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Dr Athan Fox is a scientist and technology entrepreneur based in Cambridge, UK. He is the co-founder and Chief Technology Officer of Regenerate Technology Global (USA) and Ever Resource Limited (UK), two pioneering Cleantech companies focused on sustainable innovation in battery recycling. Athan holds a PhD in Chemistry from the University of Cambridge and has spent over a decade developing advanced processes for converting waste into high-performance materials. Under his leadership, Ever Resource has received numerous awards, including the Cambridge Independent Cleantech Company of the Year (2022) and UK Global-Start Up (2024) awards. Athan is a former Member of the Board of a high-tech company acquired by General Motors, and has served as a consultant on intellectual property and technology commercialisation. He is a Fellow of the Royal Society of Chemistry (FRSC) and Fellow of the Institute of Materials, Minerals and Mining (FIMMM).

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Declaration Form

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Declaration

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The Physics of Catastrophe - Hidden Tail Risk in an Electrified World

Abstract

Electrification is one of the central pillars of the clean energy transition. Electric vehicles (EVs), e-mobility and stationary storage are expanding at remarkable speed – by end of 2024, there were nearly 58 million EVs on the road globally, more than triple the stock in 2021 and displacing over 1 million barrels of oil demand per day (IEA, 2025).

Per vehicle, today's battery-electric cars appear less likely to catch fire than internal combustion engine (ICE) vehicles (ICCT, 2024; County Durham and Darlington Fire and Rescue Service, n.d.). Yet as e-mobility and stationary battery systems proliferate, the global stock of lithium-ion cells now runs into the tens of billions – often clustered in car parks, depots, ships and buildings where a single failure can damage thousands of assets and disrupt critical services (IEA, 2025).

This essay argues that lithium-ion technology creates a distinctive, under-recognised tail risk: rare cell-level defects, multiplied by huge numbers of cells and intensified by co-location, can drive low-frequency, high-severity losses that current models underestimate. Using a simple model based on three parameters (per-unit defect probability p, cluster size N and collateral factor C), I argue: how scaling and clustering change the nature of risk; how incidents like the Kings Dock car park fire, the Luton Airport fire and the Felicity Ace demonstrate aggregation; how a leverage factor L, which captures software-based early warning systems and better operational design, can reduce expected loss.

The final section outlines recommendations for the Chief Risk Officer (CRO): making lithium-ion tail events in high-density settings an explicit risk category; mapping concentrations of N and C; embedding fire-safety guidance and early-warning analytics into underwriting standards; and building telemetry-sharing partnerships with fleets and charging platforms. The core message is to surface and manage hidden fragilities – before a tipping point in aggregation risk turns rare cell failures into recurring systemic losses.

1. Introduction: the electrified numbers game

The International Energy Agency (IEA) estimates that by end of 2024 there were almost 58 million electric cars on the road worldwide, with global sales of EVs reaching around 17 million in that year alone – about one in five new car sales, and far higher shares in some markets such as China (IEA, 2025). Battery-electric buses, delivery vans, trucks and e-bikes are also being added to vehicle fleets, while lithium-ion battery storage systems are growing. From a climate perspective, this is good news; road transport makes up about a quarter of global energy-linked CO_2 emissions, and electrifying vehicles on increasingly low-carbon grids is a proven decarbonisation route (ICCT, 2021; IEA, 2025).

At the same time, headlines about EV and e-bike fires have become more common. Images of vehicles burning in car parks, on ships or in residential streets create a perception that lithium-ion batteries are uniquely volatile. However, a growing body of analysis suggests a different picture. A recent review for the International Council on Clean Transportation (ICCT) suggests that battery-electric vehicles may be less likely to experience fires than conventional vehicles, based on incident data from several countries (ICCT, 2024). UK guidance from County Durham and Darlington Fire and Rescue Service similarly notes that EVs do not appear more likely to catch fire than petrol or diesel cars, while emphasising that when fires do occur, they behave differently and may require different tactics (County Durham and Darlington Fire and Rescue Service, n.d.).

So why should a CRO at a global P&C insurer be worried? The answer lies less in the per-car failure rate and more in the geometry of exposure.

