

Electric Vehicles (EV)

The purpose of this guide is to provide the fire service a roadmap on how to conduct a safe and informative familiarization of an electric vehicle.

This is meant to supplement and not replace training from a recognized source.



Electric Vehicles (EV)

Familiarization Focus Areas

High-Voltage Safety: High-voltage components in EVs (e.g., battery packs, power cables).

EV Fire Behavior: Fire behaviors of EVs, particularly lithium-ion battery fires, and appropriate suppression tactics (e.g., copious amounts of water for cooling).

Extrication Procedures: High voltage systems and dealing with reinforced vehicle frames.

Charging Stations: EV charging stations operation and the associated electrical hazards.



Electric Vehicles (EV)

Hybrid Electric Vehicle (HEV)

What type of electric vehicle are you familiarizing yourself with?

Hybrid Electric Vehicle (HEV)

Introduction

Two types of propulsion working together



Toyota Prius

Photo courtesy of Toyota

Characteristics

- Use batteries and electric motors to assist internal combustion engine (ICE)
- Better fuel economy than conventional vehicle
- ICE shuts down when not needed
- No external action needed to recharge battery



Electric Vehicles (EV)

Plugin Hybrid Electric Vehicle (PHEV)

What type of electric vehicle are you familiarizing yourself with?

Plugin Hybrid Electric Vehicle (PHEV)

Introduction

Two types of propulsion working together and external charging

Characteristics

- HEV which allows battery to be charged from external source
- Increased power capacity over HEV
 - Improves range on battery
 - Greater reduction of ICE use



Photo courtesy of Toyota



Electric Vehicles (EV)

Hybrid Electric Truck/Bus (HEV)

What type of electric vehicle are you familiarizing yourself with?

Hybrid Electric Truck/Bus (HEV)

Introduction



Characteristics

- Same principle as hybrid passenger vehicles
- Diesel motor and larger scale HV system
- The ICE may or may not shut down when stationary



Electric Vehicles (EV)

Electricity Types

EV's rely on AC and DC electrical circuits. As you familiarize yourself with the vehicle, locate each.

Electricity Types

Basic Electrical Concepts & Hazards

Types of Electricity Found in P/HEVs and EVs

DC

- Found in all P/HEVs and EVs
- All use batteries for Electrical storage

AC

- Found in most P/HEVs and EVs
- These models use AC motors
- DC converted to AC



Electric Vehicles (EV)

Hazards by Vehicle Type

Does this vehicle also have another fuel/power source besides electricity?

Hazards by Vehicle Type

Introduction

High Voltage and Fuel

- Hybrids
- Plug-in Hybrids

High Voltage Only

- EVs



Photo courtesy of Toyota



Electric Vehicles (EV)

12 Volt Battery

Locate the vehicles 12v battery and any disconnects.

These batteries provide power that enables or disables the high voltage systems.

12V Battery

P/HEV and EV Systems & Safety Features: Vehicle Components

- Found in all passenger vehicle types covered
- Powers vehicle's 12v system



Locations

Most Common:

- Under the hood
- Trunk or cargo compartment

Less Common:

- Front wheel well
- Under 2nd row seat
- Under driver's seat



Electric Vehicles (EV)

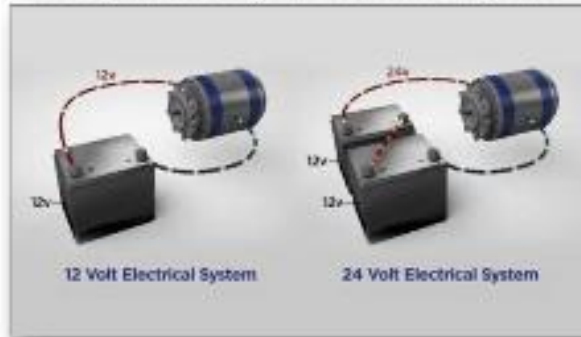
24 Volt Battery

Is there a 24 volt battery?

Locate it and any disconnects.

24 Volt Battery

P/HEV and EV Systems & Safety Features: *Vehicle Components*



- Commonly found in truck and bus applications
- Two 12-volt batteries wired in series



Electric Vehicles (EV)

High Voltage Batteries

Are there high voltage batteries?

Identify the types.

High Voltage Batteries

P/HEV and EV Systems & Safety Features: Vehicle Components

Two Major Types

NiMH
Nickel Metal
Hydride



Li-Ion
Lithium Ion



Electric Vehicles (EV)

Battery Pack Construction

Refresh yourself on battery construction.

Battery Pack Construction

P/HEV and EV Systems & Safety Features



Electric Vehicles (EV)

High Voltage System Operation

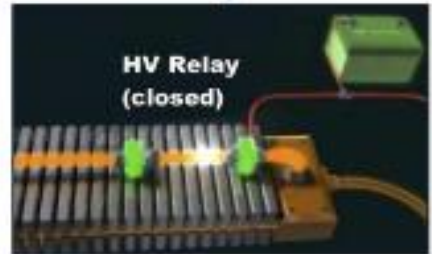
Does this vehicle have a high voltage relay?

