

## Energy Storage Systems (ESS)

The purpose of this guide is to provide the fire service a roadmap on how to conduct a safe and informative familiarization of energy storage systems.

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



# Energy Storage Systems (ESS)

## Considerations

As you familiarize yourself with DER, take note of the various components, signage and posted safety precautions.

**Fire Behavior:** Apply lessons learned from BESS thermal runaway incidents to the specific location to illustrate the resources required to respond to a fire.

**Energy Isolation:** Familiarize firefighters with procedures/tactics that can be used to isolate energy during an emergency event.

**Ventilation and Hazmat Considerations:** Discuss procedures/tactics that can be used at the site for ventilation of toxic gases and containment of hazardous substances.



# Energy Storage Systems (ESS)

## BESS Installation Locations

As you prepare for your familiarization activity, survey the site and answer what type of BESS location is this? Residential, Commercial, or Utility Scale?

## BESS Installation Locations

Battery Energy Storage Systems (BESS)

### Residential

- Typically located close to electrical panel, in garage, basement or outside
- Similar in appearance to a wall mounted cabinet
- Rarely found in homes without PV systems present



# Energy Storage Systems (ESS)

## BESS Installation Locations

Identify if Commercial, Residential, or Utility Scale Installation.

### BESS Installation Locations

Battery Energy Storage Systems (BESS)

#### Commercial

- In battery rooms
- Outdoor enclosures
- Separate buildings
- Rooftops
- Barges



# Energy Storage Systems (ESS)

## BESS Installation Locations

Identify if Commercial, Residential, or Utility Scale Installation.

## BESS Installation Locations

Battery Energy Storage Systems (BESS)

### Utility Scale

- Small to large substations
- Power generation plants
- Neighborhood micro-grids
- May or may not be owned by utility



# Energy Storage Systems (ESS)

## BESS Locations In the Grid

And next, where is the BESS located relative to the main electrical distribution network?

Is it a supply source feeding the grid or a consumer location taking from the grid?

## ESS Locations In the Electrical Grid

Introduction

### Utility Side of the Meter



### Customer Side of the Meter



Residential



Commercial/Industrial



# Energy Storage Systems (ESS)

## BESS Applications

What is the primary purpose of this BESS?

## ESS Applications

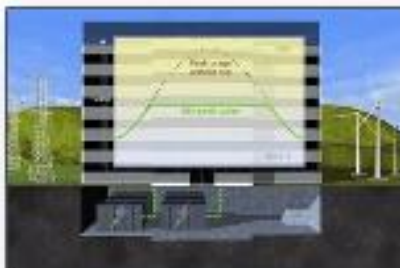
Introduction



Backup Power



Off-Grid



Cost Savings (Peak Shaving)



Renewable Energy Support



# Energy Storage Systems (ESS)

## BESS Design & Components

Take a minute to review the critical BESS components you should be looking for.

### BESS Design and Components

Battery Energy Storage Systems (BESS)

**Inverter:**

**Changes DC from panels to AC...**



**...and AC back to DC to charge batteries**





# Energy Storage Systems (ESS)

## BESS Design & Components

Knowing how the safety systems for this site function will be useful information when responding to it.

## BESS Design and Components

Battery Energy Storage Systems (BESS)

### Safety Systems

Charge Controller	Battery Management System (BMS)
<ul style="list-style-type: none"><li>• Regulates battery charging</li><li>• Prevents over and under charging</li></ul>	<ul style="list-style-type: none"><li>• Monitors battery temperature and voltages</li><li>• Found on most rechargeable battery packs</li><li>• Isolates and stops charging to cell, module or rack – depending on where the problem is</li><li>• Critical to safe system operation</li></ul>



# Energy Storage Systems (ESS)

## BESS Design & Components

Pay attention to what type of batteries and their chemistries are present.

You may find more than one battery type/chemistry at this BESS site.

## Lead Acid Batteries

Battery Energy Storage Systems (BESS)

### Wet Cell Lead Acid

- Most common flooded cell type
- Sulfuric acid and water mixture
- Used in Telecom for over 100 years
- Common in off-grid and backup ESS



### Dry Cell Lead Acid

- Some lead acid batteries do not have liquid electrolyte
- Similar to deep-cycle maintenance free batteries
- VRLA: Valve Regulated Lead Acid

**VRLA batteries are prone to thermal runaway if overheated**



# Energy Storage Systems (ESS)

## BESS Design & Components

Each type has specific hazards.

