ARAANI
VISION ON SAFETY

Video fire detection for e-bus depots

Detect e-bus fires in time and limit the impact

www.araani.com

Electric buses catching fire: the heat is on

Cities around the world are trying to reduce air pollution and improve quality of life in general. As a result, the electric bus market has been growing in recent years like never before. Thanks to their zero emissions, electric buses (e-buses) are a green solution to our mobility problem, especially in cities. E-buses do not have a traditional combustion engine running on fossil fuels such as diesel or gasoline, but an electric motor and batteries that are charged with electricity.

Charging at the bus depot

Charging typically happens in large depots where the buses are parked at night or during times of inactivity. Seemingly proportionate to the number of electric buses that are entering traffic, there is an increasing number of news reports on fire incidents with electric buses during their charging procedures.

The common story for many of these incidents is that battery electric bus fires are very hard to extinguish. Consequently, these fires spread easily, causing neighboring vehicles to go up in flames as well. The damage to buildings and infrastructure is often considerable too.

Since electric bus fires are hard to stop, the most sensible thing to do is to contain the problem and limit the collateral damage as much as possible. Obviously, this requires timely action. The question bus depot managers now need to ask is: can they detect these fires early enough in the process, so that they can intervene in time to limit the damage and prevent worse from happening?

In this eBook, we will argue that a fire recognition system based on smart video analytics offers e-bus depot operators a reliable way to protect their assets, safeguard business continuity, and potentially save lives.

Recognition, detection and monitoring

Video fire recognition technology comes in two flavors: Video Fire Monitoring and Video Fire Detection.
Video Fire Monitoring is supporting your fire safety measures in situations where no fire detection is mandatory and/or is used to generate an early warning where conventional fire detection is already installed.
Video Fire Detection on the other hand can be used as a primary detector, linked to your Fire Alarm Control Panel.

How serious is the problem?

In recent years, several electric bus fires have made headlines worldwide, some of them catastrophic enough to destroy multiple vehicles.

STUTTGART, GERMANY, SEPTEMBER 2021

25 electric buses, a charging hub and a depot were destroyed when a technical fault triggered a fire when the bus was charging.

GUANGXI, CHINA, JUNE 2021

Four open sided buses on a university campus were destroyed when one caught fire and triggered a blaze that spread to three other buses.

PARIS, FRANCE, APRIL 2022

Two buses of the same model caught fire in Paris in less than a month. The possible cause may have been a hidden material defect in the battery pack.

HERTFORDSHIRE, UK, MAY 2022

An e-bus caught fire at a Hertfordshire town center transport depot and took five other buses with it in flames.

HAMDEN, CONNECTICUT, USA, JULY 2022

An electric bus started to emit smoke from the rear compartment, after the battery had been charged the day before. The bus failed to power up the following day. A defective battery may have been the cause.

HYDERABAD, INDIA, APRIL 2023

An electric bus caught fire after its overhead battery unit scraped the side of a flyover beam.

These recent examples demonstrate that the risk of battery-caused fires is very real. However, there is no reason to believe that electric buses pose a greater risk than conventional buses. At least, there are no concrete figures to prove this. Still, battery packs in electric buses are significantly larger and more complex compared to regular electric vehicles, which means that their energy load and heat release will be far more impactful.

The impact of an e-bus fire incident

Due to the nature of battery electric bus fires – hard to extinguish and easily spreading – the impact of a fire incident can be enormous. Obviously, there is the destruction of e-vehicles and possible damage to the depot and charging infrastructure. But the impact often goes far beyond the pure **physical damage**:

- **Business disruption:** After the fire at Potters Bar depot in Hertfordshire, UK, Transport for London recalled 90 electric buses as a precautionary measure. Due to the suspension of its e-bus fleet, the transport company reported a serious disruption around five routes. The Paris incidents of April 2022 were even worse. There, 149 buses were temporarily taken out of service.[1] And on top of the actual business disruption, when a public transport company fails to meet its Service Level Agreement (SLA), the relevant authority may also impose penalties or provisions for reimbursements.

