



Industry Showcase 2024

# Fire Safety for Green Energy: Battery, Solar and Hydrogen Risks

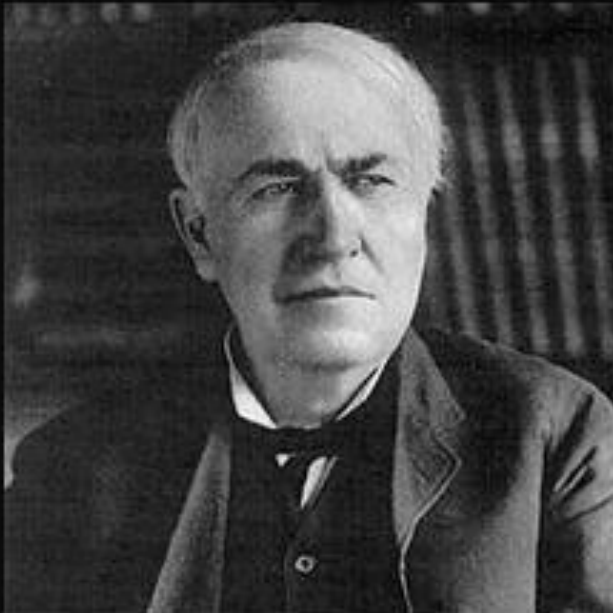
Presented by: Prof Richard Walls

(Hannes Loots, Lourens Pretorius, Rendani Sinyage, Mrs Courtney Devine, Dr Natalia Flores Quiroz)

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# A technology so dangerous...

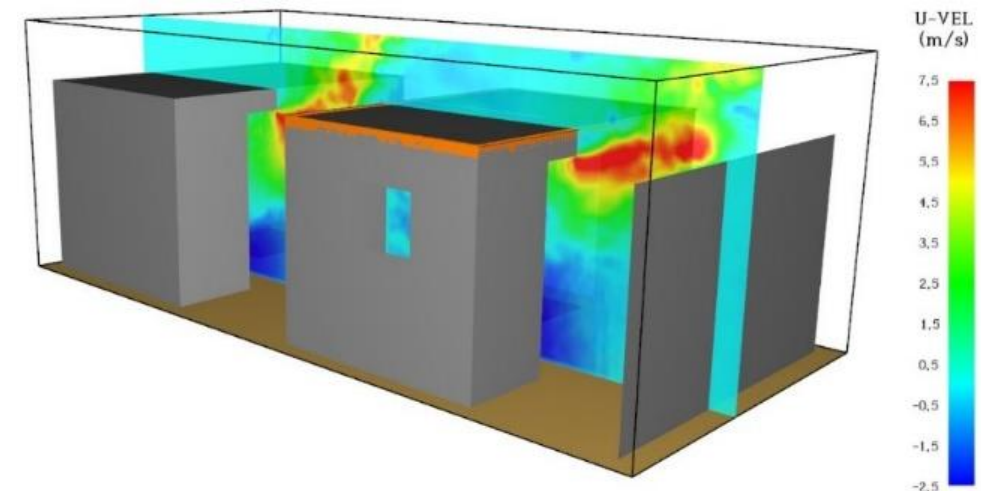
Thomas A. Edison



Fooling around with alternating currents is just a waste of time. Nobody will use it, ever. It's too dangerous... it could kill a man as quick as a bolt of lightning. Direct current is safe.

# Fire safety engineering at SU

- MEng and PhD programs
- Short courses
- **Online distance-learning masters in fire engineering launched in 2024.**
- Research, consulting, expert witness, and development work for industry.



# Meet the Team



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RESEARCHER

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# Research topics

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- Biomass and recycled products
- Agricultural and bulk storage facilities
- 3D printed concrete
- Mass timber buildings
- Green energy fire risks (green hydrogen, solar, etc.)
- Fire investigations
- Informal settlement fire safety
- Wildland fire safety

# Overview of presentation

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- The rise of green and sustainable systems.
- Green hydrogen.
- Solar / photovoltaic fire risk.
- Lithium-ion batteries.

