Challenges and gaps in modelling the thermo-mechanical performance of glass-glass BIPV modules exposed to fire accidents

Integrated Photovoltaic Conference

UNIVERSITÀ DEGLI STUDI DI TRIESTE

Dipartimento di Ingegneria e Architettura

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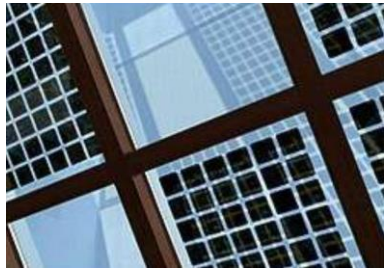
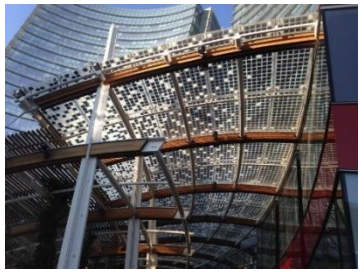
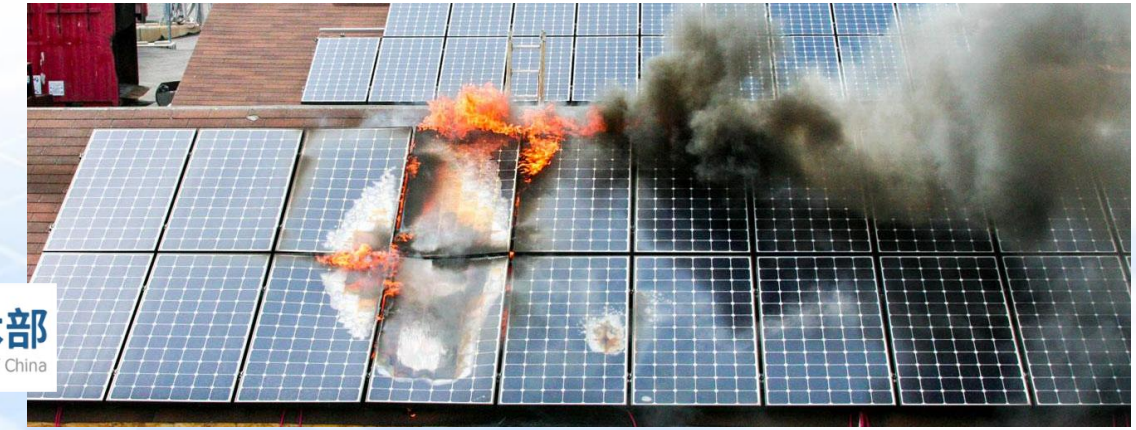
Introduction

- High vulnerability of BIPV solutions to extreme design loads, such as fire
- Need of robust startegies for both experimental and numerical validation, especially against fire conditions
- Need of additional technical knowledge for understanding (and improving) resisting and failure mechanisms under extreme conditions
- All these research activities are part of the running «Particular Relevance» Italy-China «3FiRES» bilateral project (2024-2025)