A modern lithium-ion traction pack contains hundreds or thousands of cells connected in series and parallel, and larger commercial vehicles can contain substantially more (Laserax, 2022). When EVs and stationary systems are clustered – in covered car parks, depots, ships or high-rise buildings – we are no longer insuring isolated devices. We are insuring dense clusters of tens to hundreds of millions of cells, many in locations where firefighting access is difficult, collateral damage is high and business interruption is costly.

Recent incidents illustrate the emerging pattern. In 2017, a fire at the Kings Dock multi-storey car park in Liverpool destroyed around 1,400 vehicles and caused structural damage that led to the car park's demolition; sprinklers were not installed, and large-scale evacuation was required (Merseyside Fire & Rescue Service, n.d.). In 2023, a fire believed to have started in a diesel SUV at Luton Airport's Terminal 2 car park spread very quickly, damaging/destroying more than 1,300 vehicles, causing partial structural collapse and major airport disruption (Bedfordshire Fire and Rescue Service, 2024). In 2022, the car carrier Felicity Ace, carrying approximately 3,965 vehicles, caught fire in the Atlantic and eventually sank; while the ignition source remains uncertain, lithium-ion batteries on board were widely reported as sustaining the fire, and cargo losses were widely reported in the low-US$400 million range (Reuters, 2022; The Guardian, 2022).

At the smaller but more frequent end of the spectrum, UK fire services are seeing a sharp rise in e-bike and e-scooter incidents. Freedom of Information data analysed for QBE and reported by the British Safety Council suggest that UK fire and rescue services attended around 1,330 lithium-related fires in 2024 – a 93% increase on 2022, averaging more than three incidents per day (British Safety Council, 2025). Separate analysis reported by MoneySuperMarket indicates that London saw over 200 e-bike and e-scooter fires in 2025, causing multiple fatalities and serious injuries (MoneySuperMarket, 2026). The National Fire Chiefs Council (NFCC) has warned that "lithium-ion batteries are everywhere – but safety standards haven't caught up", calling for stronger product regulation and clearer responsibilities (NFCC, 2025).

These data do not show that EVs are "firebombs on wheels". On a per-vehicle basis, they reinforce the conclusion that battery-electric vehicles are at least no more likely to catch fire than ICE vehicles (ICCT, 2024; British Safety Council, 2025). Nor do they suggest that lithium-ion is incompatible with safe decarbonisation. Instead, they point to a different risk problem: as the number of lithium-ion cells and devices grows, and as we cluster them in high-density settings, the nature of tail events changes. Individual defects that would be manageable in isolation can lead to systemic, collateral-heavy losses as they occur within dense, hard-to-fight environments.

For now, overall EV loss experience still looks manageable, and political attention to EV-specific fire regulation has arguably peaked in several markets. Yet the underlying drivers of systemic risk – global EV stock, stationary storage deployments and the share of lithium-ion devices in high-density locations – are still accelerating. Projections in the Global EV Outlook show electric cars taking a rapidly increasing share of the global fleet through the 2030s, even in conservative scenarios (IEA, 2025). That combination – rising N and C with lagging standards – creates a near-term tipping point for insurers: portfolio-level loss experience can remain benign until concentrations cross a threshold, then deteriorate abruptly as aggregation risk shows up in capital and reinsurance strains. Three guiding questions thus motivate this essay:

1. **How does the combination of scaling (*N*) and clustering (*C*) change the nature of lithium-ion risk?**
2. **What can software-based early warning realistically do to change expected loss, and where is it most valuable?**
3. **What should a CRO do – in underwriting, risk architecture and data – to internalise this tail risk without overreacting?**

To answer these, I first sketch a deliberately simple model linking per-unit defect probability *p*, cluster size *N* and collateral factor *C* (Section 2); I then use recent incidents/data to show how aggregation risk manifests in practice (Section 3). Finally, I explore how early-warning analytics on battery telemetry and changes in underwriting architecture can give the CRO a meaningful leverage factor *L* on expected losses (Section 4), before concluding with recommendations.

2. From single-cell defect to systemic loss: a simple model

Lithium-ion cells can fail internally in several ways. Manufacturing defects (such as metallic particles or misaligned separators) can create latent weak points; mechanical abuse from impact or vibration can cause internal damage; electrical abuse from over-charging or over-discharging accelerates degradation. A widely reported pathway is lithium plating: metallic lithium deposits growing on the anode. Over many cycles these deposits can grow into needle-like dendrites that may eventually pierce the separator and create an internal short circuit (Balakrishnan et al., 2006; Huang et al., 2021).