# We like green - even Green facades

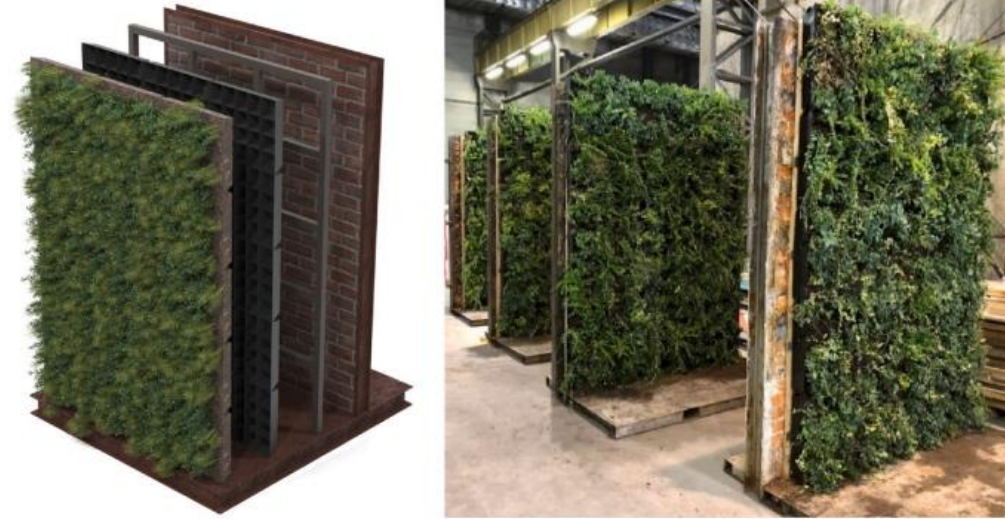


Fig. 1. Modular living wall technology scheme (on the left) and all specimens for full-scale fire spread test (on the right).



Fig. 10. Time-varying pathway of wind-forced fire spread along LW with live plants.

# Green hydrogen



<https://dayakdaily.com/sarawak-attracts-interest-for-green-hydrogen-production/>



# Hydrogen cars



# Hydrogen cars



# Green hydrogen vehicles



<https://www.angloamerican.com/our-stories/innovation-and-technology/driving-the-hydrogen-economy-in-south-africa>

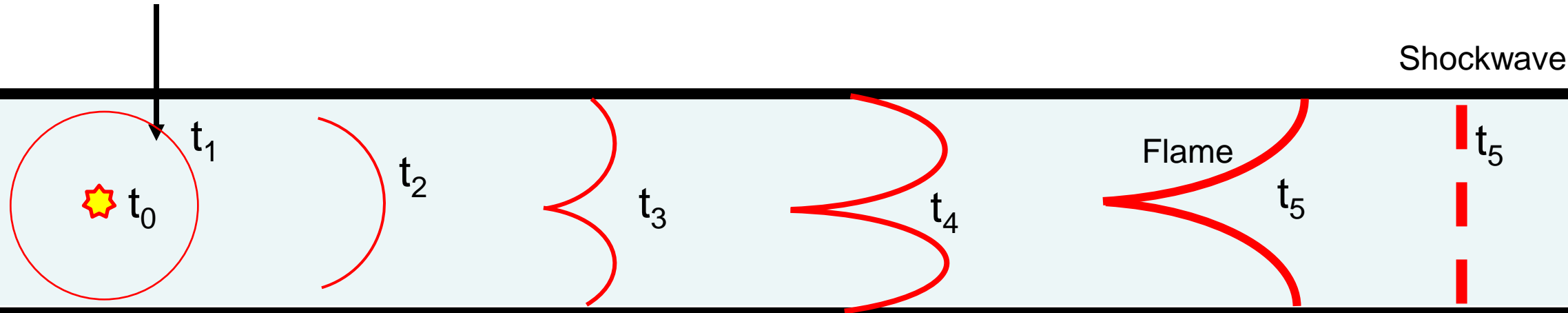
# Properties of Hydrogen

- Formula:  $H_2$
- Colour: Colourless (not green)
- Density: Liquid  $70 \text{ kg/m}^3$   
Gas  $0.08 \text{ kg/m}^3$  (vs.  $1.2 \text{ kg/m}^3$  for air)
- Flam. limits:  $5\% - 75\%$  (LFL – UFL)  
(e.g. methane:  $5\% - 15\%$ )
- Ignition energy:  $0.01 \text{ mJ}$  (vs.  $0.26$  for methane)
- Heat of combustion:  $141.8 \text{ MJ/kg}$   
(vs.  $45 \text{ MJ/kg}$  for hydrocarbons)



# Deflagration to detonation transition

Flammable gas mixture



Pipe / tunnel / shaft / enclosed space

2021-07-19 17:29:50



Su Mo Tu

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9 10 11  
16 17 18  
23 24 25  
30 31