https://3fires.dia.units.it/







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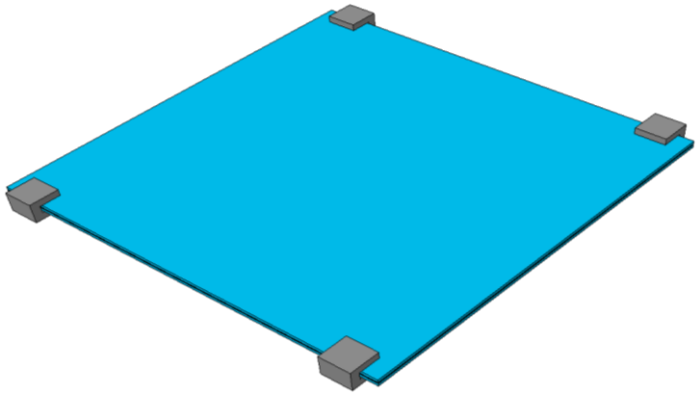
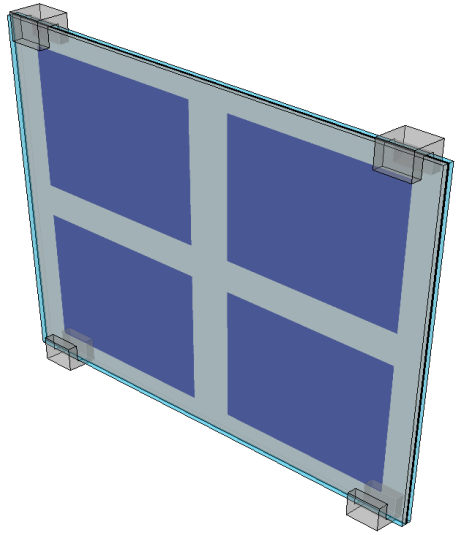
Typical scenario



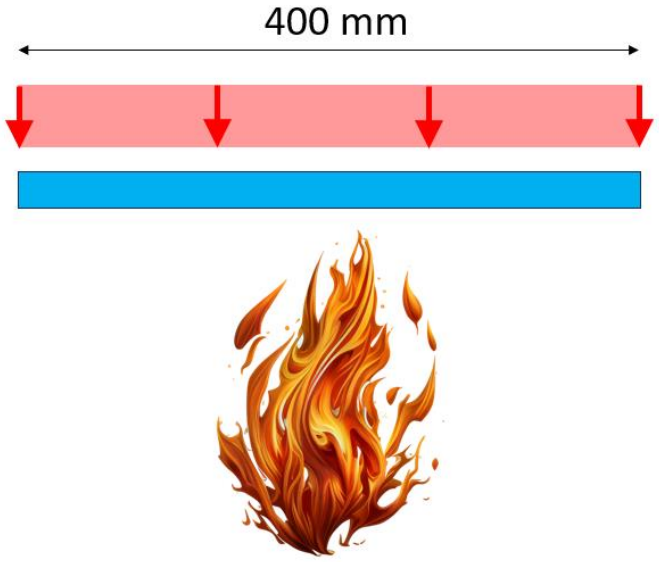


Challenges:

- Vulnerable materials (glass)
- Thin glass-glass BIPV systems
- Size effects
- Several possible configurations of mechanical boundaries
- Thermal loads due to fire
- Superimposed mechanical loads

Gaps:

- Lack of standardized performance indicators to capture and predict thermal shock, progressive damage and failure in fire
- Lack of procedures for a robust numerical modelling and analysis (in support of experiments)



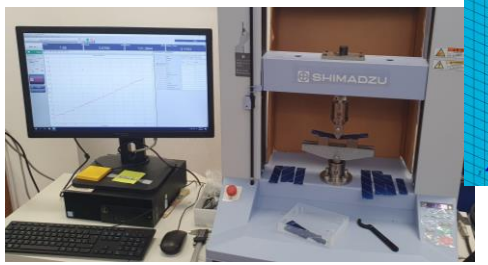
Mechanical load
Self weight

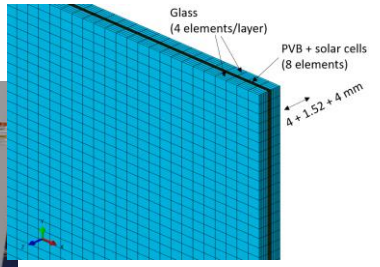
PV module
4+4 glass
1.52 PVB + solar cells