High Voltage System Operation

P/HEV and EV Systems & Safety Features: Vehicle Operation

High Voltage Battery Relay

- Located in HV battery
- Functions like a switch
- Activated by 12V/24V power from the low voltage system
- Removal off all 12V/24V current to relay causes it to open, stopping the flow of HV current



Electric Vehicles (EV)

Electrical Cables

Look for the electrical cables throughout the vehicle and pay attention to any color/labeling.

Electrical Cables

P/HEV and EV Systems & Safety Features: Vehicle Components

Low Voltage

<30 Volts

Typically:

- Red (+)
- Black (-)



Intermediate Voltage

30-60 Volts

Typically:

- Yellow
- Blue



High Voltage

>60 Volts

SAE Standard

- Orange



Electric Vehicles (EV)

Intermediate/High Voltage Cables

Intermediate/High Voltage Cables

P/HEV and EV Systems & Safety Features: *Vehicle Components*

Intermediate and high voltage cables should both be considered highly dangerous



Always treat yellow and blue cables as high voltage



Electric Vehicles (EV)

Intermediate/High Voltage Cable Locations

Intermediate/High Voltage Cable Locations

P/HEV and EV Systems & Safety Features: Vehicle Components



Typically routed on the underside of vehicle and under hood in cars/light trucks



Electric Vehicles (EV)

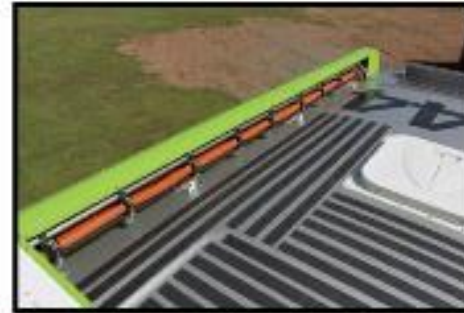
High Voltage Cables - Transit Buses

High Voltage Cables- Transit Buses

P/HEV and EV Systems & Safety Features: *Vehicle Components*

Locations

- Roof along roof rail
- Rear roof support posts
- Rear engine compartment



Electric Vehicles (EV)

Inverter/Converter - Passenger Vehicle

Locate the inverter/converter on the vehicle

Inverter/Converter – Passenger Vehicle

P/HEV and EV Systems & Safety Features: *Vehicle Components*



Found in vehicles using
AC drive motors



Electric Vehicles (EV)

Inverter/Converter - Transit Buses

Inverter/Converter – Transit Buses

P/HEV and EV Systems & Safety Features: *Vehicle Components*

Varied Locations

- Roof
- Rear engine compartment



Electric Vehicles (EV)

Inverter / Converter

Use extreme caution when using tools, halligans, near inverters/converters.

They contain high voltage electricity and pose shock hazard if penetrated.

Inverter/Converter

P/HEV and EV Systems & Safety Features: Vehicle Components

Emergency Responder Concerns:

- Dangerous to penetrate cover with tools
- Capacitors inside unit can store energy for some time
- If damaged, capable of rapid energy discharge that can cause severe injury



Electric Vehicles (EV)

High Voltage Battery Charging Methods

Determine how the vehicle high voltage batteries are recharged

High Voltage Battery Charging Methods

P/HEV and EV Systems & Safety Features: *Vehicle Types*

Engine



- Engine used to generate electricity

Regenerative Braking



- Electric motor helps slow vehicle down
- As motor turns, electricity is produced

Can damage HV system if towed with drive wheels on the ground (fire hazard)

External Charger



- Charging station used to recharge HV battery



Electric Vehicles (EV)

Charging Port - Passenger Vehicles

Locate the charging port

CAUTION:

During charging operations the vehicle does not provide an electrical ground.

Grounding may occur when water is sprayed on a vehicle or by personnel coming into contact with the charging cable/vehicle.

This can complete the circuit and cause electrical shock.

Charging Port – Passenger Vehicles

P/HEV and EV Systems & Safety Features: Vehicle Components



**Access to
connect the
charging station
to the vehicle**



Electric Vehicles (EV)

Truck & Bus Safety Systems

If you are looking at a bus or truck, locate the emergency shutdown.

Truck & Bus Safety Systems

P/HEV and EV Systems & Safety Features: *Vehicle Operation*

Emergency Shutdowns

- Some trucks and buses are equipped
- Cuts 12V/24V power to HV relays
- Disables HV system
- Locations vary with application



Electric Vehicles (EV)

Electrical Vehicle Supply Equipment (EVSE)

EV charging systems in a residential garage may have components that look like this.