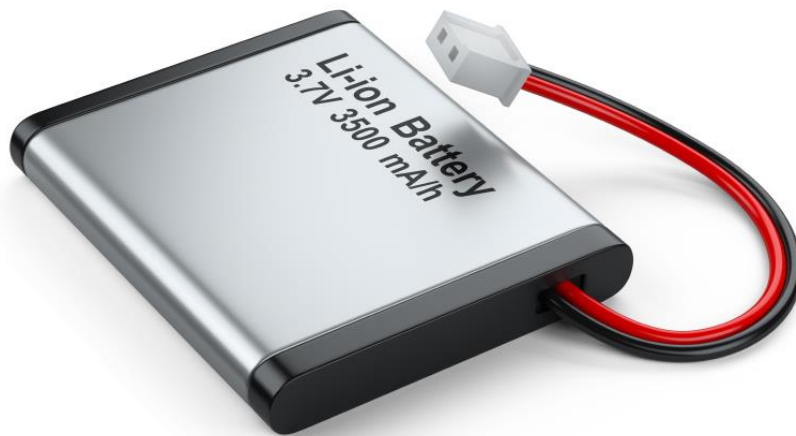
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# Considerations regarding green H<sub>2</sub>

- Lighter than air.
- Wide flammability limits. Hence, almost always in the flammable range.
- Can get trapped under structures, in tunnels, etc.
- May be used in cars, buses, mining vehicles, power generation and other industries.
- Can you just imagine how epic SA roads are going to be with hydrogen powered taxis?

# Lithium-ion batteries

- Most popular rechargeable batteries.
- Power most of the devices we frequently use.
- Lightweight and high energy density.





# Battery Energy Storage System (BESS)



- Type of energy storage system that stores and distributed energy in the form of electricity
- Consists of one or more batteries

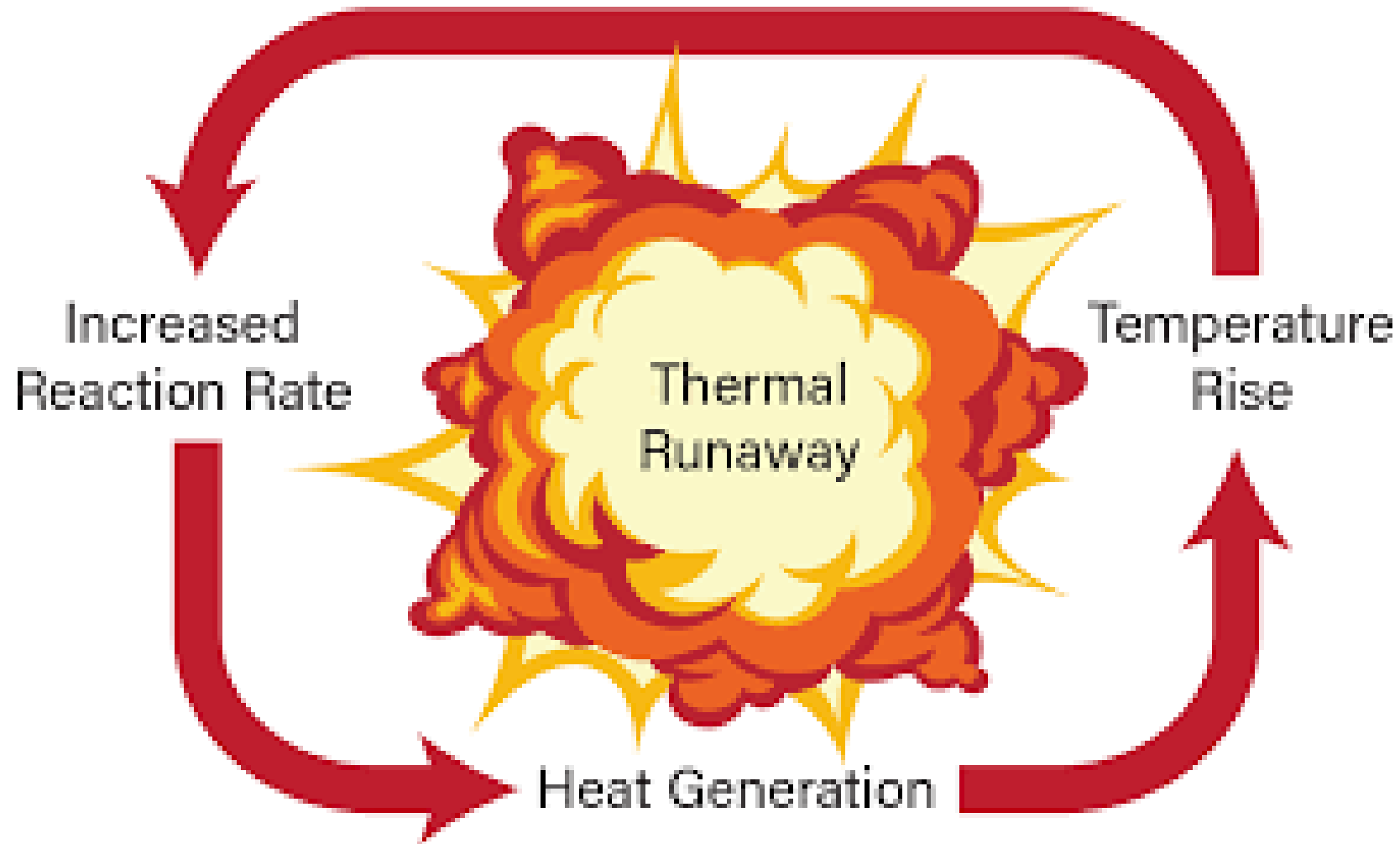
# Thermal Runaway

- It is a chain reaction that occurs because of an increase in the internal temperature of the battery.
- The increased temperature leads to a chemical reaction that produces more heat, resulting in higher temperatures and more chemical reactions.