Batteries may contain different fluids that support safe operation of the battery.

## Lithium-Ion Batteries

Battery Energy Storage Systems (BESS)

### Electrolyte

- Flammable organic solvent
- Made up lithium salts impregnated in other materials
- Contains very little in a liquid state
- Commonly found in hybrids, EVs, BESS and emobility devices



**Does not contain pure lithium which is a reactive metal**



# Energy Storage Systems (ESS)

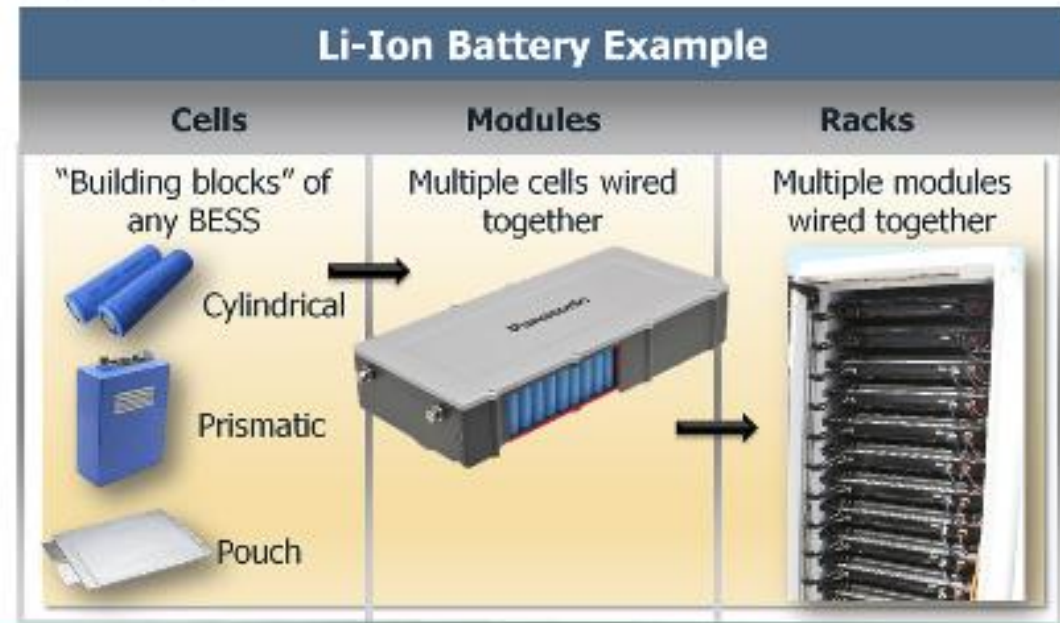
## BESS Design & Components

Remember, batteries will be found in different configurations and enclosures.

Often batteries contain assemblies of small cells/pouches that can be connected and placed in racks/enclosures.

## BESS Design and Components

Battery Energy Storage Systems (BESS)



# Energy Storage Systems (ESS)

## Hazards - Thermal Runaway

Thermal runaway is a hazard of Lithium-Ion batteries and can produce fire and flammable gases.

## Hazards – Thermal Runaway

Battery Energy Storage Systems (BESS)

### Process

- Internal temperature of a cell rises above operating range
- Can propagate from cell to cell
- Can occur without fire



Often results in fire or explosion

### Signs

- Bulging of battery
- Temperature increase
- Visible white smoke or gases
- Heat and flames
- Clicking, hissing, or popping noises