Electrical Vehicle Supply Equipment (EVSE)

Charging Stations (EVSE)



Service Panel

Typical Setup



Charging Station

Charging component which converts to DC for battery is found on vehicle



Vehicle

Acts as an interface between building power supply and vehicle



Electric Vehicles (EV)

Level II Charger

Higher levels of energy are used in Level II Chargers to provide faster recharging.

Level II Charger

Charging Stations (EVSE)

Types of Level II Chargers

Portable



Commercial



Residential



Electric Vehicles (EV)

DC Fast Charger

These type chargers use DC current and usually are for commercial applications.

DC Fast Charger

Charging Stations (EVSE)

Fastest charging system

Utilizes 208V or 480V 3-phase AC power @ <125 Amps (Typ. 60 Amps)

Electrical requirements and expense will limit it to commercial applications



Estimated Charge Time from Empty

- PHEV: N/A
- EV: 20 Min to 1 Hour
- Typical Power Output: 50-350 kW
- Found in Public Applications

Output 400 V – 1000 V DC Output to Vehicle

Illustration courtesy of the ChargePoint



Electric Vehicles (EV)

Passenger Vehicle Safety Systems

Internal safety systems should shut down high voltage systems, does the EV you are looking at have this feature?

Passenger Vehicle Safety Systems

P/HEV and EV Systems & Safety Features: *Vehicle Operation*

High Voltage Systems are Designed to Shut Down During:



Electric Vehicles (EV)

Flammable Gas Release and Ignition

EV batteries can release flammable gasses that can ignite during emergency operations.

Many EV's have vent ports installed to direct the flow of these gasses, where are the vent ports on the EV you are looking at?

Flammable Gas Release and Ignition

Emergency Operations



PHOTO BY MATHEU WAGNER / CBC on Twitter

Gas Buildup & Ignition

- Especially in confined areas
 - Interior to the vehicle
 - Vehicle storage – Such as a garage
- Off-gassing from battery builds up flammable gases
- Ignition source can cause deflagration type event
- Be careful when venting – may bring below UEL



Electric Vehicles (EV)

Vehicle Fires - Post Fire Storage

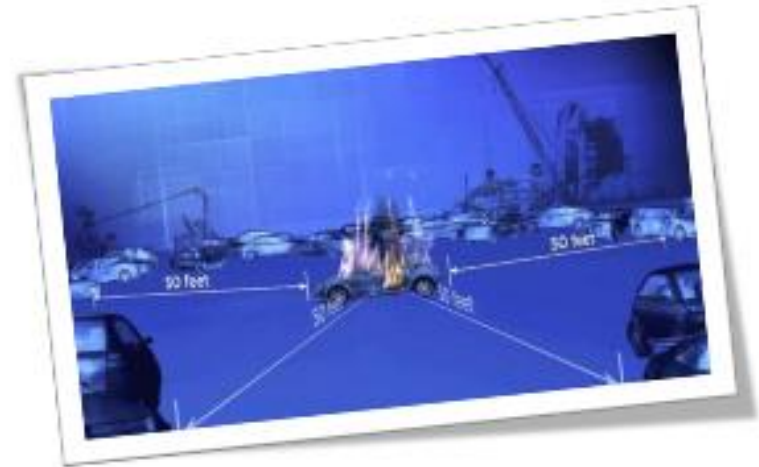
A EV involved in a fire or crash should be stored away from exposures and monitored for reignition of the high voltage battery.

Vehicle Fires – Post Fire Storage

Emergency Operations

Re-ignition

of burned HV battery can occur after several hours or more



NHTSA

recommends involved vehicles stored at least 50 feet (15.25 meters) away from exposures