<https://dragonflyenergy.com/thermal-runaway/>

# Thermal Runaway



# Less the Cheaper Results



FIRE & RISK  
\*\*ALLIANCE\*\*

0:42





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## New York

# E-bike batteries have caused 200 fires in New York: 'Everyone's scared'



**Wilfred Chan** *in New York*

Tue 15 Nov 2022 06.00 GMT









Courtesy: Fire Safety Research Institute



<https://www.cbsnews.com/video/test-shows-explosive-power-of-a-lithium-ion-battery-thermal-runaway/#x>









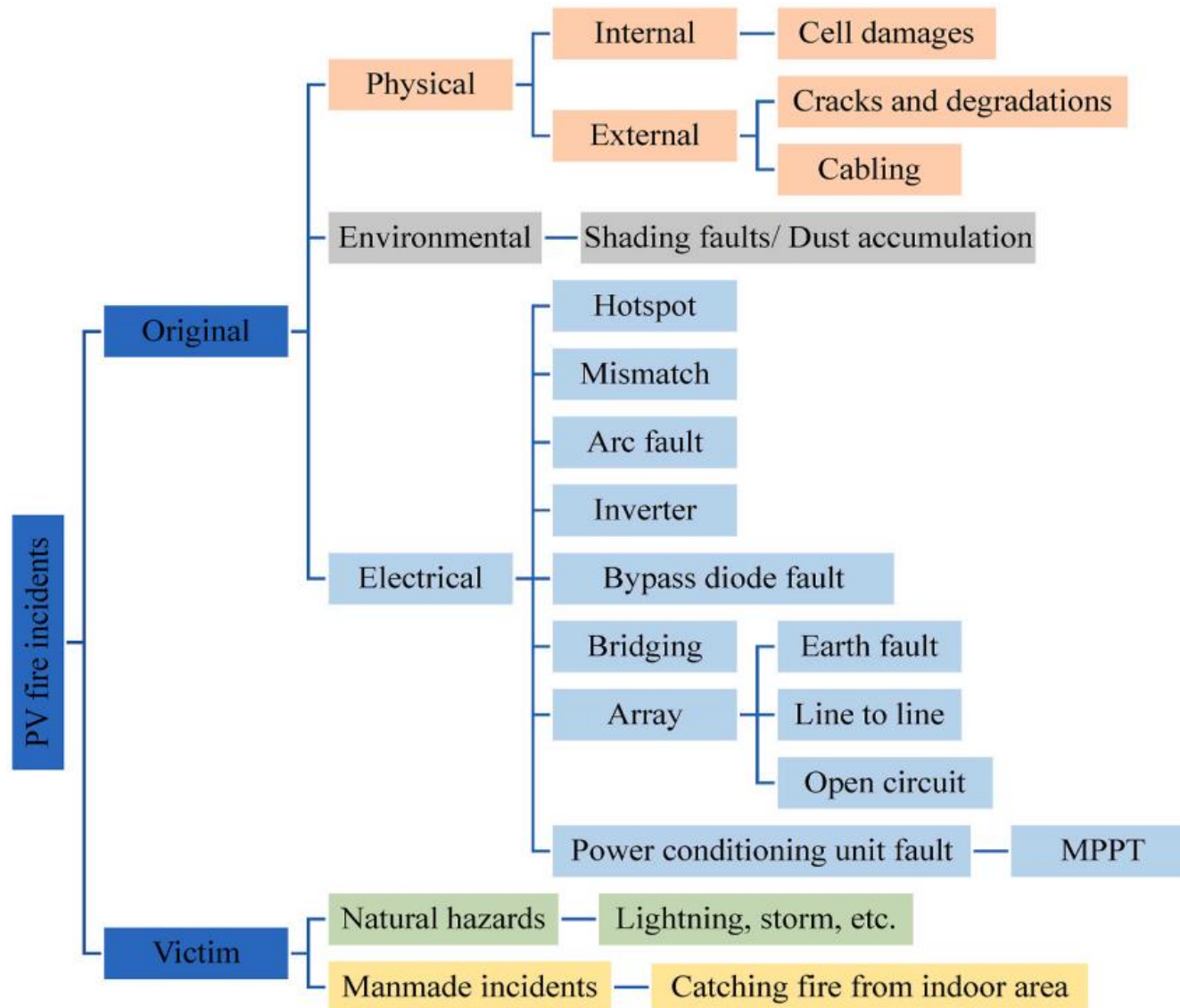
# Solar / Photovoltaic systems (PV)