From the outside, a pack with growing internal defects can look healthy. Voltage and temperature remain in expected ranges; the car drives; the state-of-charge gauge behaves normally. Only when a critical threshold is reached does a localised hot spot develop, triggering thermal runaway in one cell. Heat then propagates into neighbouring cells and modules, and a cascading failure produces intense heat, flammable vapours and toxic smoke in seconds. This is the stage captured in dramatic videos – and the moment when conventional protections, such as fuses, contactors and temperature sensors, finally react.

An analogy I like to use is from human health. Imagine training a clinician – or a machine-learning model – on the heart rate and breathing patterns of thousands of healthy people. From that data, you can construct a "normal" pattern for a healthy human. When a person catches a virus or develops a cardiac issue, subtle deviations appear days before the person feels unwell: a slightly elevated resting heart rate, reduced variability, shallower breathing. A skilled observer (or AI, potentially) can detect those changes early – providing an opportunity for early intervention.

In my opinion, lithium-ion packs are analogous. Their current and voltage responses to standard driving and charging patterns form a consistent fingerprint when healthy. As internal defects grow, the fingerprint distorts: relaxation curves lengthen, hysteresis in charge-discharge cycles changes, small asymmetries appear between parallel strings. Today's battery-management systems (BMS) already record current and voltage at high resolution. The question is whether we treat that data as a rich health signal – or merely as an input to simple control algorithms.

Before returning to diagnostics, consider the underlying probability structure. Take a cluster of *N* vehicles or packs – a car park, a bus depot, a roll-on/roll-off (RoRo) deck, a bank of residential batteries. Over a given time window (a year, a voyage, a storage period), let *p* denote the probability that any given unit develops an internal defect that would, in the absence of intervention, lead to a serious fire. For now, assume independence between units. The probability that at least one unit in the cluster has such a defect in that window is then:

$$\boldsymbol{P = 1 - (1 - p)^N}$$

In words, this is "one minus the probability that every unit stays healthy". If *p* is small and *N* is small, *P* is tiny. If *p* stays small but *N* becomes very large, *P* can become material. To illustrate, suppose the annual probability that a given vehicle experiences a serious fire originating in its traction battery is on the order of 10^{-4} (one in ten thousand) – consistent with the view that EVs are at least no worse than ICE vehicles in fire frequency (ICCT, 2024; British Safety Council, 2025). A car parked on a driveway is effectively $N \approx 1$, so $P \approx 0.01\%$. A 1,500-space car park that is full for many hours each day might experience an effective *N* of several hundred "vehicle-years" over a year; a crude approximation of *N* = 1,500 yields:

$$P \approx 1 - (1 - 10^{-4})^{1500} \approx 14\%$$

That's a non-trivial chance that at least one vehicle experiences a serious defect in a given year. A RoRo ship carrying 4,000 vehicles for a two-week voyage might have a smaller effective *N* over that window, but still far larger than one.

The second piece is collateral; *C* denotes the collateral factor: the expected number of significant asset losses (vehicles, structural elements, adjacent property) given that an uncontrolled fire has taken hold. *C* is shaped less by the vehicle/battery than by geometry, construction, detection and firefighting access. A single EV on a driveway may yield *C* close to 1: the car is lost, and part of the façade may be scorched but the house is usually saved. A tightly packed bus depot with vehicles parked nose-to-tail under a lightweight roof might see *C* in the 10s. Kings Dock or Luton show that a multi-storey car park can experience *C* in the thousands, plus total structural loss and business disruption (Merseyside Fire & Rescue Service, n.d.; Bedfordshire Fire and Rescue Service, 2024). On a ship like Felicity Ace, *C* approaches the total cargo and possibly the ship (Reuters, 2022).

A third ingredient, which I will return to, is the **early-warning leverage factor**, *L*. This is the ratio between expected loss without early warning and expected loss with early warning. If analytics and operational protocols allow us to cut *C* – e.g. by identifying and isolating suspect vehicles before a fire spreads – then *L* > 1.