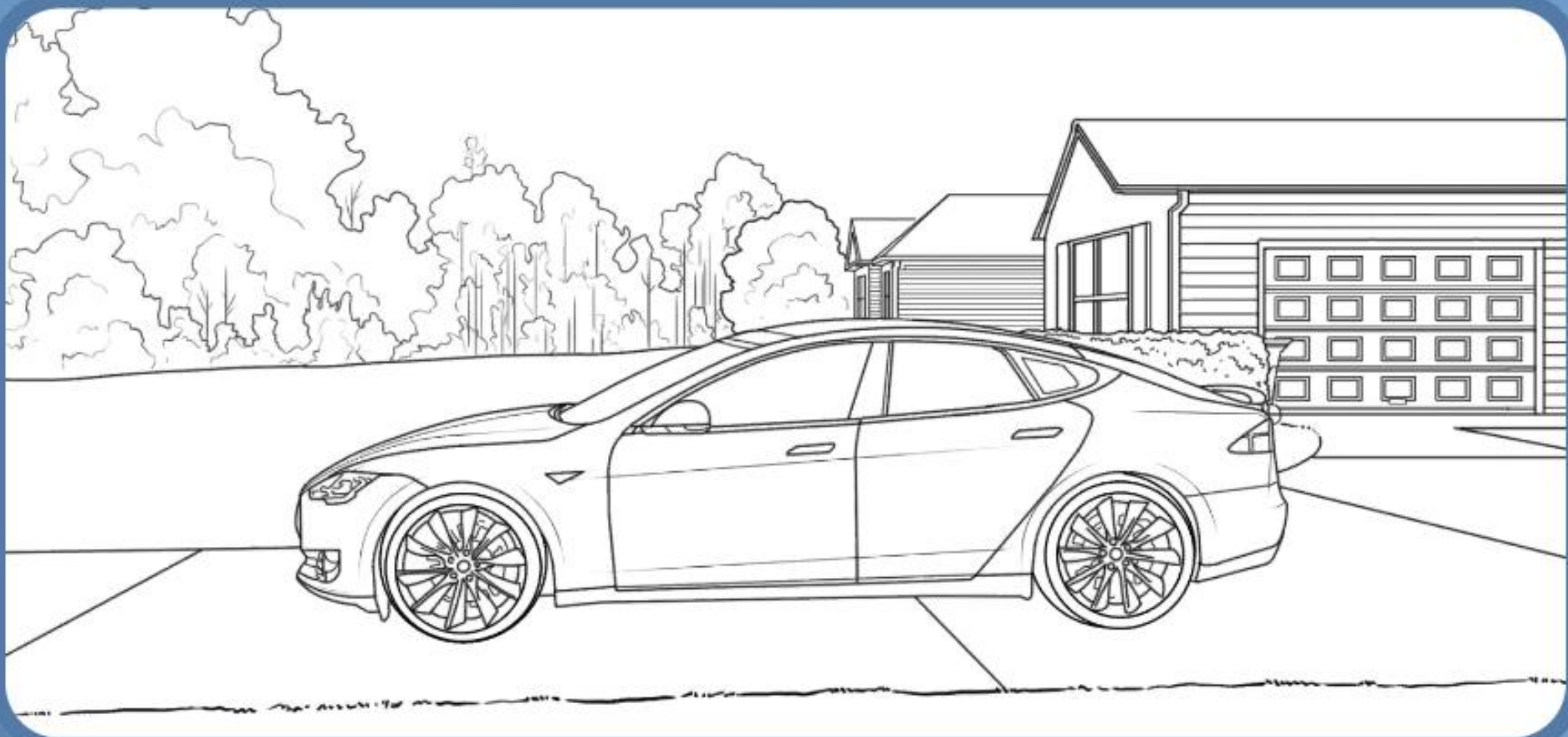




Congratulations!

You have completed the EV module. Let's explore an incident scenario.

CONTINUE



Let's explore an incident scenario.