- Earth experiences enough solar irradiance to meet its energy demands
- 268 GW of new solar capacity installed worldwide in 2022
- 315 GW projected for 2023
- RSA industry: Rapidly growing
- However, solar PV has associated fire risks



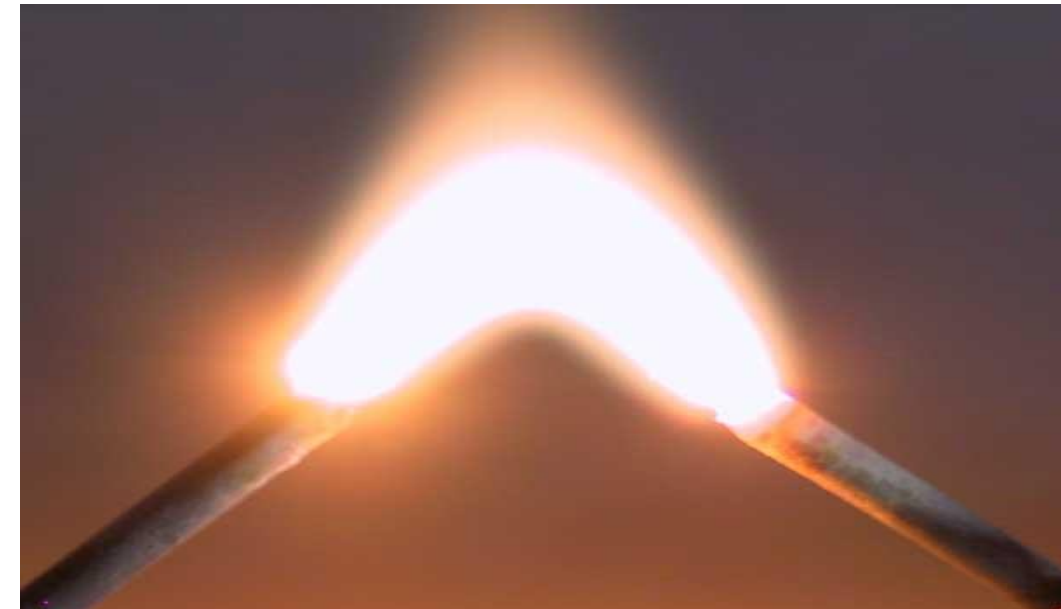
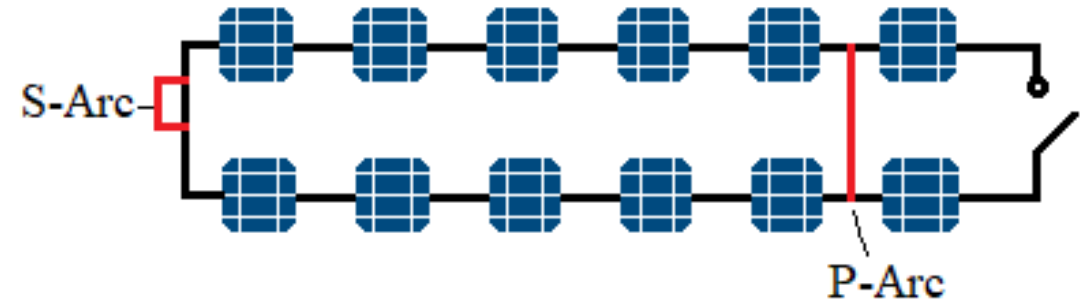
<https://www.solarsmiths.com/>

# Fire incidents



# Arc Faults

- DC arc faults are a critical ignition hazard
- Two types of DC arc faults: Series and Parallel
- Series Arcs:
  - Current through an interruption in the circuit
  - Stopped by opening the circuit or disconnecting the power source
- Parallel Arcs:
  - Creates a closed-loop circuit
  - Must be disconnected from within the circuit
  - Series arc can develop into a parallel arc