Putting these together, a CRO can think of a lithium-ion tail event in a cluster as having an expected loss roughly proportional to:

$$\textbf{Expected loss} \sim P \times \frac{C}{L}$$

with *P* capturing the probability that at least one dangerous defect exists in the cluster over the relevant horizon, *C* the collateral given a serious fire and *L* the reduction in expected loss from early warning and operational response. The key insight is that *P* is small but grows with *N*; *C* can be very large in dense, hard-to-fight environments; and *L* is, today, **largely absent from portfolios**.

3. What the last decade is telling us: incidents and aggregation risk

Real incidents over the past decade provide a first sketch of this risk landscape.

Kings Dock, Liverpool (2017). The Kings Dock multi-storey car park fire started in a vehicle on the third level and spread rapidly through the structure, ultimately destroying around 1,400 vehicles and causing structural damage severe enough to require demolition of the car park (Merseyside Fire & Rescue Service, n.d.). Fortunately, there were no serious injuries, but thousands of motorists lost their vehicles, and the adjacent arena and local businesses suffered disruption. At the time, EV penetration was modest; most vehicles involved were ICE. From our perspective, *N* was roughly 1,400 vehicles; *C* was in the same order, plus structural loss and business interruption.

Luton Airport car park (2023). In October 2023, a fire believed to start in a diesel SUV at Luton Airport's Terminal 2 car park spread rapidly through the structure, damaging or destroying more than 1,300 vehicles. The top deck partially collapsed and the fire caused major disruption to airport operations, displacing thousands of passengers and disrupting operations for several days (Bedfordshire Fire and Rescue Service, 2024). Again, the initial ignition appears to have involved an ICE vehicle, but EVs were present – and their lithium-ion fire changes the game. Looking ahead a decade, as EV penetration in the UK vehicle fleet rises, the same car park geometry implies a similar *C* but a growing share of lithium-ion packs within *N*. That in turn raises the probability that any structural fire, whatever its origin, will involve batteries that are difficult to extinguish and may reignite (CFPA-E, 2025; OZEV, 2023).

Felicity Ace (2022). The Felicity Ace incident is the marine analogue. Carrying around 3,965 cars from Europe to the United States, the vessel caught fire in the Atlantic and burned for days before sinking. The ignition source remains uncertain, but lithium batteries on board were reported as sustaining the fire. Regardless of cause, the loss was effectively total: cargo and ship, with cargo losses widely reported in the low-US$400 million range (Reuters, 2022; The Guardian, 2022). For our purposes, *N* was in the millions of cells; *C* was effectively the entire cargo and vessel. The combo of high *N*, high *C* and difficult access for fire crews demonstrates a lithium-ion tail event.

Urban e-mobility clusters. UK data on e-bike and e-scooter fires illustrate a different facet. FOI-based analysis for QBE suggests that fire and rescue services attended 1,330 lithium-related fires in 2024, a 93% increase on 2022 (British Safety Council, 2025). London Fire Brigade data show over 200 e-bike and e-scooter fires in 2025, many in high-rise buildings or shared hallways (MoneySuperMarket, 2026). Here, individual events often involve small *N* (a handful of devices) but high vulnerability: narrow escape routes, sleeping occupants and limited firefighting access. The NFCC has warned that poor-quality chargers and user behaviour are driving these incidents and that standards and enforcement lag behind deployment (NFCC, 2025).

These events highlight **aggregation risk** in classic insurance parlance. Most motor portfolios are priced as if individual vehicles are largely independent risks, correlated mainly by weather or crime patterns. In reality vehicles are often co-located: in car parks, on a deck, in a depot. A single fire in such settings can turn many independent policies into one correlated loss. Aggregation risk is not new (hailstorms, earthquakes and floods do the same) but the interaction with lithium-ion batteries adds a twist: fires can be harder to extinguish, produce toxic smoke, and in some cases re-ignite after suppression (Arup, 2023; CFPA-E, 2025; NFCC, 2025). Guidance now emphasises the need to plan for persistent burning, large water demand, run-off management and post-fire structural assessment in EV car parks (Arup, 2023; BPA, 2024; OZEV, 2023).