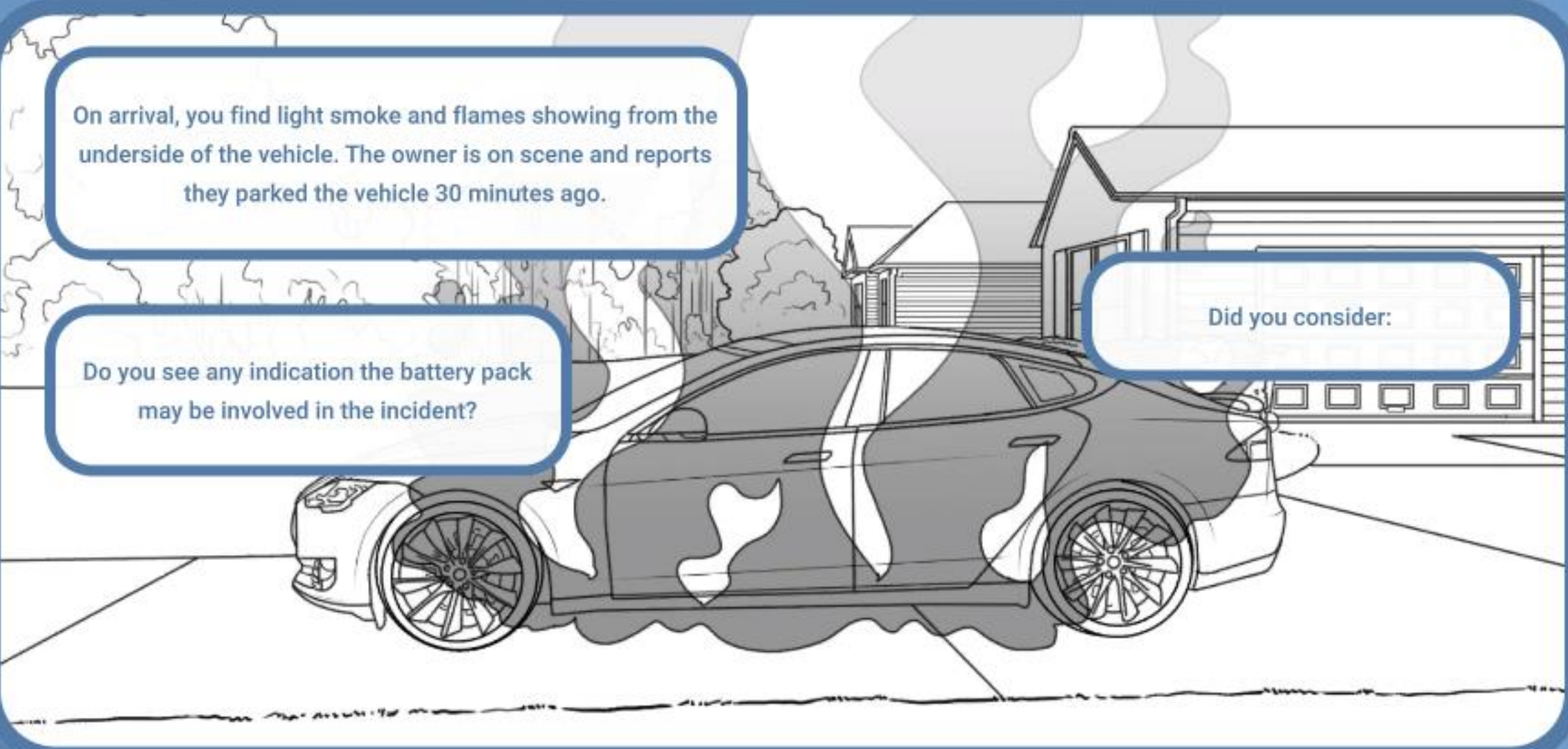


On arrival, you find light smoke and flames showing from the underside of the vehicle. The owner is on scene and reports they parked the vehicle 30 minutes ago.



You are dispatched to a possible car fire in a residential driveway, caller reports smoke coming from the underside of the vehicle.





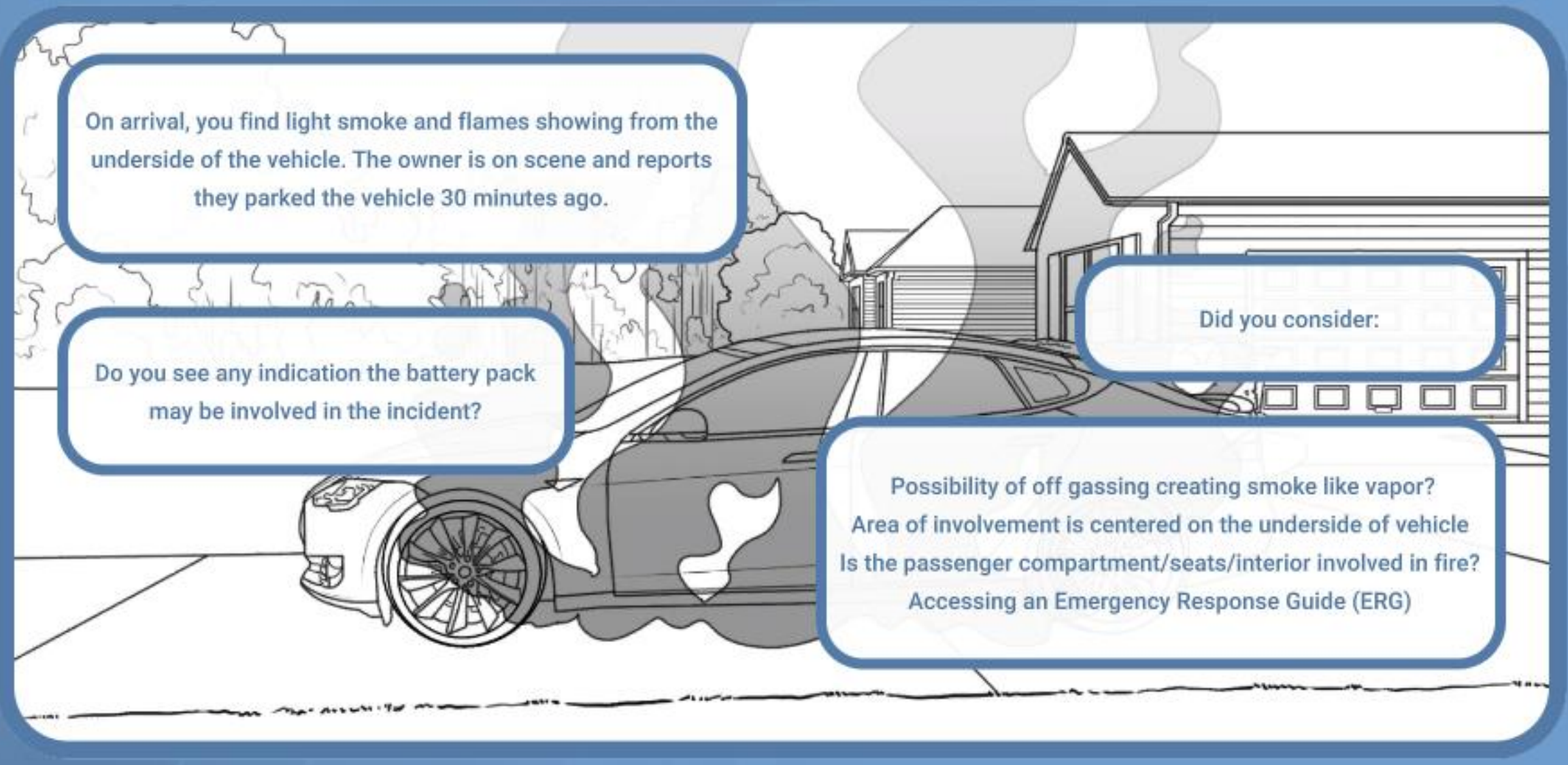
On arrival, you find light smoke and flames showing from the underside of the vehicle. The owner is on scene and reports they parked the vehicle 30 minutes ago.