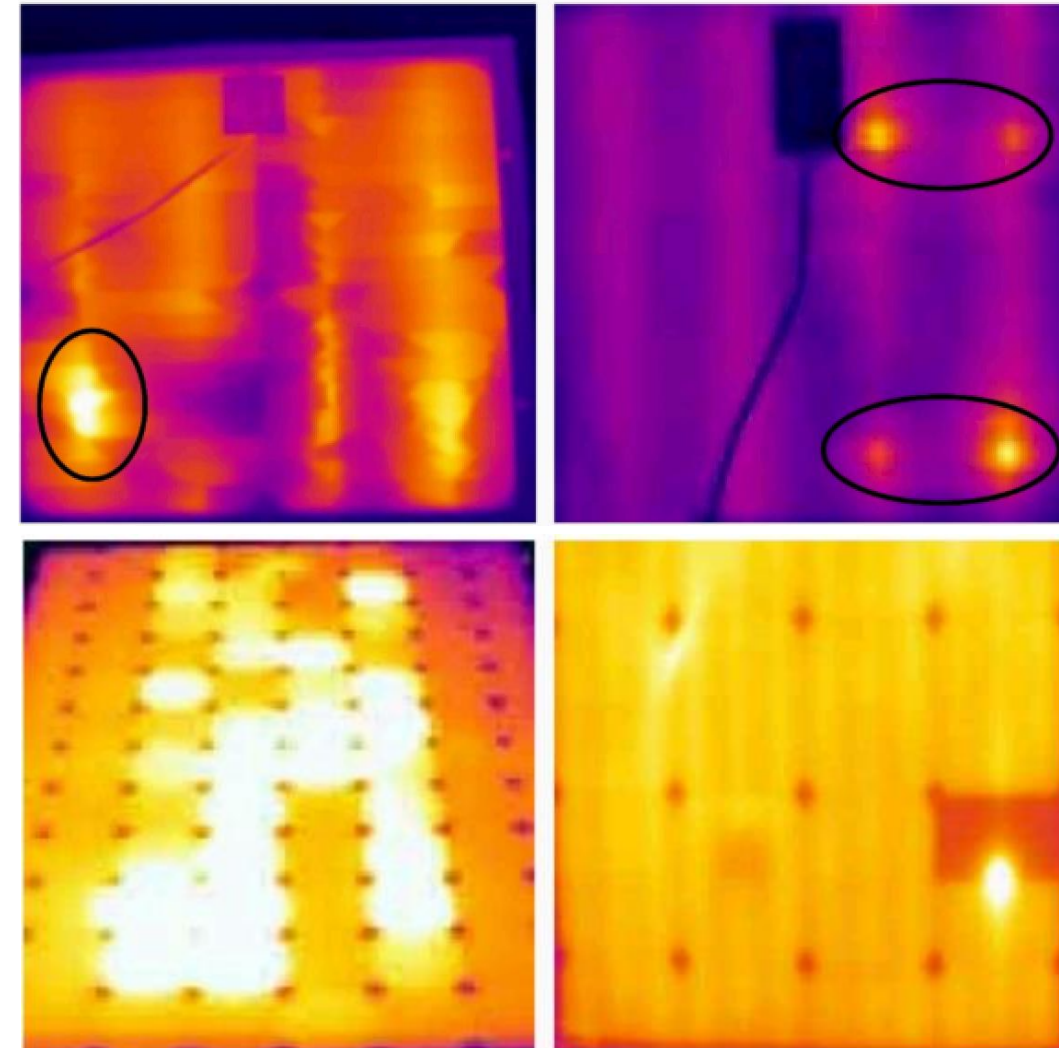


<http://smartlighthub.eu/>

# Electrical ignition hazards

- Hotspots
  - Can lead to ignition of encapsulant and backsheet
- Ground faults
  - Generates heat, damages electrical components, and leads to DC arcs
  - Ground faults can occur due to issues such as damaged insulation, faulty wiring, or improper grounding