Beyond direct property damage, real-world tail events bring impacts that our simple $P \times C$ model does not capture. Luton experienced business interruption (airport closure); Kings Dock required large-scale evacuations and long-term loss of parking facilities; Felicity Ace caused pollution from fuel and cargo, and added emissions from replacing nearly 4,000 cars. Analysts estimate that the embodied emissions in a typical mid-size EV are several tonnes of CO_2-equivalent higher than in a comparable ICE vehicle, largely because of battery production; those emissions are "paid back" over the vehicle's lifetime via lower operating emissions (ICCT, 2021). When an EV burns early in its life, that environmental payback is lost, and additional emissions from fire, salvage and replacement are incurred – costs seldom reflected explicitly in pricing models.

For a CRO the message isn't to panic about EVs, but to recognise a structural shift. At the portfolio level, the electrified world brings (a) more lithium-ion devices; (b) more high-density clustering of those devices in locations with high *C*; (c) still-limited data on the true distribution of tail events. Against this backdrop, doing nothing and "learning as we insure" is one option. Or, we can do better – by listening to batteries before they scream and redesigning our risk architecture.

4. Listening before it burns: early warning and a risk architecture for P&C

4.1 Early warning and the leverage factor *L*

A key observation from Section 2 is that internal defects in lithium-ion "announce themselves" in electrical behaviour before they reach the point of visible failure. That creates an opportunity for early warning. A new generation of analytics firms and researchers are treating BMS data – voltage, current and sometimes temperature – as a source of health signals. Rather than predicting state of charge or range, their models learn the normal response of a given pack chemistry under different operating conditions and flag trajectories that diverge from that norm. The aim is to identify a small subset of vehicles/modules whose behaviour is consistent with internal defects.

General Motors' acquisition of start-up Algolion in 2023 illustrates how seriously leading OEMs now treat this idea. GM's acquisition of Algolion highlighted growing OEM interest in using BMS voltage and current data to detect battery abnormalities earlier (Reuters, 2023). Independent academic work has demonstrated similar "drift detection" capabilities in laboratory settings, where evolving internal defects produce measurable changes in relaxation curves and hysteresis (Balakrishnan et al., 2006; Huang et al., 2021).

For a CRO, the details of algorithm design are less important than the operational question: **if you can get days or weeks of lead time on a small subset of assets, what can you do with it?** This is where the leverage factor *L* comes in.

Suppose that without early warning, the expected loss from a particular high-density cluster – say, a bus depot – is proportional to $P \times C$. If an early-warning system and associated protocols allow you to cut *C* (e.g. moving suspect buses to isolation bays; adjusting charging patterns; or bringing forward maintenance), then *L* captures the ratio between expected loss without and with this capability:

$$L = \frac{\text{Expected loss without early warning}}{\text{Expected loss with early warning}}$$

In practical terms, *L* will vary by setting:

- **Single EV in an attached garage.** Without early warning, a latent defect that progresses to thermal runaway while charging overnight could result in loss of the vehicle plus significant damage to the house, and potential injury to occupants. With days of warning – a message to the owner to book a service check, avoid overnight charging, or park outside – *C* could fall from "car + partial house" to "car only" or even "battery pack only". *L* might be modest, perhaps 2-3, but meaningful.
- **Bus depot.** Without early warning, one bus combusts overnight, propagates to adjacent buses and the depot structure, giving *C* in the tens. With early warning, suspect vehicles can be removed from the main shed or parked in isolation bays; *C* could fall by an order of magnitude if a single loss replaces a multi-vehicle conflagration. *L* of 5-10 is plausible in such high-density settings if protocols are robust.
- **RoRo car carrier.** On a vessel carrying thousands of vehicles and tens of millions of cells, *C* approaches the total cargo and ship. Operational constraints are tight; moving individual vehicles at sea is difficult, and crew time is limited. Yet even here, a well-designed early-warning system that flags a handful of vehicles or deck zones for enhanced monitoring could enable targeted thermal imaging, re-positioning of suspect vehicles on loading, or adjustments to ventilation and firefighting readiness (Gard, 2023). Given the scale of *C*, even a small reduction in the conditional probability of a full-scale fire – e.g. by catching and isolating one vehicle with a latent defect before departure – can yield an *L* in the high single digits.

These sketches illustrate that *L* is context-dependent: early warning is most valuable where *N* and *C* are large, lead time *T* is non-trivial, and there is a feasible operational response. False positives, data-sharing hurdles and human factors (alarm fatigue, reluctance to take assets out of service) will constrain *L* in practice.