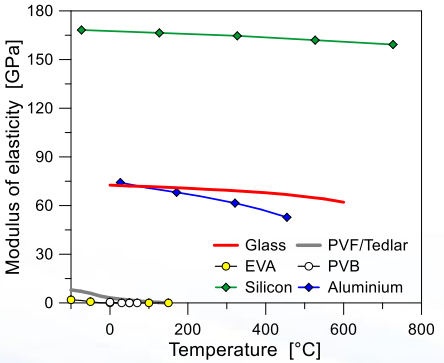
Fire
Standard time-temperature curve

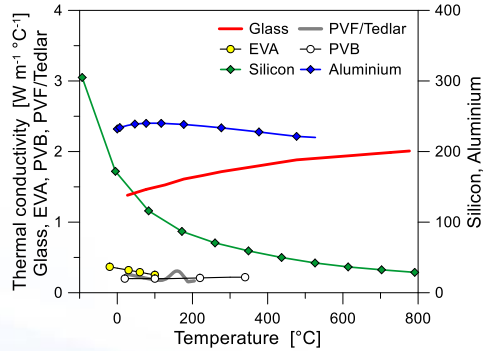
Thermo-physical and mechanical calibration of BIPV components

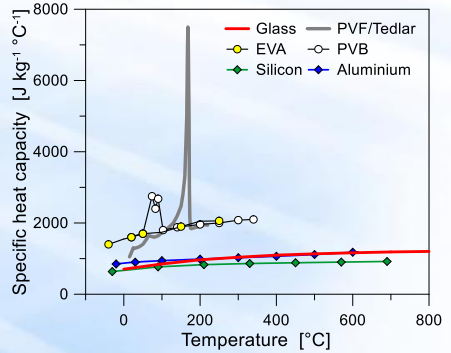
- Material analysis (glass, encapsulant, cells, frame, restraints,
  - ✓ literature data
  - ✓ new experiments
- Characterization of components and systems under
  - ✓ ordinary operational conditions
  - ✓ high temperatures
- Analysis of thermo-mechanical (+ electrical) performances and analysis in fire conditions
- Definition and calibration of possible performance indicators
- Elaboration of mitigation strategies for improving the resisting mechanisms of BIPV systems in fire



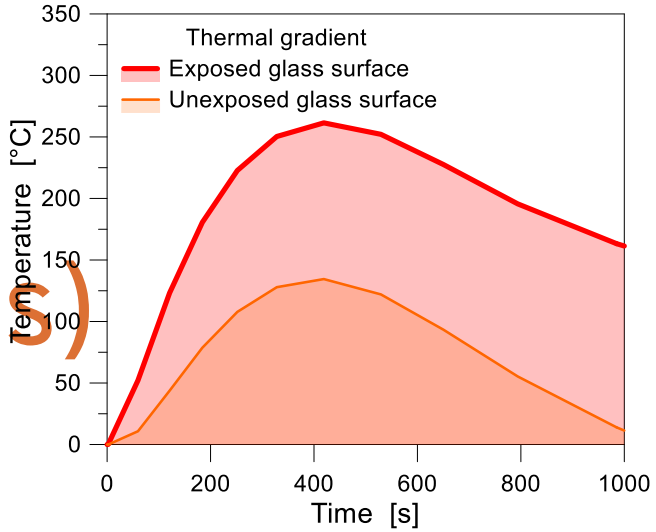


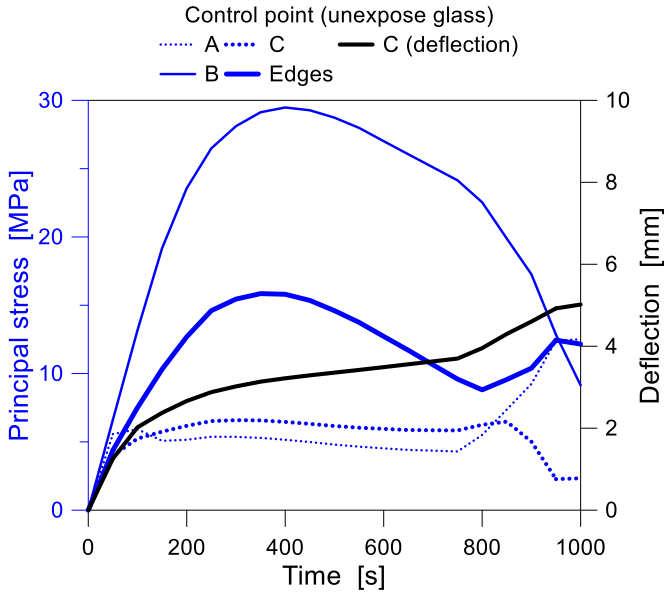






Results (in progress)