# Energy Storage Systems (ESS)

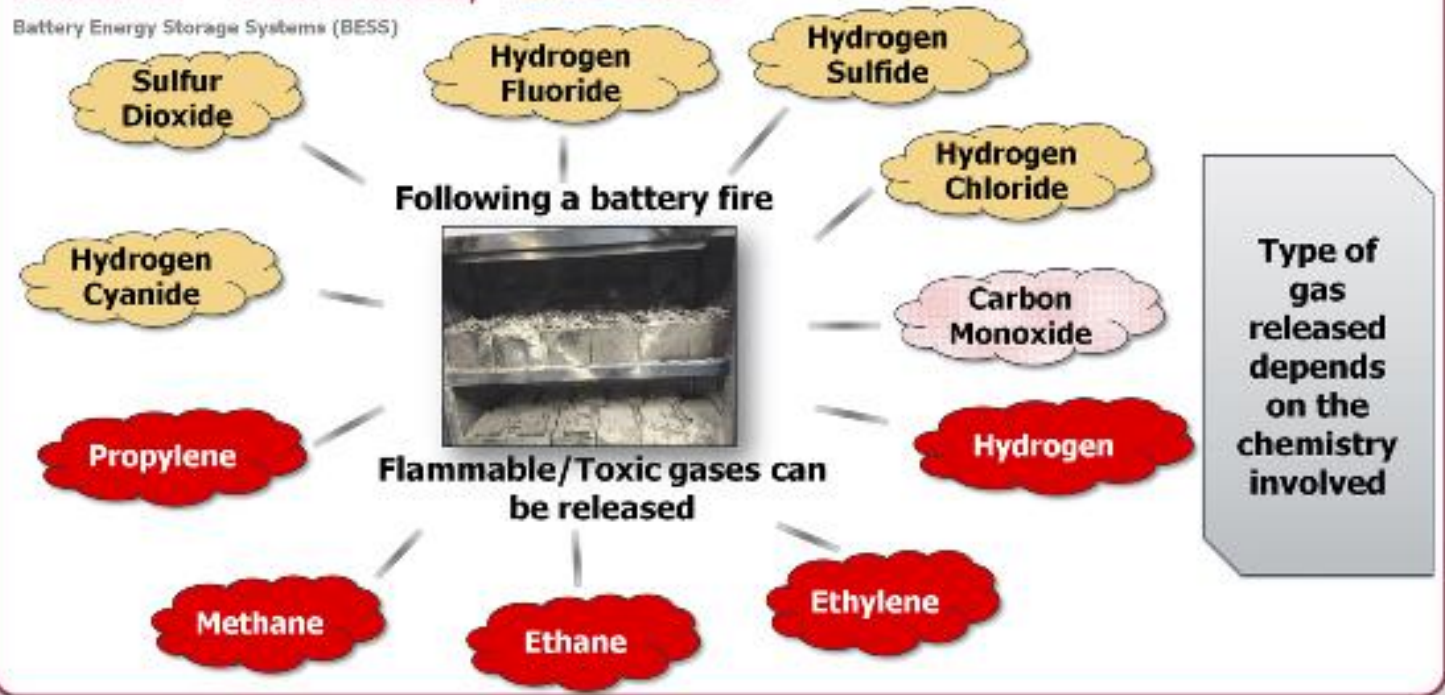
## Hazards - Flammable/Toxic Gases

These gases contain many chemical by products.

Always utilize full PPE , including SCBA, during all phases of a BESS incident.

### Hazards – Flammable/Toxic Gases

Battery Energy Storage Systems (BESS)



# Energy Storage Systems (ESS)

## Hazards - Fire / Explosion

Developing an awareness of the impact of a fire/explosion at this site needs to be a primary consideration during your familiarization.

## Hazards – Fire/Explosion

Battery Energy Storage Systems (BESS)

### Fire Concerns

- Thermal runaway
- Rapid cell to cell heat/fire spread (propagation)
- Potential flashover due to built up gases



### Explosion Concerns

- Prone to explosion during failure
- Pressure may cause breach of outside containment
- Lead acid batteries release hydrogen



# Energy Storage Systems (ESS)

## Hazards - Contact with Electrolyte

Consider what event at the site could result in leaking electrolyte.

Refer to site Safety Data Sheets (SDS) for information on electrolytes at this site.

## Hazards – Contact with Electrolyte

Failure Modes and Hazards

### Possible Results:

- Inhalation hazard/contact exposure
- Skin, eye or irritation burns
- PPE degradation
- Protect the environment from leaking electrolyte or water runoff





# Energy Storage Systems (ESS)

## HAZARDS

Electrical shock

BESS energies can be high voltage and posses dangerous amperage levels.

