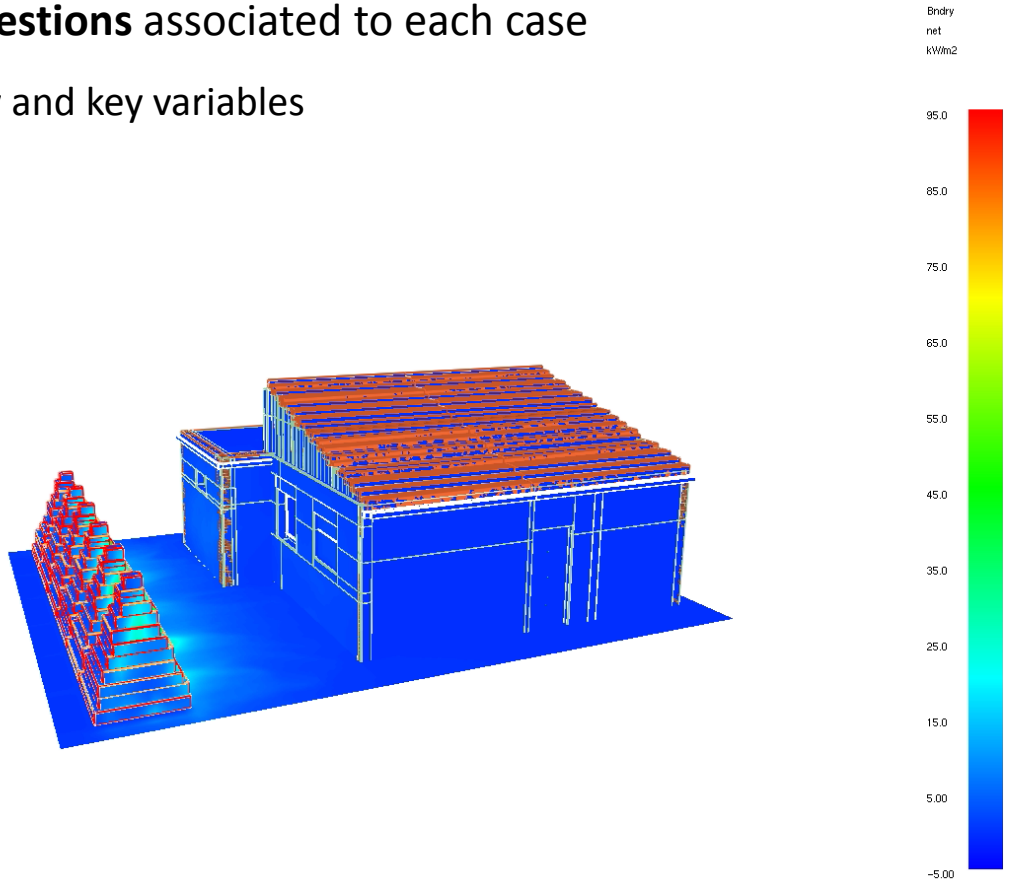
WUI fires in Europe – lessons learnt at microscale



Pattern scenarios and research needs – the appraoch

- Inventory of simplified **pattern scenarios** with **research questions** associated to each case
  - Idealisation of particular situations with simplified geometry and key variables
  - Different types of fire sources / building systems

- The WUIVIEW analysis method
  - **CFD simulations** coupled with fire experiments to characterize particular fire sources
    - Physics based modelling
    - Well-established fire protection engineering tool (FDS)



Pattern scenarios and research needs – the appraoch

- Inventory of simplified **pattern scenarios** with **research questions** associated to each case
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  - Different types of fire sources / building systems

- The WUIVIEW analysis method
  - CFD simulations coupled with **fire experiments** to characterize particular fire sources
    - Natural and non natural fuels
    - Heat Release Rate and flame geometry

Pattern scenarios and research needs – whishlist

- Glazing exposure to radiation and flame impingement
- Degree of protection of blinds / shutters
- LPG tank exposure to nearby wildland fire / combustion of residential fuels
- Fuel pack combustion in semi-confined arrangements
- Fire propagation over green hedges and ornamental elements