Do you see any indication the battery pack may be involved in the incident?

Did you consider:

You are dispatched to a possible car fire in a residential driveway, caller reports smoke coming from the underside of the vehicle.





On arrival, you find light smoke and flames showing from the underside of the vehicle. The owner is on scene and reports they parked the vehicle 30 minutes ago.

Do you see any indication the battery pack may be involved in the incident?

Did you consider:

Possibility of off gassing creating smoke like vapor?
Area of involvement is centered on the underside of vehicle
Is the passenger compartment/seats/interior involved in fire?
Accessing an Emergency Response Guide (ERG)

You are dispatched to a possible car fire in a residential driveway, caller reports smoke coming from the underside of the vehicle.

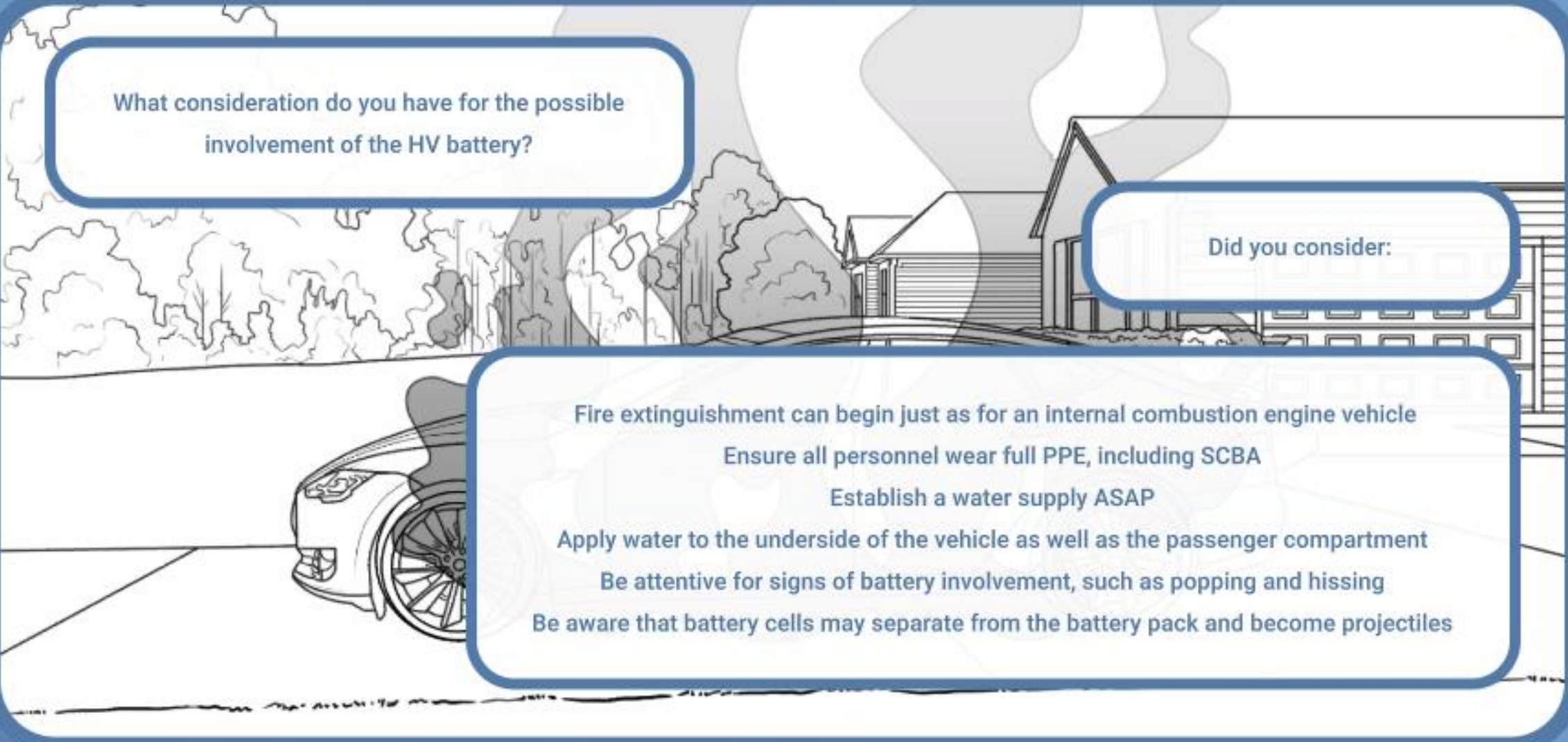


What consideration do you have for the possible involvement of the HV battery?