BESS can pose hazards if personnel come in contact with live parts during familiarization activities.

**SAFETY:** Always follow site safety protocols

## Hazards – Electrical Shock

Battery Energy Storage Systems (BESS)

### BESS Voltage Ranges

#### Commercial

• 480 – 1,500 Vdc



#### Residential

• 48 – 400 Vdc



These voltages can exist after utilities are shutdown



# Energy Storage Systems (ESS)

## Preplanning

Do you have a knowledgeable person guiding you during the familiarization?

Have you reviewed the pre-incident plans for the site?

## Preplanning

Pre-Incident Planning

### Pre-Incident Planning:

Completed by operational personnel to establish a working knowledge of the installation and procedures

### Reach Out

To building officials to see if systems are being installed



### Request

Building official notify FD of permits/applications



# Energy Storage Systems (ESS)

## BESS / PV Items to Identify

Before you begin the familiarization, here are some key areas to focus on.

### ESS/PV Items to Identify

Pre-Incident Planning

#### Common Items

- Emergency contact information
- Signage & markings
- Unidentified installations

#### Photovoltaic

- Array locations
- Inverters
- Disconnects

#### Energy Storage

- System type, size & chemistry
- Safety Data Sheets (SDS)
- Battery disconnects
- Gas and fire detection
- HVAC & exhaust
- Fixed suppression systems

Reference any applicable department SOPs during preplanning process



# Energy Storage Systems (ESS)

## BESS Installation Type and Hazards

Remember, you want to understand where this site is located and the method the batteries are assembled and their chemistries by the end of the familiarization.

## ESS Installation Type and Hazards

Pre-Incident Planning

### Determine:

- Locations and size of system
- Interior or exterior install
- Potential life safety hazards
- Assembly – open racks vs. cabinets
- Chemistries utilized and potential hazards
- Application



**Identify any additional resources that may be required**



# Energy Storage Systems (ESS)

## Safety Data Sheets

Locate and review any Safety Data Sheets.

Look for information about electrolytes.

## Safety Data Sheets

Pre-Incident Planning

### Always Review SDS

**A123 SYSTEMS**

Product Name: High Power Lithium Ion Cell, Cylindrical Battery  
Revision: 001  
Revision Date: August 24, 2010  
Page 4 of 9

**SAFETY DATA SHEET**  
According to Regulation (EC) No. 1907/2006

**Section 1: Pre-Incident Planning Measures**

Section 1: Pre-Incident Planning Measures	Identify all batteries in the area and check the labels for any and all hazards. Do not open or attempt to repair a battery. Do not use a battery that is damaged or leaking. Do not use a battery that is not labeled for use in the area.
Section 2: Hazards	Section 2: Hazards GHS05 - Corrosive GHS09 - Flammable GHS07 - Toxic GHS08 - Explosive GHS02 - Highly Flammable GHS03 - Irritant GHS06 - Harmful GHS04 - Irritant GHS07 - Toxic GHS08 - Explosive GHS09 - Flammable GHS10 - Carcinogenic GHS11 - Environment
Section 3: Physical/Chemical Properties	Section 3: Physical/Chemical Properties Appearance: Dark grey, cylindrical Odor: No odor Boiling Point: 150°C Melting Point: 150°C Flash Point: 150°C Auto-ignition Temperature: 150°C Decomposition Temperature: 150°C Stability: Stable under normal conditions Reactivity: No reaction with water Incompatibility: No incompatibility Hazardous Decomposition Products: No hazardous decomposition products Hazardous Combustion Products: No hazardous combustion products

### SDS Provides Key Info

- Battery chemistry
- Health hazards
- Firefighting measures
- Not always available for Li-ion

Any updates should be added to the preplan



# Energy Storage Systems (ESS)

## Emergency Contact Information

Locate where the emergency contact information is located and ensure all participants know where it is located and what is a qualified person.

## Emergency Contact Information

Pre-Incident Planning

### NEC 2017 Definition: **Qualified Person**

One who has skills and knowledge related to the construction and operation of the electrical equipment and installations and has received safety training to recognize and avoid the hazards involved.