Pattern scenarios and research needs - glazing

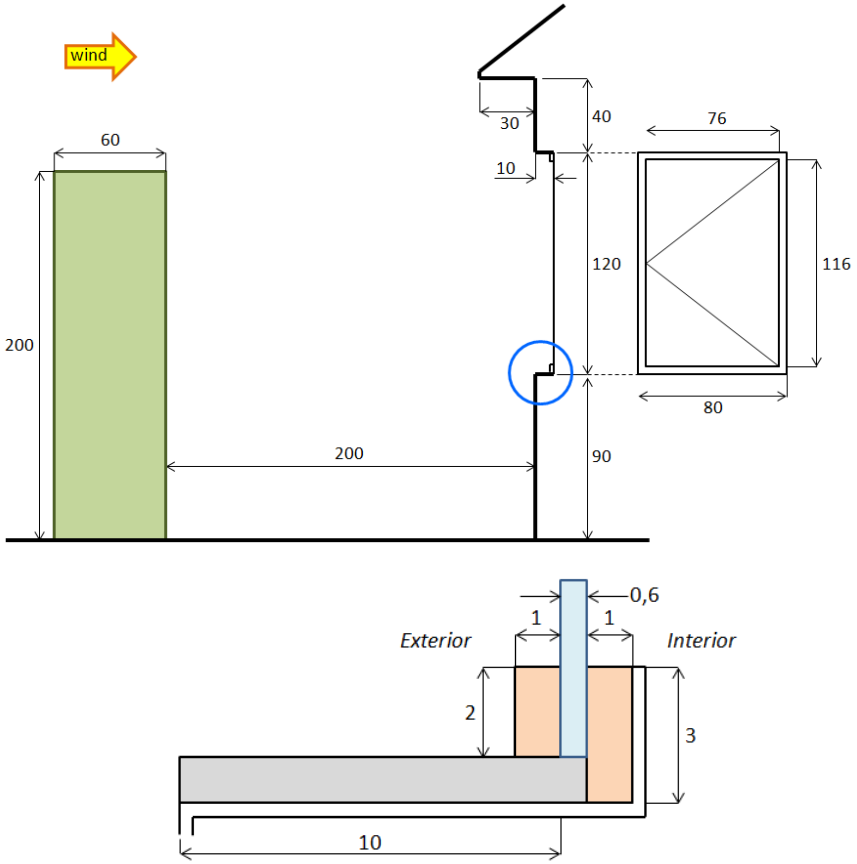
- **Glazing** exposure to radiation and flame impingement
  - Windows are one of the most exposed elements
  - Cracking: flame impingement or ΔQrad
  - Collapsing: quick HHR or glass sealing is degraded
  - Melting: longer exposures


Source: D. Caballero


Source: D. Caballero

Pattern scenarios and research needs - glazing

- **Glazing** exposure to radiation and flame impingement
  - Which type of residential fuel can provide enough heat to cause damage to windows?
  - At what minimum distance have to be fuels and windows separated?
  - Under which conditions can a wildfire damage glazing systems?
  - Key variables: type of fuel, window geometry and materials, wind speed.



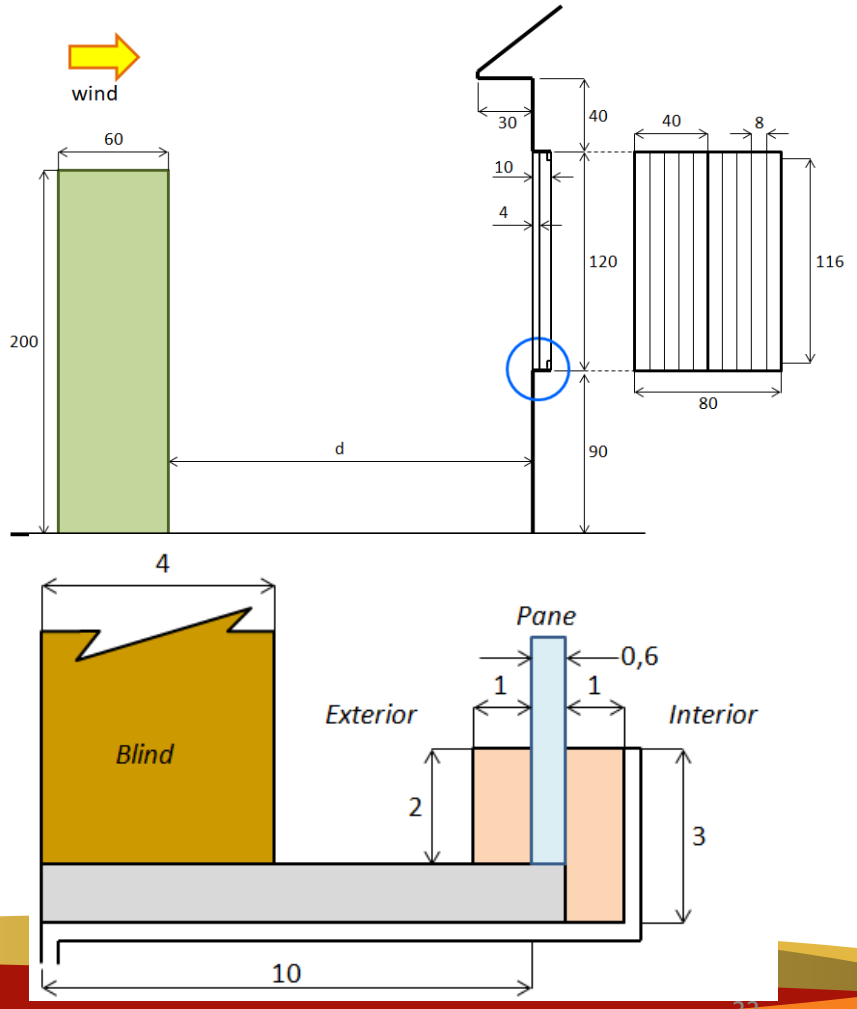
Glazing single pane mounted on a timber frame in a window box separated from a green hedge under wind conditions