You are dispatched to a possible car fire in a residential driveway, caller reports smoke coming from the underside of the vehicle.





What consideration do you have for the possible involvement of the HV battery?

Did you consider:

Fire extinguishment can begin just as for an internal combustion engine vehicle

Ensure all personnel wear full PPE, including SCBA

Establish a water supply ASAP

Apply water to the underside of the vehicle as well as the passenger compartment

Be attentive for signs of battery involvement, such as popping and hissing

Be aware that battery cells may separate from the battery pack and become projectiles

You are dispatched to a possible car fire in a residential driveway, caller reports smoke coming from the underside of the vehicle.

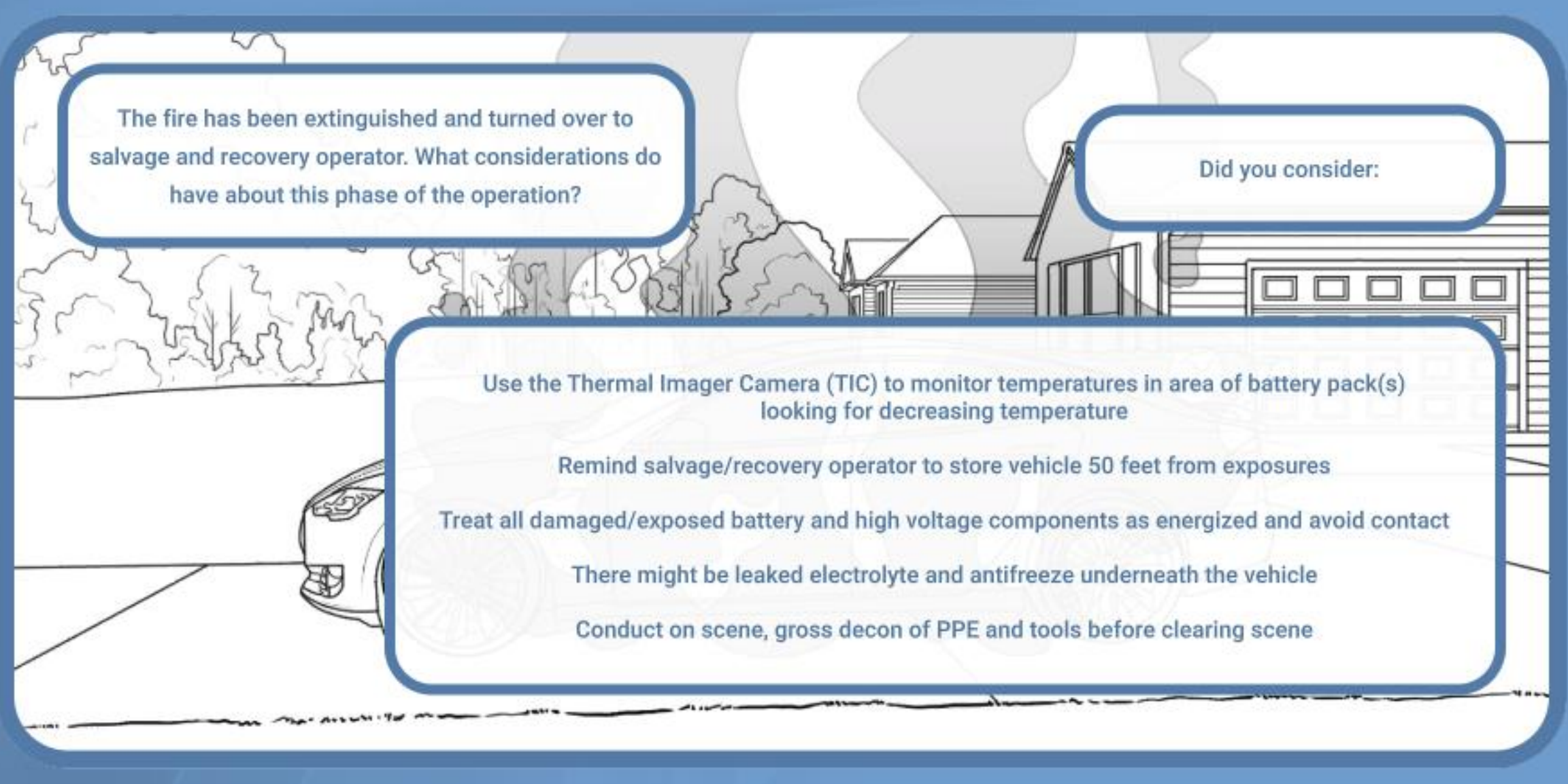


The fire has been extinguished and turned over to salvage and recovery operator. What considerations do have about this phase of the operation?