The implication for a CRO is simple. In low-density, easily accessible settings, conventional protections may suffice and early-warning analytics are "nice to have". In high-density, hard-to-fight settings – multi-storey car parks, dense depots, RoRo decks, containerised battery systems – early warning is a natural candidate for inclusion in underwriting standards.

4.2 A risk architecture for P&C portfolios

A CRO deciding what to do about lithium tail events faces two temptations. One is complacency: keep EVs within existing motor and property models, assume per-car fire probabilities will stay low, and "learn as we insure". The other is overreaction: treat EVs as uninsurable and/or hike rates indiscriminately. The history of cyber insurance shows both patterns: in the 2000s and early 2010s, low uptake and relaxed underwriting led to underpriced, poorly specified exposures; major ransomware waves then forced a tightening of wordings, exclusions of some systemic perils and re-pricing risk (The Geneva Association, 2016; Munich Re, 2025; RSM, 2026).

Lithium-ion tail events call for a more measured approach. I suggest four building blocks.

1. Taxonomy and metrics. First, make "lithium-ion tail events in high-density environments" an explicit risk category in internal taxonomies and risk registers, rather than burying it within generic "fire" or "operational" risk. The category should distinguish: (a) frequency risk, captured by per-unit defect probability p (differentiated by technology, quality and age); and (b) clustering risk, captured by N (number of units in the cluster) and C (collateral factor given a serious fire).

Scenario exercises can then stress-test combinations of p, N, C at portfolio hotspots – for example, an airport car park with a rising EV share; a flagship RoRo route with growing EV cargo; or a city with multiple bus depots transitioning to electric fleets.

2. Concentration × containment map. Second, visualise where in the portfolio high N and high C overlap. A simple "concentration × containment" matrix can help. The horizontal axis ranges from low to high asset density/co-location; the vertical axis from easy to difficult containment and emergency access. Examples include:

- Detached house with driveway charging – low concentration, relatively easy containment.
- High-rise flat with e-bikes charging in corridors – moderate concentration, difficult containment and evacuation.
- Multi-storey car park with EV charging on several decks – high concentration, mixed containment depending on design.
- Bus depot with tightly parked vehicles under a lightweight roof – high concentration, challenging containment.
- RoRo vessel with fully loaded car decks – extreme concentration, very difficult containment.

By mapping exposures into this grid, a CRO can identify where lithium-ion tail events are most likely to have systemic consequences and where interventions (design changes, operational protocols or early-warning deployment) can move exposures towards safer quadrants.

3. Underwriting standards and incentives. Third, use underwriting levers to reward genuine risk reduction and discourage unmanaged concentrations. In high-risk cells of the matrix, coverage and pricing could be made explicitly conditional on:

- **Design and operational controls.** For buildings and car parks, adherence to emerging guidance like the UK Office for Zero Emission Vehicles' interim fire-safety guidance for EVs in covered car parks, developed with Arup, and European car-park and EV-charging guidelines issued by organisations such as CFPA-E and the British Parking Association (Arup, 2023; BPA, 2024; CFPA-E, 2025; OZEV, 2023). They stress: compartmentation; adequate ventilation; run off control; suppression systems; isolation bays; and clear responsibility for risk assessment.

- **Safe charging and access protocols.** Documented policies on where and how EVs may charge, limits on charging in confined spaces, and arrangements for fire-service access and post-fire structural assessment, in line with national guidance and NFCC recommendations (NFCC, 2025; County Durham and Darlington Fire and Rescue Service, n.d.).

- **Early-warning analytics where feasible.** For fleets, depots and vessels above a defined threshold of *N* and *C*, the use of certified early-warning diagnostics on BMS data (either via OEM systems or third-party providers). In practice this may mean requiring telematics feeds from OEMs, fleet-level analytics, or, in marine, early-warning overlays on existing fire-detection systems (Reuters, 2023; Gard, 2023).

Insurers can then differentiate terms: offering premium credits, better capacity or broader cover where controls are in place and evidenced; pricing sharply or limiting cover where they are not. This avoids treating "EV" as the relevant variable; instead it prices the combination of EV share, geometry and controls.

