Fire Safety Requirements of the application of BIPV in Australia

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- **Introduction**

While the energy consumption caused by buildings has been occupied a substantial percentage, Solar PV has applied widely in global area as one of cost-effective resolution. Specially, building-integrated photovoltaic (BIPV) as one of new techniques has been applied to build environments widespread (Mazziotti, L., et al, 2016). The integration of PV panel on buildings means the PV panel replaces conventional building materials serviced on the building roof or façade (Biyik, E., et al 2017). This aesthetic design can improve the electrical generation by PV panels due to the expansion of the area of PV panels (Zhang, T., Wang, M., and Yang, H., 2018). However, a significant potential hazard of the application of BIPVs is fire safety due to characteristics of BIPVs (Skandalos, N., et al 2022). It is important to realise what causes the fire hazards of BIPVs, and how can mitigate these fire hazards.

The aim in this research is to understand the fire safety requirements regarding the application of BIPV on building facade and roofs. This research except following aspects:

1. Mechanical resistance and stability of the BIPV module and system.
2. Hygiene, health and the environment.
3. Safety in use.
4. Protection against noise.
5. Energy economy and heat retention.
6. Sustainable use of natural resource.
7. Electrical properties (other than as a possible ignition source).

- **Solar panel fire hazard in Australia**

Australasian Fire and Emergency Services Authorities Council (AFAC) completed a statistic regarding fire incidents caused by solar panels. The statistic result presented 400 fire incidents involving solar PV arrays during 2009 to 2015.

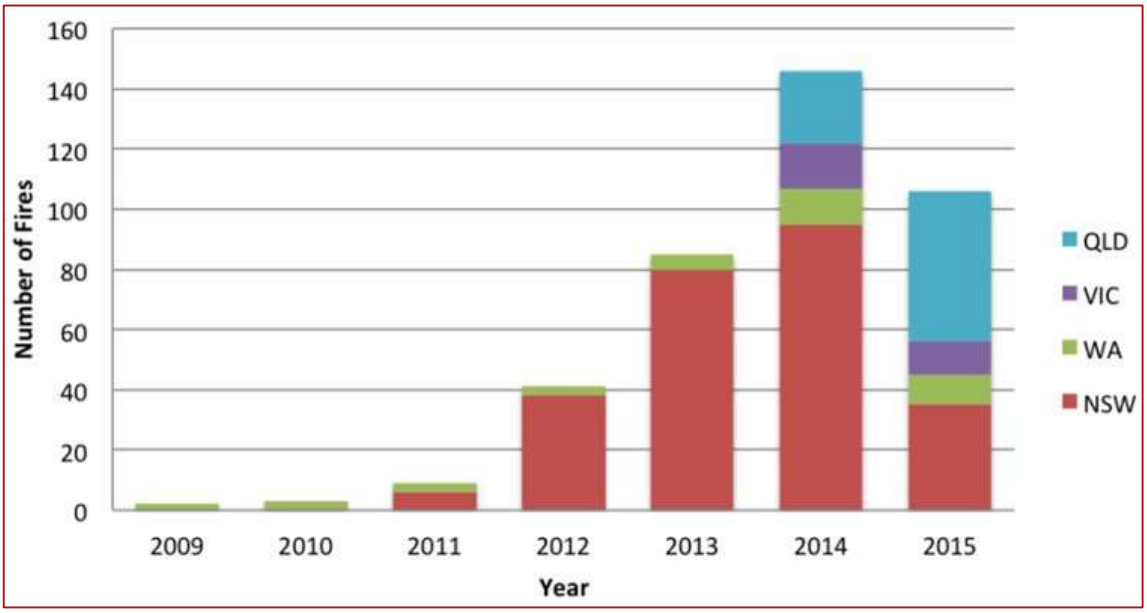

Figure 1: Solar panel-related fires in the different Australian States from 2009 to 2015 (ATA, 2016)

The above figure presents an increasing of the installation of solar panels in Australia. In NSW and VIC, the number of fire cases related to solar panel constantly increased from 2011 to 2014. The similar trend in QLD appeared from 2014 to 2015. Another data illustrated the main reasons to cause fire incidents. Figure 2 showed that multiple electrical reasons can result in the fire safety issue. In particular, the main reasons caused ignition of BIPV modules are hot-spots, arcing, and installation errors.