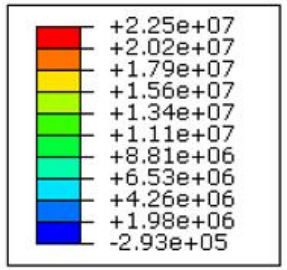


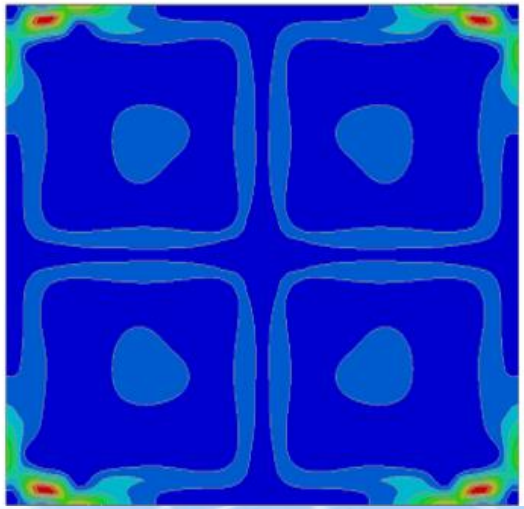
Performance indicators:

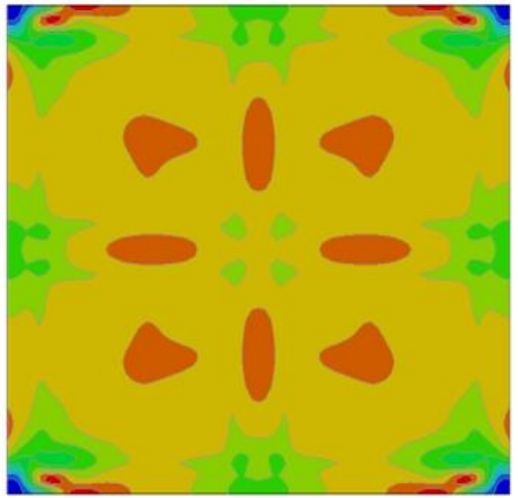
Min

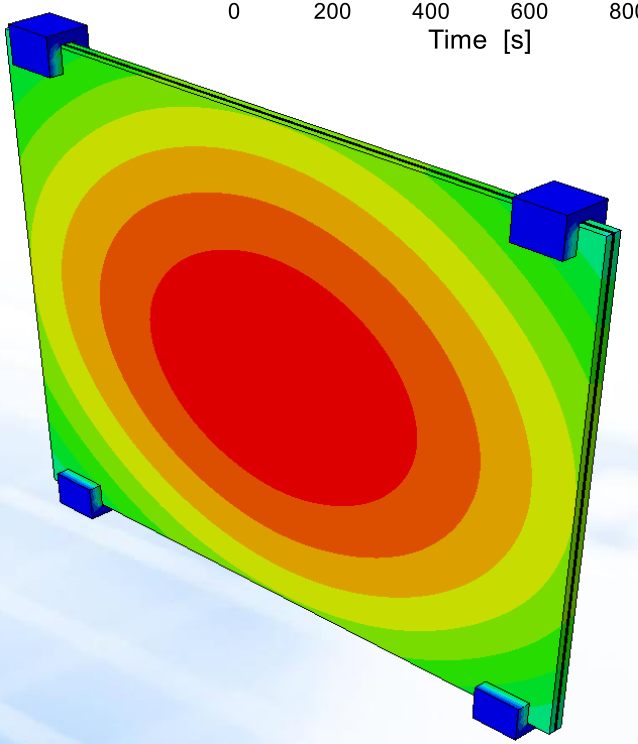
- Thermal gradient (for thermal shock only)
- Thermal + mechanical stress evolution
- Deflection
- Delfection rate

? Limit values?