4. Data and telemetry loop. Finally, design policies to improve the data that underpins *p*, *N*, *C* and *L*. Cyber insurance has learned – sometimes painfully – that under-reporting and limited sharing of telemetry make it hard to model low-frequency, high-impact events and their correlations (The Geneva Association, 2016). Lithium-ion tail risk is at a similar stage.

Operators of EV fleets, depots, RoRo routes and battery energy storage systems are increasingly connected to smart-charging platforms and grid services – e.g. Octopus Energy's "Intelligent Octopus Go" tariff already shows how charging can be orchestrated through connected vehicles and chargers (Octopus Energy, 2025). That infrastructure is a potential asset for risk management as well as for customer savings. Policies could require anonymised sharing of BMS and charging telemetry, along with structured post-incident reporting, as a condition of cover in high-density settings (British Safety Council, 2025; MoneySuperMarket, 2026). Over time, this would allow insurers and reinsurers to refine their estimates of *p* (by age, model and use case), *C* (by geometry and suppression design), and *L* (as early-warning systems and protocols mature).

This should be framed as a partnership rather than surveillance. Fleet operators and charging platforms also benefit: better data enable them to target maintenance, manage warranty risk and demonstrate to regulators and customers that they run safe systems. For a CRO, the medium-term payoff is improved pricing accuracy and more robust capital allocation for a line of risk that will only grow with the transition.

5. Conclusion: from freak accident to priced, preventable risk

This essay started with a simple question: as we electrify transport and infrastructure, are we creating a new class of tail events that our current risk tools underestimate? The answer, from a P&C perspective, is "yes – unless we update those tools".

On the first guiding question – how scaling and clustering change risk – the core insight is that per-vehicle fire probability is the wrong focal point for tail events. Emerging evidence suggests that EVs are, if anything, less prone to fire per car than ICE vehicles (ICCT, 2024; British Safety Council, 2025). The risk arises when small per-unit probabilities *p* are multiplied by large *N* and high *C* in environments such as covered car parks, depots and RoRo decks. Kings Dock, Luton and Felicity Ace are therefore better read as previews of a structural tail than as rare anomalies.

On the second question – what early warning can do – the answer is that we now have the ability to "listen" to batteries before they scream. BMS data already in the field can, with the right analytics, provide days or weeks of lead time on a small subset of assets drifting towards failure (Reuters, 2023; Huang et al., 2021). In high-density settings, even a modest leverage factor *L* (cutting expected loss by a factor of five/ten) can translate into materially different capital and insurance outcomes. Early warning is not a magic bullet; it is a portfolio-level mitigation tool whose value is highest where *N* and *C* are largest and operational responses are feasible.

On the third question – what must change in risk architecture and incentives – the key move is to make lithium tail events in high-density environments an explicit part of the CRO's parsing of risk.

That means naming the risk category; separating frequency *p* from clustering (*N* and *C*); mapping concentrations against containment; embedding emerging fire-safety guidance and early-warning analytics into underwriting; and building telemetry-sharing partnerships that improve the data over time (Arup, 2023; BPA, 2024; CFPA-E, 2025; OZEV, 2023; Octopus Energy, 2025).

For a CRO, the practical question is not whether the simple model in this essay is perfect. It is whether the organisation can plausibly explain, to its board and regulators, how it is identifying and managing emerging systemic risks in an electrified world. Lithium-ion tail events are now visible in real losses; they cut across motor, marine, property and specialty lines; and they are likely to grow as EV penetration and stationary storage expand (IEA, 2025; NFCC, 2025).

Over the next 12-24 months, a P&C CRO can realistically: mandate a lithium-ion tail-risk category in internal taxonomies; commission a concentration-versus-containment map of the portfolio; update underwriting guidelines to reference emerging fire-safety guidance and early-warning analytics; and pilot telemetry-sharing arrangements with one or two willing fleet or charging-platform partners. None of these steps requires waiting for perfect data or new hardware, they only require treating battery telemetry, layout geometry and operational protocols as part of the same risk system.

Electrification is rightly central to our climate strategy. The role of insurance should be to surface its hidden fragilities and reward those who address them. With the tools now available (and with deliberate action from CROs), single-cell failures that would otherwise burn ships, car parks or depots can become the kind of tail risk we understand, price and largely prevent.

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