Pattern scenarios and research needs – blinds

- Degree of protection of **blinds / shutters**
  - Windows protection to sunlight …and fire?
  - Rolling shutters (aluminium or PVC)
  - Timber or metal swinging blinds

Pattern scenarios and research needs – blinds

- Degree of protection of **blinds / shutters**
  - Windows protection to sunlight …and fire?
  - Rolling shutters (aluminium or PVC)
  - Timber or metal swinging blinds
  - ➢ Which is the protection effect of blinds and shutters?
  - ➢ Under which scenarios PVC may melt o timber blinds may sustain combustion?
  - ➢ Key variables: type of fuel, window and blind/shutter geometry and materials, wind speed.



Timber blind of double swing sheet placed in the border of a window case separated from a green hedge under wind conditions

Pattern scenarios and research needs – LPG tanks

- **LPG tank** exposure to WUI fire
  - Affordable way to provide fuel for house services
  - Surface tanks are often placed close to buildings and fuels
  - Fire exposure → tank overpressure → jet fire
  - BLEVE / fireball explosion?


Source: KABC - TV

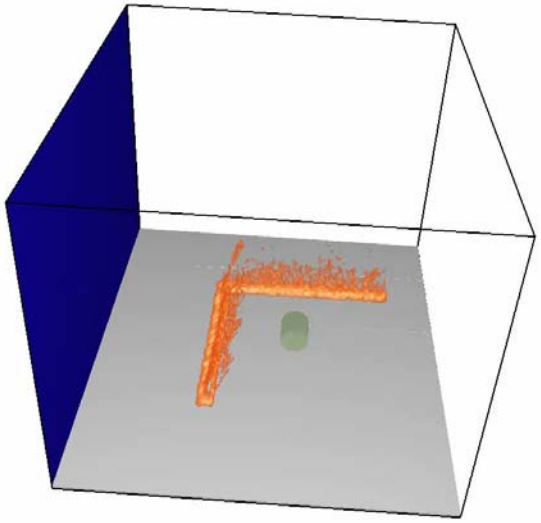

Source: D. Caballero

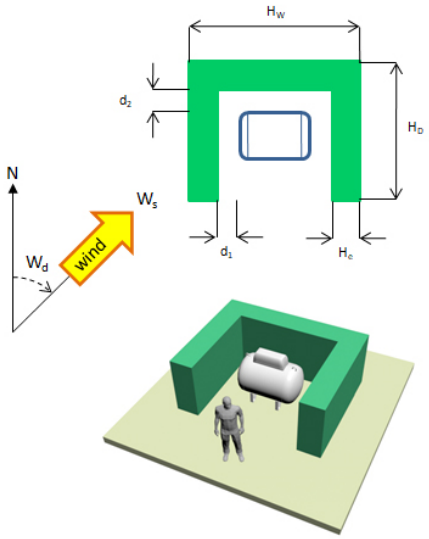

Source: D. Caballero

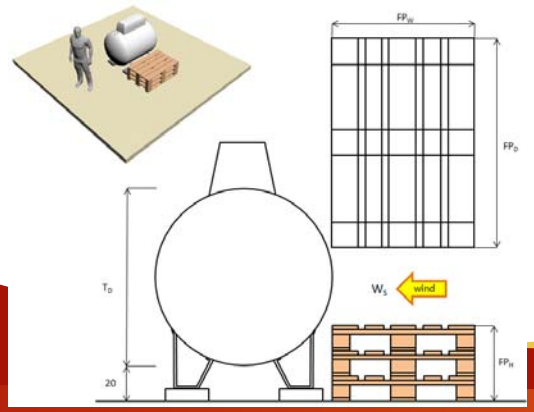

Source: D. Caballero

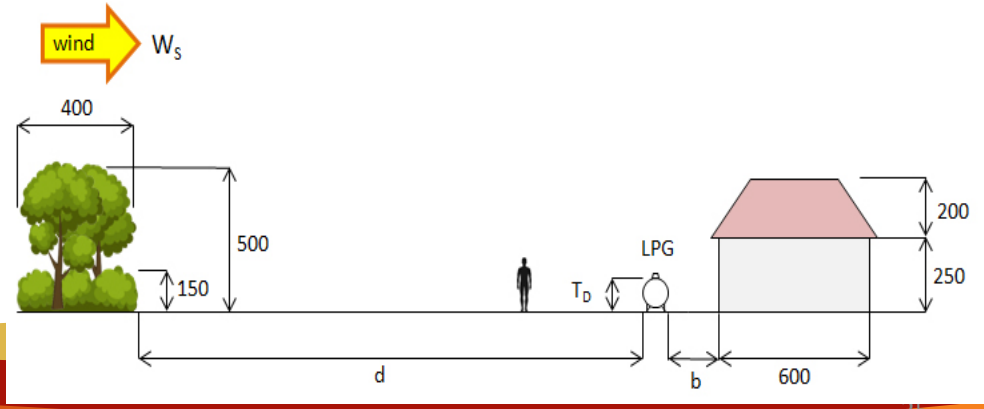
Pattern scenarios and research needs – LPG tanks

- **LPG tank** exposure to WUI fire
  - ➢ What fire sources/distances could entail tank overpressure leading to the opening of SRV?
    - ➢ Incoming forest fire front?
    - ➢ Green hedges? Packed fuels?
  - ➢ Key variables: heat sources, distances, tank dimensions and filling degree.