IR Images of Hotspots

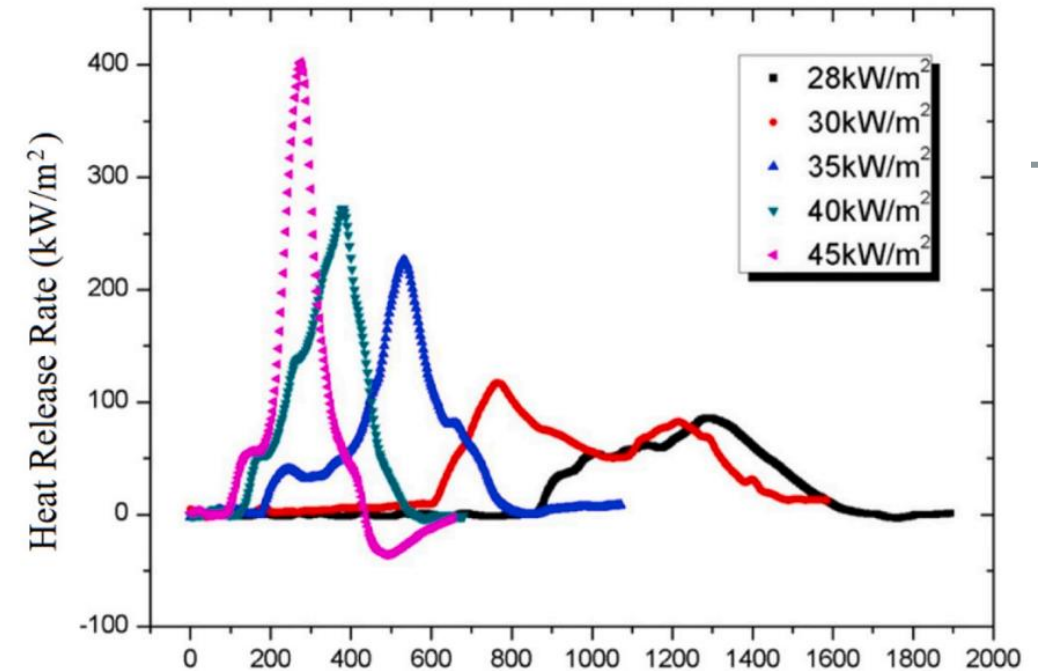




# Fire behaviour

- PV modules are combustible:
  - Encapsulant (PVA)
  - Back sheet
  - Junction box
- Not a significant fuel source.
- Module standoff height is critical.
- Toxic emissions based on combustible components .
- Focus of studies mostly on individual components

Heat Release Rate of a PV module as a function of time



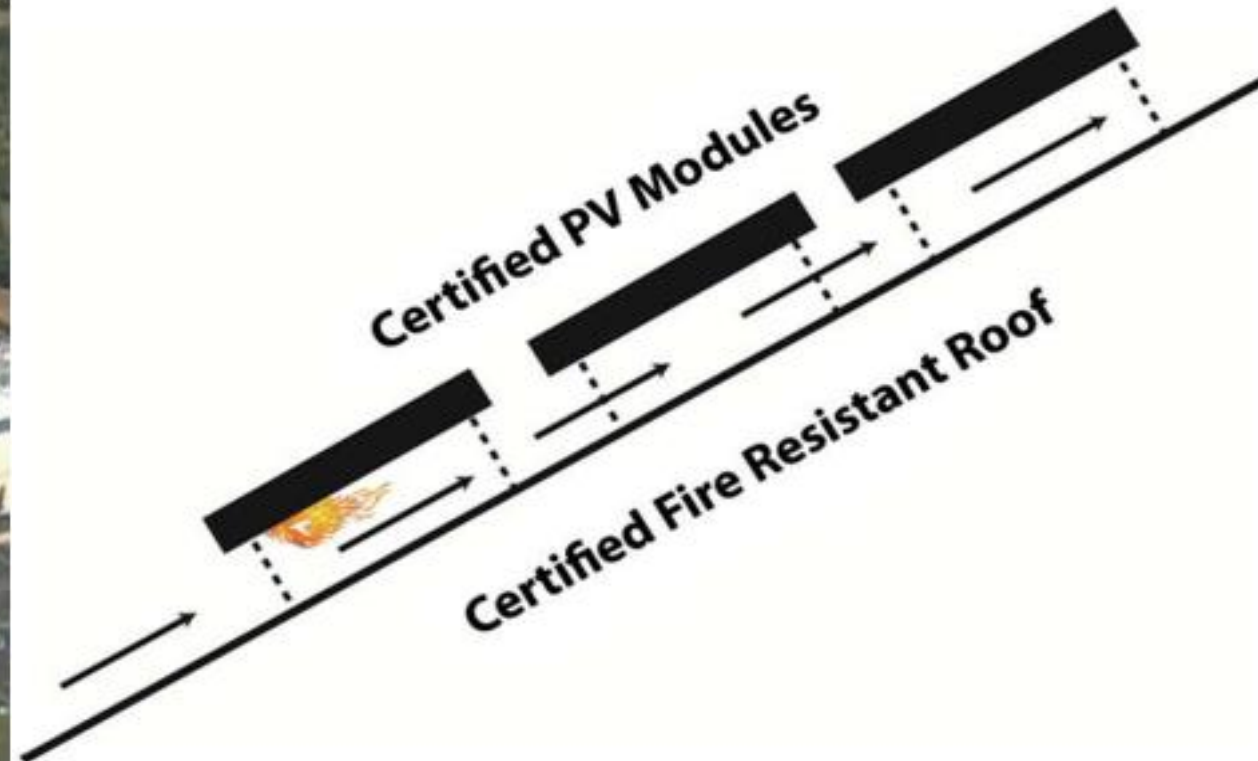
(Yang et al., 2015)



# PV Hazards



**Delanco, New Jersey, US in September 2013:** a fire occurred at a cold-storage food warehouse that was approximately 300,000 ft<sup>2</sup> (28,000 m<sup>2</sup>) in size with more than 7,000 PV modules covering most of the roof.