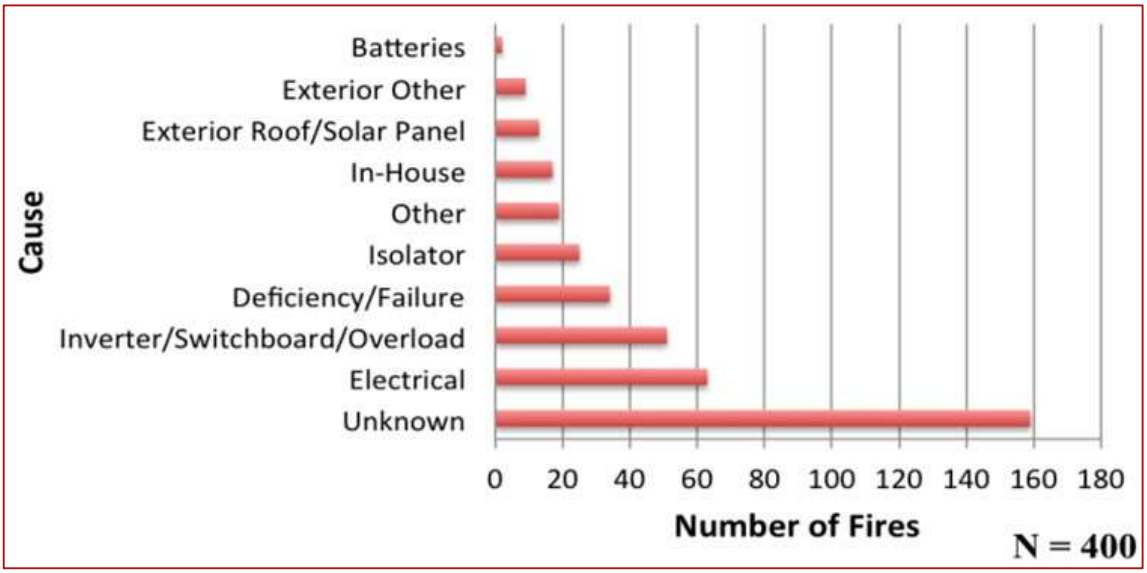

Figure 2 Causes of solar panel-related Fires in Australia, 2009 to 2015 (ATA, 2016)

- **Fire safety requirements for BIPV as a building element in NCC**

In NCC, according to fire resisting level, buildings are classified to three types, titled Type A, Type B, and Type C. While Type A requires the highest level of fire resistance, the fire resisting level in Type C is lowest. Both building classification and building height determines the construction type of the building (Yang, R. et al. 2023).

Table 1 Types of construction (ABCB, 2019)

Rise in storeys	Class of building (2, 3, 9)	Class of building (5, 6, 7, 8)
4 or more	A	A
3	A	B
2	B	C
1	C	C

To satisfy fire safety requirement in NCC, the building with BIPV application must satisfy the Performance Requirements in NCC. The Performance Requirements can be satisfied by using one of the following methods, including (i) A performance solution; (ii) a Deem-to-Satisfy (DtS) solution; and (iii) a combination of performance solution and DtS solution. Meanwhile, the combination of these method also be accepted to be used to justify the Performance Requirements.

In relation to BIPV applied as external wall on building facade, Performance Requirements of CP2 and CP4 should be complied with. To satisfy these Performance Requirements, Clauses C1.9(a)(i), C1.14(a), C2.6, C2.12, and clause C2.4 of Specification C1.1 should be considered for Type A and B construction to satisfy Deemed-to-Satisfy Provisions. Additionally, Verification Method CV3 also must be considered.

For BIPV roofs, while BIPV roof is possible to accelerate the fire spread on the rooftop, it is significant to ensure BIPV roofs comply with relevant Performance Requirements in NCC. Although NCC has no requirement of non-combustibility of roof, BIPV roofs must follow with the FRL of roof for Type A construction.

- **4. Recommended tests for BIPV applied on buildings**

The following fire tests need to be considered for application of BIPV in buildings in Australia (Yang, R. et al. 2021):

1. Fire resistance (ISO 834-1, ISO 834-3, ISO 13501-5:2005, AS 1530.1-1994, AS 1530.4:2014)
2. Reaction to fire (ignitability) (ISO 5657, ISO 11925-2:2020)
3. Horizontal and vertical fire propagation (AS 5113, BS 8414-2, ISO 13785-2)
4. Critical heat fluxes, heat release rate and smoke production. (ISO 5660-1:2015+A1:2019, ISO 9705-1:2016)

To explore the characteristic of fire resistance it is necessary to complete the fire test of fire resisting level. Internationally, ISO 834-1, ISO 834-3, ISO 13501-5:2005 are complied with widely. AS 1530.1-1994, AS 1530.4:2014 are the relevant test methods in Australia.

The possibility of ignitability is used to justify reaction to fire. The test methods of ignitability include ISO 5657 and ISO 11925-2:2020.

As the mention above, the fire spread on external wall should be considered in terms of NCC. In Australia, the fire propagation testing in the standard of AS 5113:2016 can be used to classify external walls of buildings according to their tendency to limit the spread of fire via the external wall and between adjacent buildings. AS 5113 refers to BS 8414-1, BS 8414-2 and ISO 13785-2 as acceptable test standards.

Critical heat fluxes, heat release rate and smoke production are main characteristic to determine fire performance. To ensure critical heat flux, ISO 5660-1:2015+A1:2019 is one of main test methods. Additionally, ISO 9705-1:2016 is the test to evaluate heat release rate and smoke production.

- **Conclusion**

In Australia, the concern of fire safety caused by BIPV has been widely realised. However, there is no specific requirement regarding BIPV fire safety NCC for the application of BIPV on buildings. Referring conventional building elements, BIPV applications must comply with Performance Requirements of CP 2 and CP 4.

To mitigate the fire risk of BIPV applications, the following aspects must be fully considered.

- For Type A and B constructions, the following Deem-to-Satisfy Provisions in the BCA must be considered including C1.9(a)(i), C1.14(a), C2.6, C2.12, and C2.4 Specification C1.1.
- It is necessary to evaluate the fire performance of BIPV application via multiple fire tests, including (i) fire resistance test; (ii) reaction-to-fire test (ignitability); (iii) vertical and lateral fire propagation; and (iv) critical heat fluxes, heat release rate and smoke production.

- **Reference**

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