- **Environmental damage:** E-bus fires can release toxic fumes and smoke into the air, which can contain harmful pollutants and particulate matter. E-buses typically contain various hazardous materials, such as batteries, coolant fluids, and electronic components. Last but not least, the firewater runoff from firefighting activities, as well as the materials released during an e-bus fire, can potentially contaminate the soil and nearby water bodies. For example, to extinguish and cool the e-bus fire in Stuttgart (September 2021), the fire department needed no less than two million liters of water.

- **Human lives:** Due to their fast development and explosive nature, e-bus fire incidents always include the risk of injuries and even human casualties.

- **PR and reputation damage:** An e-bus fire can have significant repercussions on the reputation of the public transport company operating the bus and potentially impact the perception of electric buses as a whole. It can create doubts among passengers and the general public about the overall safety of using electric buses as a mode of transportation.

[1] https://www.lemonde.fr/economie/article/2022/04/29/paris-la-ratp-retire-temporairement-149-bus-electriques-de-la-circulation-apres-deux-incendies_6124178_3234.html

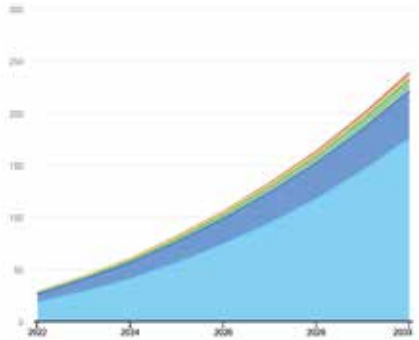
E-bus deployment is growing exponentially

Electric buses are clearly gaining popularity in our cities. Although fires do occur in combustion engine buses as well, fire incidents with e-buses containing lithium-ion batteries are going to gain more attention in the press in years to come, just because we will see more of these buses in our streets.

The e-bus market is booming indeed. In the next few years, electric buses will replace the traditional models with internal combustion engines in local passenger transport systems. In 2019, the European Union adopted a revision of its Clean Vehicles Directive, which sets minimum targets for the public procurement of clean vehicles for EU Member States. These targets range across countries from 24% to 45% in 2025, and from 33% and 65% in 2030, depending on population and gross domestic product.

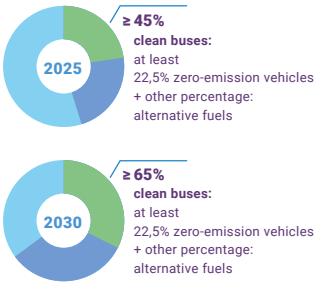
All market research and energy outlook reports seem to agree that the global e-bus market will grow fast in the coming decade. For example, according to the Stated Policies Scenario (STEPS), an energy outlook scenario developed by the International Energy Agency (IEA)[2], the global electric bus fleet reaches 1.4 million in 2025 and 2.7 million in 2030, at which point around one in ten buses will be electric. In the near term, electrification is expected to progress most rapidly within the publicly owned urban bus fleet, which is covered by government procurement regulations and, in some cases, government funding.

While Asia is showing the highest demand, this market growth is a fact for every part of the world. A lot of local regulatory limits for emission, noise and speed in urban zones will force public transport to move quickly towards new technologies.



1 in 10

buses are expected to be electric in 2030



45%

of the EU's newly registered city buses need to be equipped with alternative powertrains by the end of 2025 and at least 65 percent by 2030 [3]

[2] https://www.iea.org/reports/global-ev-outlook-2023/prospects-for-electric-vehicle-deployment

[3] "EU clean vehicles directive" https://transport.ec.europa.eu/transport-themes/clean-transport/clean-and-energy-efficient-vehicles/clean-vehicles-directive_en

Why do e-buses catch fire?