You are dispatched to a possible car fire in a residential driveway, caller reports smoke coming from the underside of the vehicle.





The fire has been extinguished and turned over to salvage and recovery operator. What considerations do you have about this phase of the operation?

Did you consider:

Use the Thermal Imager Camera (TIC) to monitor temperatures in area of battery pack(s) looking for decreasing temperature

Remind salvage/recovery operator to store vehicle 50 feet from exposures

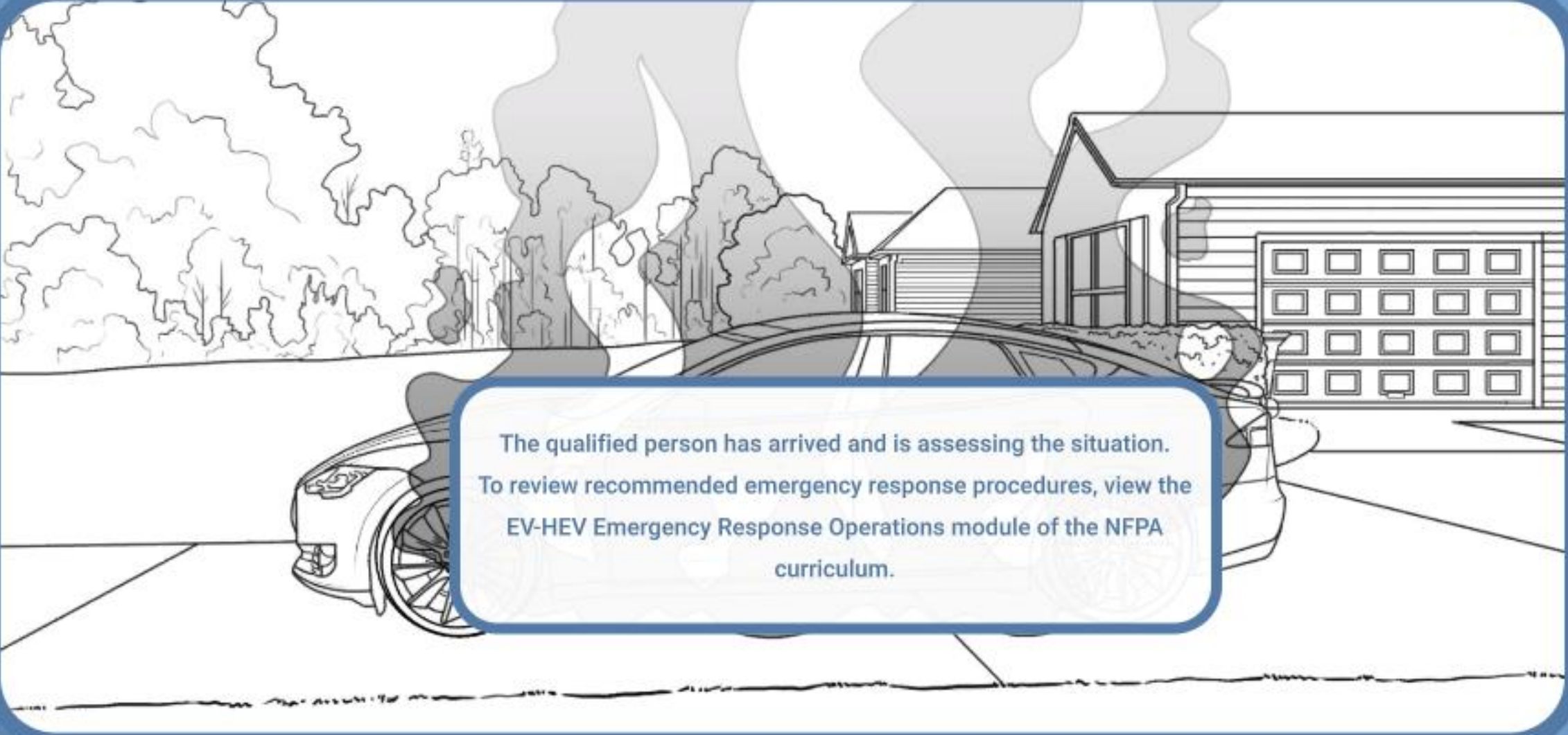
Treat all damaged/exposed battery and high voltage components as energized and avoid contact

There might be leaked electrolyte and antifreeze underneath the vehicle

Conduct on scene, gross decon of PPE and tools before clearing scene

You are dispatched to a possible car fire in a residential driveway, caller reports smoke coming from the underside of the vehicle.





The qualified person has arrived and is assessing the situation.
To review recommended emergency response procedures, view the
EV-HEV Emergency Response Operations module of the NFPA
curriculum.