# Spacing of panels

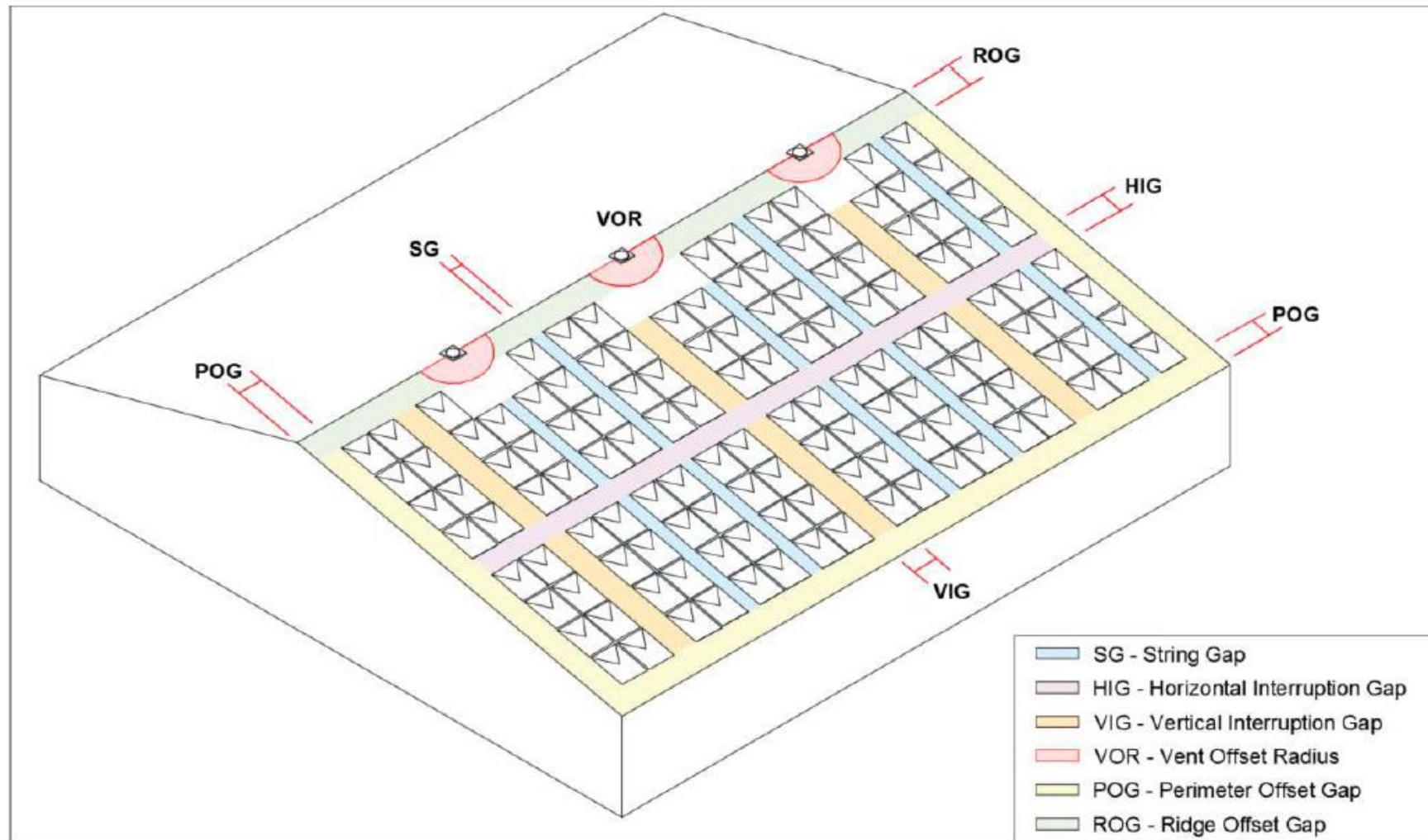


Figure 35: Strategic module placement for ease of suppression and flame spread disruption.

(Loots, 2023)



# Safety measures

- Module-level power control
- String level control
- Artificial intelligence
- Thermal imaging inspection
- Arc Fault Circuit Interrupter
- Earth Fault Circuit Interrupter
- Module placement
- Glass/Glass PV modules
- Half-cell modules (hotspots)
- Flashings
- Deflectors
- Fire testing of systems
- Maintenance and cleaning
- General good fire engineering design
- Etc.



# Summary

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- Green energy should be promoted.
- Green energy comes with many fire challenges and will lead to us having jobs for a long long long time.
- Ignition risks in homes are increasing.
- Systems are complex and can lead to explosion risks.
- SA guidance and codes need updating to account for such systems.
- Insurers need to get involved.
- Litigation imminent when things go wrong.

Thank you  
Enkosi  
Dankie