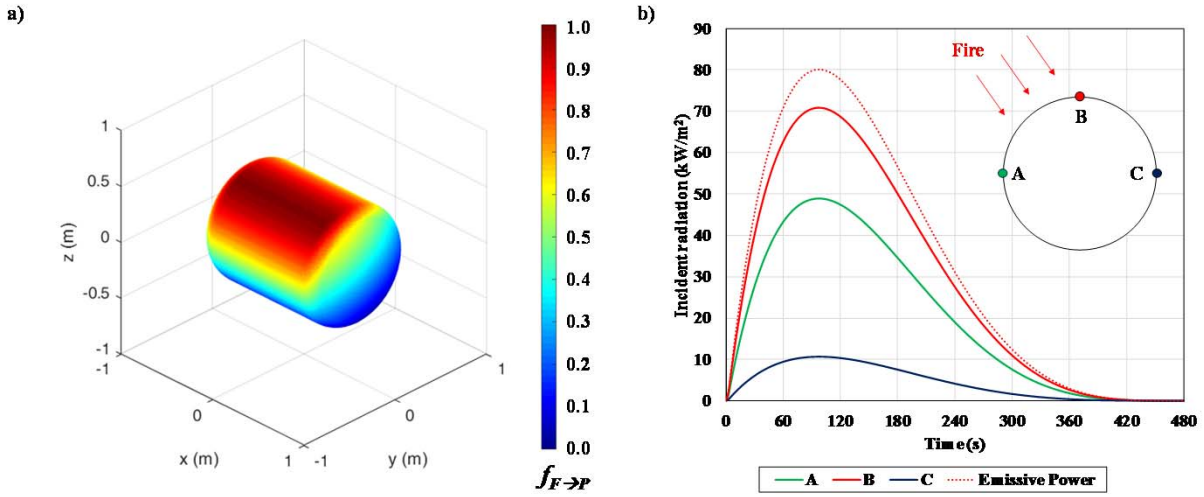


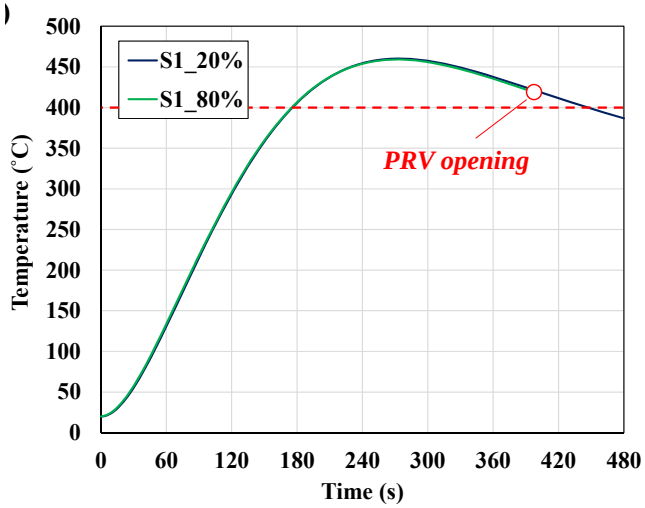




Pattern scenarios and research needs – LPG tanks

- **LPG tank** exposure to WUI fire – preliminary results





1 m3 LPG tank exposed to an unmanaged undeveloped neighbouring plot

Scarponi et al., 2019

Pastor et al., 2019

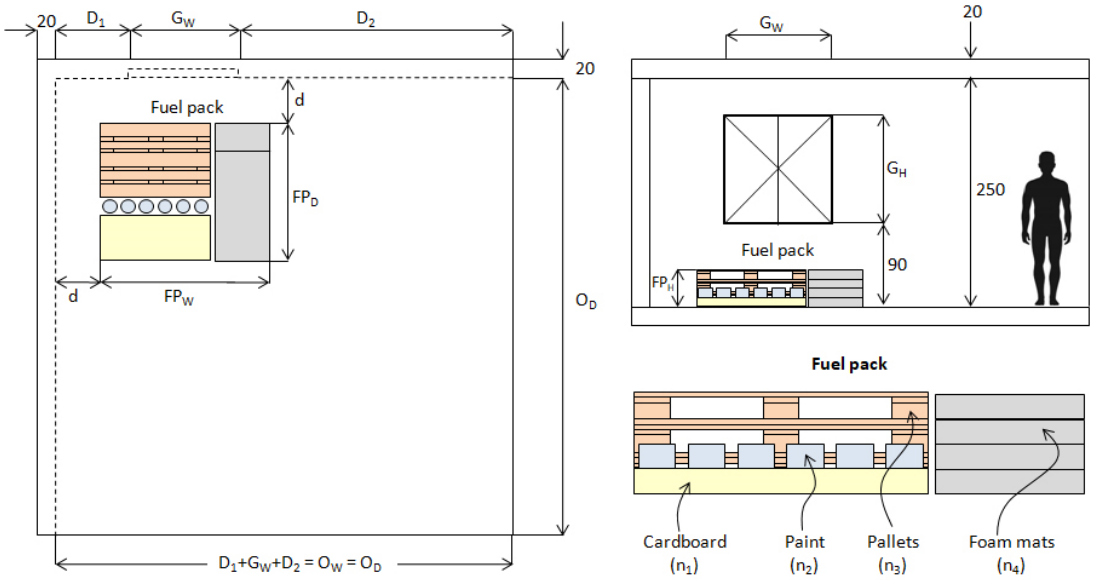
Pattern scenarios and research needs – Fuel-packs

- **Fuel pack** combustion in semi-confined arrangements
  - Accumulation of all sorts of objects (timber pallets, oil cans, plastic containers, furniture, etc)
  - Semi-confined spaces or secondary structures as extensions of the main building (inside corners, under light structures, etc.)
  - Heat accumulation may jeopardize the main structure (combustion transfer to the main body of the house)

Pattern scenarios and research needs – Fuel packs

- **Fuel pack** combustion in semi-confined arrangements
  - Critical fire load / geometry to develop flashover in semi-confined spaces?
  - Time to flashover? Effects on vulnerable elements?
  - Heat and temperature profiles at the corners?
  - Key variables: fire load, semi-confined arrangement

Overhanging porche forming a semi-enclosed environment with a fuel pack placed near the corner