Most electric buses in cities are fully battery driven. This will remain so for quite some time. There are hybrid electric buses, both powered by an internal combustion engine and one or more electric motors, but they are typically not used for public transport in cities. Also, hydrogen fuel cell technology for buses still needs to mature and its application is only expected to scale up on the longer term.[4]

In other words, most electric buses constantly carry a heavy load of batteries with them. Unfortunately, that's exactly where the fire danger looms. Lithium-ion batteries operate in a very narrow temperature range. When the temperature of the battery exceeds the critical level, **thermal runaway** can occur, which will destroy the battery or, even worse, start a fire.

What is thermal runaway?

Thermal runaway is a chain reaction within a battery cell that can be very difficult to stop once it has started. When the temperature inside a battery reaches a certain point, a chemical reaction may occur inside the battery. This will produce even more heat, which drives the temperature higher, causing further chemical reactions that create more heat.

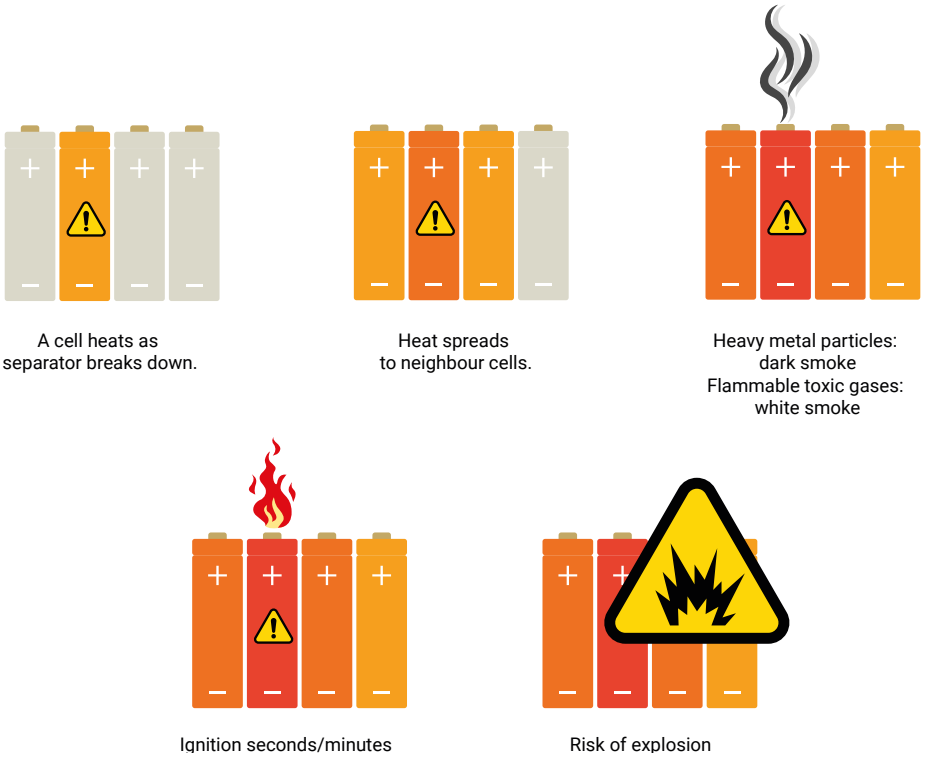


Image source: *https://www.evfiresafe.com/ev-fire-what-is-thermal-runaway*

[4] https://www.iea.org/reports/hydrogen

What causes thermal runaway?

Thermal runaway can have several causes:

- **Mechanical**: A crash or drop may cause physical damage and cause an internal short circuit.
- **Electrical**: Overcharging or fast charging may cause the battery to heat up.
- **Thermal**: High storage temperatures outside of the battery's safe region can lead to irreversible damage and can possibly trigger the thermal runaway process.
- **Manufacturing defects**: If the battery is not manufactured to proper specifications or quality control standards, it can lead to internal shorts, electrode misalignment, or other issues that can cause thermal runaway.
- **Maintenance errors**: Battery maintenance typically involves monitoring and inspecting batteries to ensure their proper functioning.

