# Power line failures and catastrophic wildfires under extreme weather conditions

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## A little about me, powerline fires, and the CPUC...

- Particle physics research (1981-1996)
- Wildland fire research (home ignition prevention 2002-?)
- CPUC expert witness for neighborhood organization (MGRA – 2006-?)
- Published in Fire Safety Journal, Fire and Materials







9 out of 20 fires associated with power lines
\$US 2 Billion in property damage

### Australia

- Black Saturday, February 2009 5 of 14 fires investigated by the Victoria Bushfires Royal Commission related to power lines. 173 deaths, \$A >4B
- Ash Wednesday, February 1983 4 of 8 fires started by power lines
- February 1977 9 of 16 fires due to power lines.

Power lines are ordinarily responsible for 1-3% of wildfires/bushfires

Why 50% under certain conditions?

### "Fire Weather"

- Conducive to growth of large wildfires (bushfires, Aus.)
- Special synoptic weather conditions ("Foehn" winds)
- Pressure gradients → <u>High wind speeds</u>
- Adiabatic heating → Low humidity
- Low vegetation moisture content -> Fire seasons

# Extreme Fire Weather



## **Power Lines**

#### **Outages and Ignitions**

#### Distribution and transmission networks millions of components

- Poles
- Crossarms
- Insulators
- Fuses

- Conductors
- Reclosers
- Lightning Arresters
- Etc.

#### And nearby objects

• Trees

Communications lines

Mobile transmitters

Approaching design limits, what will fail first?

### No single cause stands out

#### California, 2007

- Conductor clashing
   *Witch*
- Tree limb
   *Rice*
- Communications tie wire
   *Guejito*
- Overloaded pole
   *Malibu*

#### Victoria, 2009

- Conductor clashing
   *Weerite (Pomborneit)*
- Tree falling Beechworth
- Tie wire *Coleraine*
- Conductor Failure
   *Kilmore East*
- Fasteners Horsham

#### Witch Fire California 2007

Arcing seen by tanker pilot en route to other fire "bluish flashes going with the wind" Retardant drop ineffective – high winds

2 deaths, 1141 homes burned

#### Investigation:

Clashing 69 kV power lines Lines too close, long run between poles. Reclosers





**Kilmore East Fire** Victoria, Australia 2009

119 fatalities125,383 ha1,242 homes destroyed

#### Investigation:

- Fatigue failure
  42 year old conductor
  Improperly seated in connector
- 3 reclosures



# EXPECT STEEP RISE IN FAULT RATE WITH WIND SPEED

Stress Failures

$$P(v) \sim v^{-2/b}$$

- Electrical Infrastructure
- Other infrastructure (telecommunications)
- Vegetation
- Distention & Line Contact  $d(v) \sim v^2$ 
  - Clashing
  - Vegetation
- Threshold Effects
  - Approaching design limits

Hooke's Law

$$N(s,v) = N_0 \exp\left(-\left(s / Bv^2\right)^{\gamma}\right)$$

Basquin/Miner's Rules for metal

Reverse Weibull distribution

### Use Outages as Proxy for Ignition Risk

2011 - San Diego Gas & Electric public release of data in response to CPUC judge's decision



#### 13 Wind-related fires in this period



#### Excess Outage Probability SDG&E 2000-2011 Outage Data



Wind Gust Speed km/h

#### CAVEAT – Extinguishing by Wind?

Australia 2011 - Coldham, et al.)commissioned by Energy Safe Victoria indicates wind can extinguish ignition – especially for low-current faults

Ignition of fine litter by arcs. Metal droplets? Wood materials?

To date: Strongest storms had most fires

# Just how bad can it get?? How fast can the wind blow??

If it has happened already, it is not worst case!! Use extreme value statistics

Photo courtesy of <u>www.ericcastro.biz</u>

### 1700 Years

- ASCE 7-10 return interval for "buildings and other structures, the failure of which could pose a substantial hazard to the community" (Class IV hazard)
- In California, 3 second gust at <u>185 km/h</u>

# Solutions – Must be SYSTEMIC

**UNDERWAY** – California and Victoria

- Improved conductor clearance, vegetation management, inspections
- Change in automatic recloser operation (+ installation of next-generation ACRs)
- Mapping to identify highest risk areas (CA will include wind)

#### **BEING EXPLORED**

 REFCL (Rapid Earth Fault Current Limiters) – Australia May reduce fault currents 2-3 orders of magnitude (Swedish Neutral GFN – Ground Fault Neutralizer)

### Power shut off



PRO:

- Removes ignition source
- Prevents power line firestorm

#### CON:

- Economic & safety issues
- Rejected as default policy by regulators in both California and Australia
- Disrupted communications (fire reporting)

#### **NEEDS COST / BENEFIT**

Still planned by SDG&E for wind events in excess of 90 km/h – Litigation before CPUC.

# So where are we?

- What are "Worst Case" conditions?
- Will wind extinguishing exceed fault rate increase for extreme wind events?
- Will new technologies be deployed, and then effective?
  - Waiting for the winds to blow