- Look for label with system installer contact info
- Contact electrician with experience in PV & ESS

### **Emergency Contact**

- Authorized service personnel
- Building representatives
- Update information on regular basis



# Energy Storage Systems (ESS)

## PV + BESS Signage and Markings

What signs do you see?

Remember signs will not be visible in reduced visibility conditions.

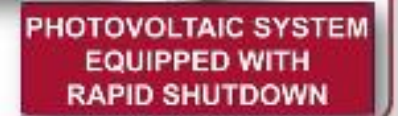
## PV + ESS Signage and Markings

Pre-Incident Planning

**Determine**  
the location and type of  
BESS and PV system

**It's Possible**  
that no markings are present  
on older installations

### Look for labels and signs



# Energy Storage Systems (ESS)

## BESS Signage and Markings

Electrical shock hazard is present throughout the site. Treat all components as energized, even during the familiarization.

## ESS Signage and Markings

Pre-Incident Planning



If Not Present or Clear  
bring to owner's attention





# Energy Storage Systems (ESS)

## BESS Battery Disconnects

Note the location and operation of battery disconnects.

Can they be safely operated by fire service personnel?

## ESS Battery Disconnects

Pre-Incident Planning

- Important: locate emergency power disconnects
- Should be in sight of electrical panel, or location noted at panel
- Must be included in preplan document



# Energy Storage Systems (ESS)

## Detection / Suppression System

- Identify remote monitoring and how to contact
- Identify external alarm/warning devices for unit level fire suppression system discharge
- Identify suppression agent product and hazards
- Identify smoke/heat/fire detection system at unit level
- Locate manual fire suppression system discharge points
- Have a supervised tour of units



# Energy Storage Systems (ESS)

## BESS Detection Systems

Locate any gas and smoke/fire detection systems.

Where do they transmit a signal to, where is the control panel?

## ESS Detection Systems

Pre-Incident Planning

### Gas Detection



- Note air monitoring systems
- Determine what they are designed to detect

### Smoke/Fire Detection



- Method of monitoring
- Detector types



# Energy Storage Systems (ESS)

## BESS HVAC and Exhaust

Understand how and when the HVAC and Exhaust systems will operate.

Identify where exhaust systems discharge and survey that area for possible exposure to civilians in discharge path.

## ESS HVAC and Exhaust

Pre-Incident Planning

### HVAC

- Does it need to be controlled?
- Specific to battery room?
- Determine how system is powered



### Exhaust



- Note exit location
- Determine how system is powered?



# Energy Storage Systems (ESS)

## Fixed Fire Suppression Systems

Locate all fire suppression systems.

How they are activated

What agent is being used

## Fixed Fire Suppression Systems

Pre-Incident Planning



- Manage fires and prevent spread – limited in effectiveness.
- Lithium ion and lead acid may be exempt in fire code
- AHJ may have requirement



# Energy Storage Systems (ESS)

## Fire Suppression Systems - Inert Gas

Inert gas systems displace oxygen and must be ventilated before entering.

## Fixed Suppression Systems – Inert Gas

Pre-Incident Planning

### Inert Gas/Clean Agent

- Carbon dioxide
- Argon
- Halon
- Nitrogen
- FM 200
- NOVEC 1230



- Displaces oxygen, limiting visible combustion
- Limited effect on thermal runaway
- Lithium-ion cells may produce their own oxygen
- Exhaust inert gas prior to entry



# Energy Storage Systems (ESS)

## Fixed Suppression Systems - Water

Where is your water supply to support water-based fire suppression systems.

### Fixed Suppression Systems – Water

Pre-Incident Planning



- Determine system type
- Note if must be supported by the FD (water based)
- FDCs and nearest adequate water supply

- Sprinklers or deluge systems
- Cabinets can prevent water from reaching batteries
- Li-ion is not addressed by NFPA 13 (2016 edition)



# Energy Storage Systems (ESS)

## WATER SUPPLY

Identify water supplies and available flow

## FIRE SUPPRESSION

Identify if fire suppression system is present and what areas are covered

Identify if/how fire department can support fire suppression system

## FIRE ALARM SYSTEM

Identify if fire alarm system is present, and note, location of fire alarm control unit (FACU) and remote annunciator panels