Due to their great diversity, it's challenging to pinpoint all possible causes of thermal runaway. This also makes it difficult to exclude thermal runaway with 100% certainty. That's why a proper fire safety risk analysis and appropriate measures always need to be in place.

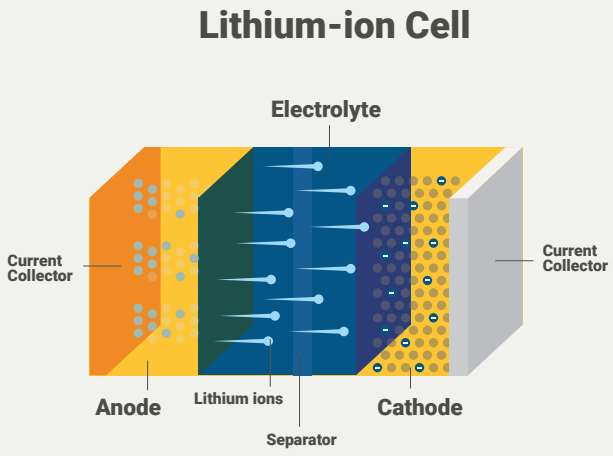
How do lithium-ion batteries work?

A lithium-ion or Li-ion battery is a type of rechargeable battery which uses the reversible reduction of lithium ions to store energy. It is the predominant battery type used in portable consumer electronics and electric vehicles.

Lithium-ion batteries operate through the movement of ions between the positive and negative electrodes. When the battery is discharging, the negative electrode (anode) moves through the electrolyte to the positive electrode (cathode). The process is then reversed when the lithium-ion battery is being recharged.

Separators in lithium-ion batteries separate the anode and cathode. At extremely elevated temperatures, the integrity of the separator itself can be lost, resulting in a short circuit between the cathode and anode in a mechanism called separator breakdown. When separator breakdown occurs, it leads to thermal runaway.

Some batteries have a safety vent allowing gases to escape when the battery breaks down. This can suppress explosive forces. Full battery systems also typically contain a cooling system (air or liquid-based).

