

# Abstract

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The fire spread under photovoltaic (PV) panels and the required spacing between PV arrays on flat roofs were studied experimentally in a custom-made set-up that represented a partial roofing segment. The roof segment was constructed by placing roof membrane on incombustible boards mounted on aluminum frames. A 10 cm by 10 cm by 6 cm wood crib was ignited under a PV panel in the experimental setup, providing a 7 kW to 10 kW ignition source. Heat flux values, heat release rate, fire spread, and temperatures were measured in the tests. Heat flux gauges were installed under and outside the PV panels to measure the fire risk under and away PV panels. The tests showed that the fire can burn stronger and grow faster under PV panels. For example, the fire under the PV panel could produce a 141-kW fire while only 5 kW was measured without panels. Nevertheless, the fire can burn less severe under burned PV panels, for instance, only 16 kW was measured under burned panels whereas 93 kW was observed under new panels, meaning the panel condition can influence the test outcome. The risk of fire spread between PV arrays is low on flat roofs when wind effects and roof orientation are not considered. The fire spread away the panels was little and the fire extinguished shortly after spreading outside the panels during the tests. The length of fire spread away panels remained small regardless the position of ignition source. Additionally, the risk of distant ignition was low based on the test results. The fire risk under PV panels can be mitigated by increasing the gap distance between panels and roofs. It was also found that the extraction flow of the exhaust hood can influence the burning under PV panels and the fire can be underestimated when testing with burned PV panels.

## Abstract (Chinese)

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本論文以實驗方式研究平面屋頂火災在太陽能光電板下的蔓延以及太陽能板所需的防火間隔。實驗設置係使用不燃材料隔板，隔板置放於訂製的鋁架上，並於隔板上鋪設屋頂防水膜以模擬局部平面屋頂。在屋頂膜上點燃一個 10 乘 10 乘 6 公分的木材堆來模擬火源。熱通量(HF)、熱釋放率(HRR)及火勢蔓延在實驗中被觀察及紀錄。熱通量計(HFG)安裝在太陽能板下及其外，以瞭解火災在太陽能板下及其外之危害。實驗顯示火在太陽能板下燃燒更強大且成長更迅速，舉例來說，火在太陽能板下的熱釋放率是 141 kW，而沒有太陽能板的時候卻只有 5 kW。然而，若重複使用太陽能板於燃燒實驗，火勢則較使用新太陽能板為弱，例如重複使用太陽能板於燃燒實驗時，測得 16 kW 的熱釋放率，而使用新太陽能板於實驗時，卻測得 93 kW 的熱釋放率；代表太陽能板的條件可能影響實驗結果。在實驗中，火災在太陽能板覆蓋的範圍外僅蔓延數公分，並且在離開太陽能板覆蓋範圍後很快熄滅。即使移動火源位置，對太陽能板外的火災蔓延亦無影響。顯示在屏除風力影響下，火災在太陽能板間的蔓延危險性並不高。實驗結果亦顯示遠端引火之危險性低。然而，風力及屋頂傾斜角度對太陽能板火災的影響，仍待未來研究。根據實驗及文獻，增加太陽能板與屋頂間的距離可減輕太陽能板火災的危險性。此外，根據實驗經驗，排煙設備下的換氣氣流可能會影響在太陽能板下的燃燒現象；而重複使用同一太陽能板進行實驗所獲得的實驗結果，則可能低估

火災在真實狀況下的強度。