Pattern scenarios and research needs – Hedges

- Fire propagation over **green hedges** and ornamental elements
  - Green hedges play a key role in the propagation of fire inside a settlement.
    - Hedge axis coinciding with the main wind direction
  - Hedges of cypress family propagate flames easily
    - Inner dead fine fuel (type of specie and gardening treatment)

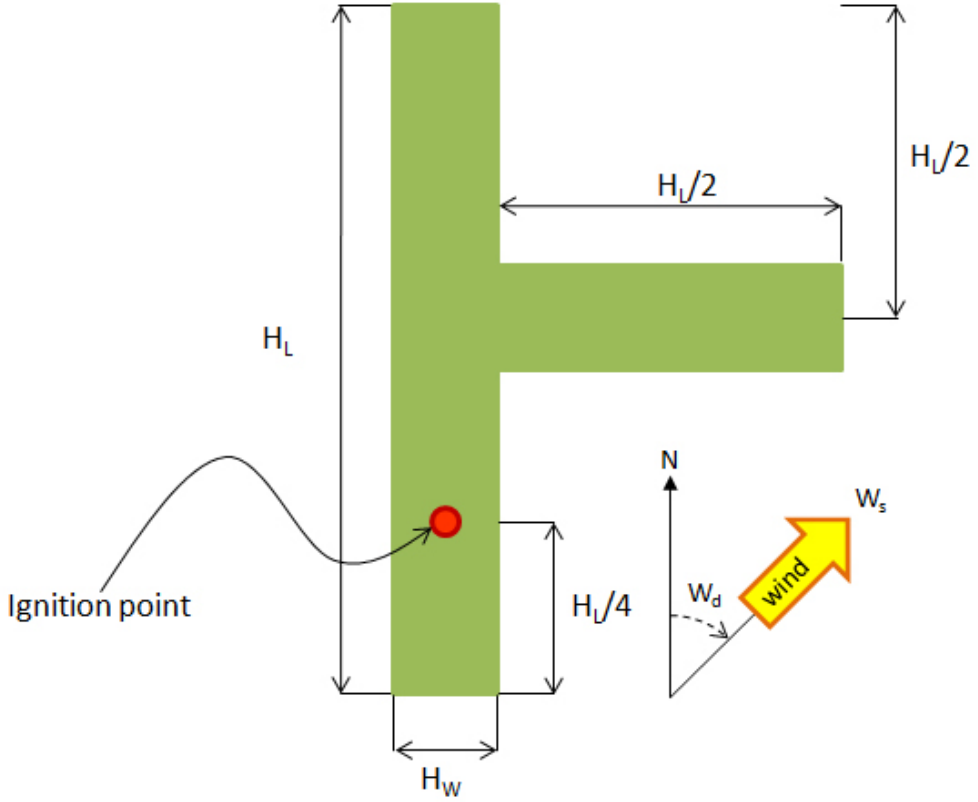

Source: D. Caballero


Source: D. Caballero

Pattern scenarios and research needs – Hedges

- Fire propagation over **green hedges** and ornamental elements
  - Fire dynamics? ROS, flame length, heat release rate, etc.
  - Effect of wind?
  - Effect of hedge geometry?
  - Proportion of dead/live fuel?

Cupressus arizonica in a "T" shape representing the border between two lots.



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Pattern scenarios and research needs –Outputs

EXPECTED OUTPUTS

- ✓ Data on fuels hazard and buildings vulnerabilities
- ✓ Modelling codes and guidelines
- ✓ Recommendations for regulations improvement
- ✓ Educational and scientific pubs

EXPECTED RESULTS

- ✓ Improved knowledge and awareness to all fire actors
- ✓ New capability to assist fire safety design

EXPECTED FOLLOW-UP

- ✓ Consultancy service to manage WUI fire risk in vulnerable communities

Take-home messages

- **Self-protection** is a real need. Communities have to get **clear messages** of how to prepare their homes to face WUI fires.
- The WUIVIEW project proposes an analytical method to take the most out of the **lessons learnt in past fires**. We have identified **patterns, factors and processes** responsible of homes damages and we are analysing those through **CFD simulations.**
- CFD engineering is a **powerful and flexible tool** that allows playing with different ranges of **key variables**.
- Outcomes will contribute to the WUI fire community with **scientific-based answers** of how to make **safer microscales** better adapted to incoming **climate change fire scenarios.**

Thanks for your attention!

More information:

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