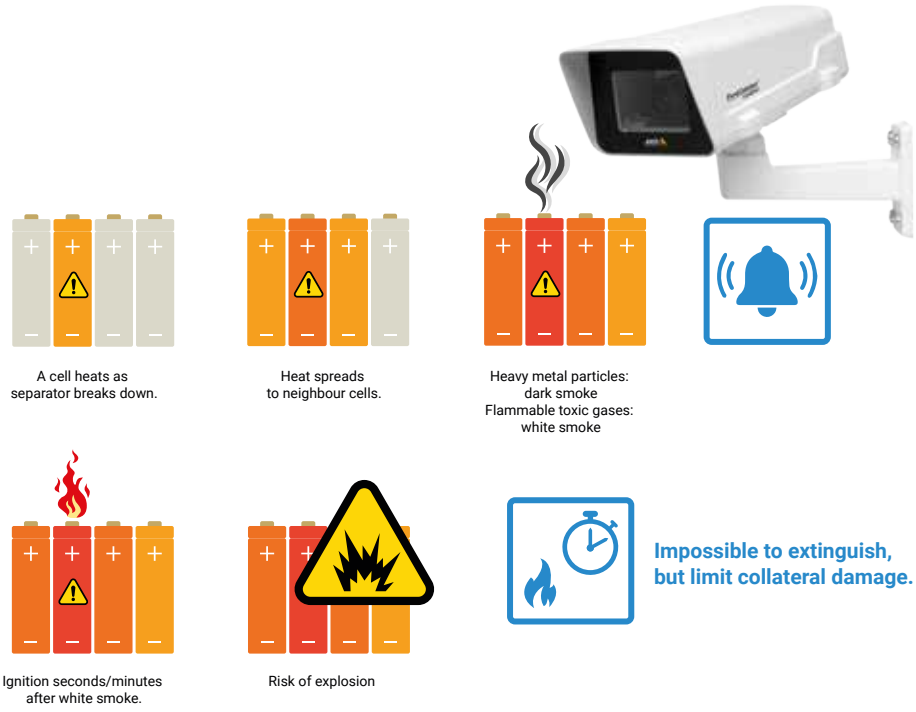


How to detect e-bus fires in an early stage

Although lithium-ion batteries are generally safe, they can present a fire risk when they are damaged or overcharged. Granted, new battery technology that is less prone to combustion and thermal runaway is being researched and developed. Lithium Iron Phosphate batteries are just one example of such innovation, but this battery type has a lower driving range. Other technological advances that can reduce fire risk are battery management systems and cooling. However, no battery is 100% fire-proof.

The thermal runaway process is hard to stop. Battery fires are hard to extinguish and spread easily. However, an early detection of fire or smoke in the process may help to reduce or avoid damage to assets that are not yet affected. So, how then can we detect these fires in time?

Many of the e-bus fires occur while the vehicles are stalled in depots at night. There they are charging, typically in an unsupervised environment. This adds to the fire risk. In worst case, individual e-buses can ignite and take neighboring parked buses with them in the flames. A visual camera-based detection system could already intervene early in the process, as we can see in the image below.



Video smoke/flame recognition

The thermal runaway can go fast. However, the first smoke plumes can already be seen minutes before the flames start to develop. This means, that a high-performance video smoke recognition solution may already give you several minutes of a head start in case of incident.

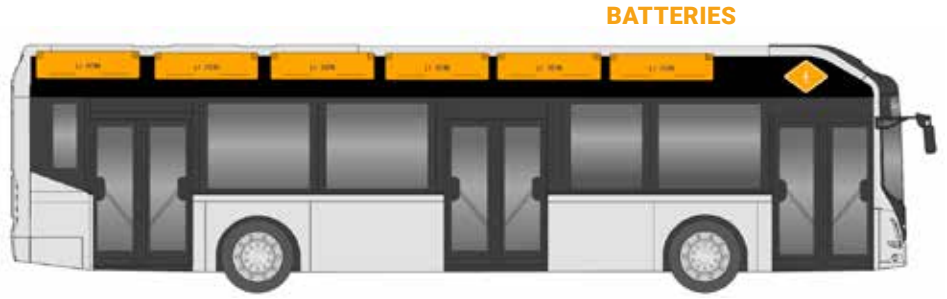
During crash tests with electric vehicles in 2017[4], the damaged batteries almost immediately generated smoke after the impact. The temperature remained relatively stable and low inside the battery compartment for several minutes. In this scenario, heat detection with thermal cameras would not have triggered an alarm. Visual camera-based fire detection however would have detected the smoke and flames almost immediately.

[4] Fullskala branntest av elbil, SP Fire Research AS, 2017

The impact of battery placement

Current trends in battery placement have an impact on the effectiveness of video-based fire recognition as well.

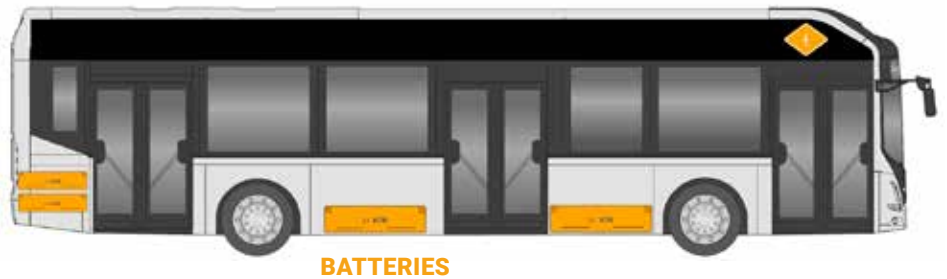
With many of the former and current e-bus models, batteries are installed on the roof or sides. This allows e-bus manufacturers to build a low-entry platform, which is required for public transport buses. It also allows them to re-use conventional bus designs. Batteries on the roof also cool down more easily thanks to the air stream, and they are easier to maintain.