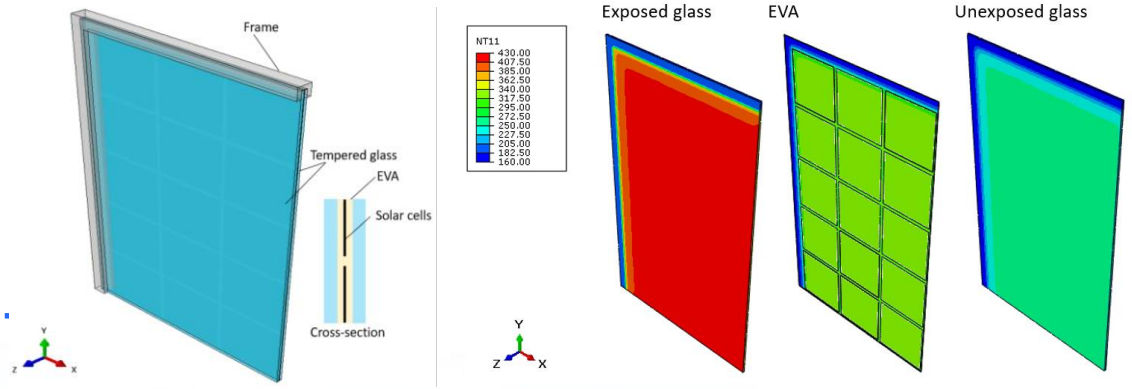


Results (in progress)

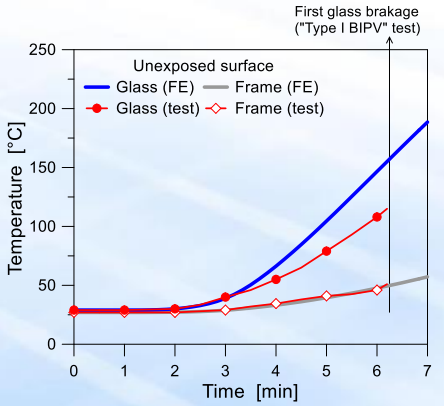
(a) Thermo-mechanical & Electrical experiments

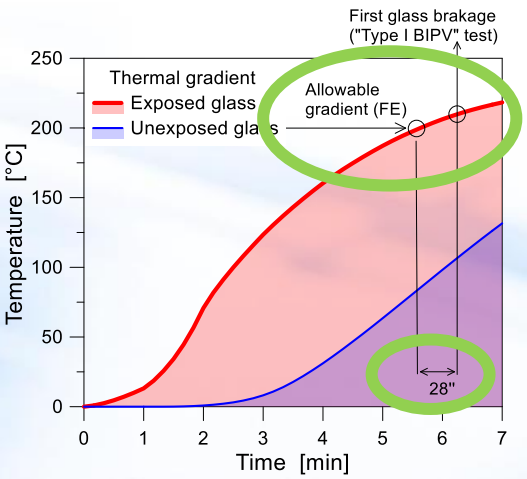
(b) Literature experiments for BIPVs in fire

(Huang et al. 2017)



(c) New experiments for BIPVs in fire (2025)





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Thank you!

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This is an initiative of

Seamless-PV

Co-funded by the European Union

Grant N°101096126. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.

Project funded by

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
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Federal Department of Economic Affairs, Education and Research EAER
State Secretariat for Education, Research and Innovation SERI