# Energy Storage Systems (ESS)

## Codes & Standards - NFPA 855 (2019)

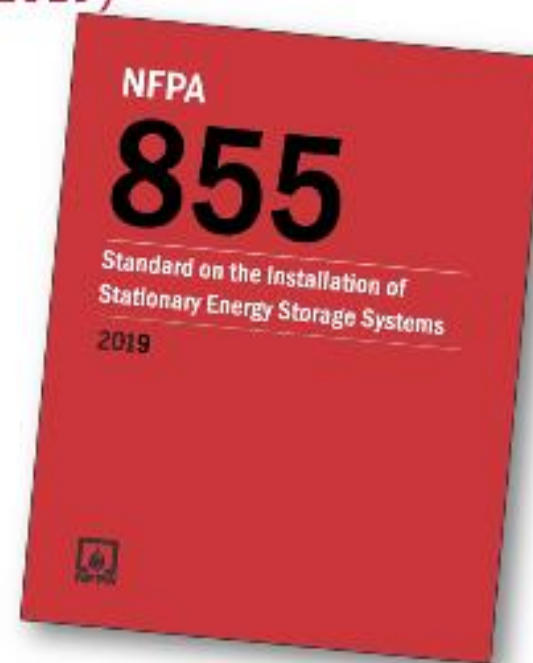
NFPA 855 is a useful resource for information about BESS design, safety recommendations, and steps to protect fire service personnel.

## Codes & Standards - NFPA 855 (2019)

Pre-Incident Planning

### Requires:

- Emergency Response Plan on site
- Decommissioning plan
- Marking of special hazards



# Energy Storage Systems (ESS)

## Codes & Standards - UL 9540A

Verify if the design and systems if this site have been tested in accordance with UL 9540A, which is another useful resource of information.

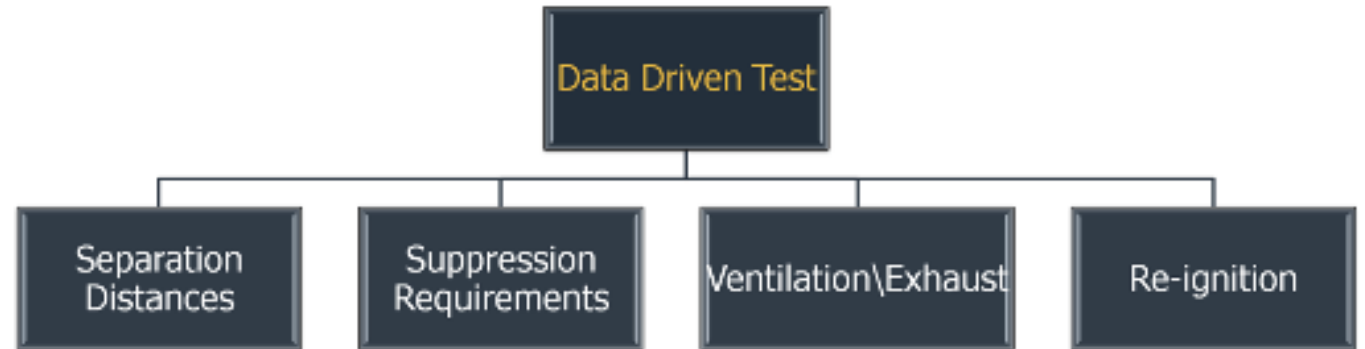
## Codes and Standards – UL 9540A

Pre-Incident Planning



### Standard for Safety

Test method for evaluating thermal runaway fire propagation in battery energy storage systems



# Energy Storage Systems (ESS)

After completing familiarization can you ...

Identify battery type

Identify if purge system is available for BESS and how it operates

Identify if deflagration panels are available in BESS and how they operate

Identify if staging area safe distance from site

Identify contact info for site access/SME's

Have emergency shutdown procedures explained and demonstrated

## Lithium-Ion Batteries

Battery Energy Storage Systems (BESS)

### Electrolyte

- Flammable organic solvent
- Made up lithium salts impregnated in other materials
- Contains very little in a liquid state
- Commonly found in hybrids, EVs, BESS and emobility devices