Today, there is a growing trend toward placing batteries on the floor. This has a few important advantages:

- Low battery placement provides more driving stability.
- Without the need for batteries, the upper structure can be much less heavy. By reducing the weight this way, the e-bus gets a higher driving range.
- Smart battery placement can still make sure there is a low-entry part.

In the new scenario, thermal camera detection from above is no longer useful to pick up the heat from batteries building up. Smoke and flame recognition with visual cameras however will detect smoke as soon as it becomes visible between or above the parked buses.



Why video fire recognition is ideal for e-bus depots

By adding intelligent video fire recognition technology, you can effectively enhance the fire safety of your e-bus depot. Video fire detection cameras can visually recognize fire outbreaks in the earliest stages and provide an early warning. Therefore, video fire recognition offers the best guarantee to be ahead of the fire and to prevent worse from happening.

Fast, early stage detection

Traditional fire detectors need to make direct contact with heat or smoke to be activated. But by the time that happens, it can already be too late. Camera-based detectors don't wait for this, but immediately see starting fires at the source. This saves valuable time, which allows you to intervene much quicker and prevent fire damage from spreading.

Visual feedback

First responders that need to go near the fire can be exposed to toxic gases and explosion risk. Video fire recognition can prevent this or at least lower the risk for security personnel. When alerted of an incident, operators can immediately see what is going on in the camera image. This allows them to assess the situation from a distance and make better decisions. Without having to go inside the premises, video fire recognition allows you to see the exact location and the nature of the fire, verify the presence of people/victims, and assess the progress of the incident in real time.

Ideal for great heights or large spaces

Video fire recognition is ideal for use in tall buildings or large (half) open spaces like bus depots. In these environments, smoke might never reach a traditional smoke detector, because of a process called stratification, which stops the upward movement of smoke. In large spaces, a single camera can oversee a wide area when it is placed on the right location.

Flexible connectivity

You can easily connect a video fire recognition camera to a conventional fire alarm control panel through physical outputs to trigger alarm devices or to a Video Management System (VMS) by sending alarm messages and streaming video to visualize.

Video fire recognition technology from Araani offers the detection speed, accuracy and reliability you need to increase fire safety in your e-bus depot. By installing video fire recognition cameras, you can:

- Minimize (collateral) damage.
- Minimize business interruption.
- Save lives and protect first responders.
- Minimize environmental damage from toxic battery gases.

Key points

- Electric vehicle battery fires do not occur frequently, but if they do, they:
  - escalate very fast due to a process called thermal runaway.
  - cause huge loss of assets and infrastructure.
  - are hard to extinguish.

- Technology advances have improved the fire safety of e-buses, but it is not possible to avoid fire risks completely.

- Conventional and thermal-based fire detection is not effective:
  - In (semi-)outdoor environments or large spaces
  - In depot buildings with high ceilings
  - With batteries installed in the bus floor

- Video fire recognition enhances the fire safety of your e-bus depot. A video fire recognition camera can spot battery fires from a large distance and in an early stage.

ARAANI®

version 20231016

About Araani

Founded in 2014, Araani is a Belgian company specializing in video analytics for people, property and process protection. Araani FireCatcher is an advanced video fire detection solution that has been designed for critical infrastructure protection.

Contact

Araani NV - Belgium
Luipaardstraat 12
8500 Kortrijk, Belgium
tel: +32 (0) 56 49 93 94
info@araani.com

Araani NV - France
135, Avenue Roger Salengro
59100 Roubaix, France
tel: +33 (0) 6 50 30 42 35

Araani NV - MEA
One JLT, Floor 6, suite 208
JLT, Dubai, UAE
tel: +971 56 979 5142

Araani NV - North Africa
3, Pl de Navarre Imm San Francisco
Niv 2 - Num 9
90000 Tanger, Morocco

www.araani.com

ARAANI VISION ON SAFETY