**Does not contain pure lithium which is a reactive metal**





## Congratulations!

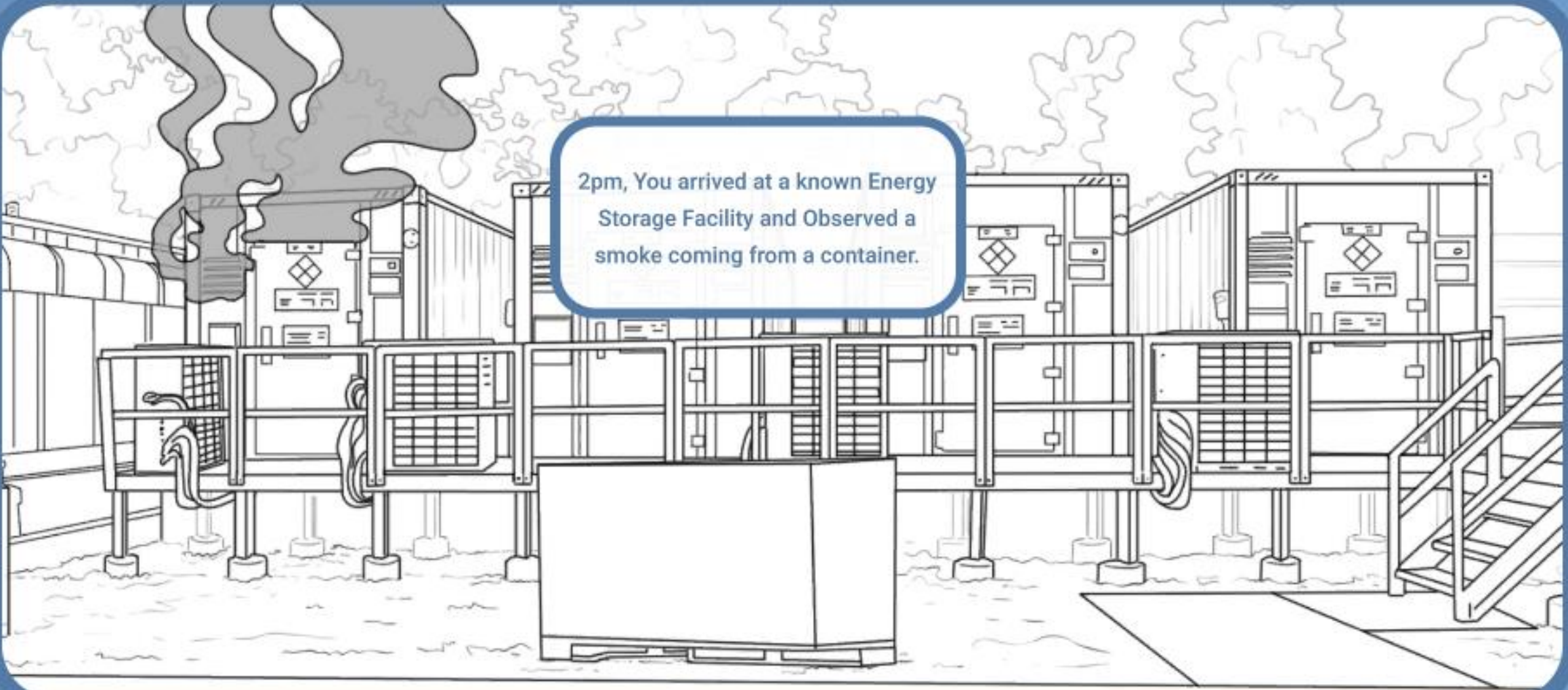
You have completed the ESS module. Let's explore an incident scenario.

CONTINUE



Let's explore an incident scenario.



A line drawing of an industrial facility, likely an energy storage facility. In the foreground, there is a large, rectangular container on a pallet. Behind it, a series of metal walkways with railings run across the scene. In the background, there are several large, rectangular storage containers or tanks. One of these containers on the left is emitting a thick, dark plume of smoke that rises into the air. The sky is filled with light, wispy clouds. The entire scene is enclosed in a rounded rectangular frame.

2pm, You arrived at a known Energy Storage Facility and Observed a smoke coming from a container.

Following the Identify-Shutdown-Watchout process found in the NFPA BESS Curriculum, use the questions in the subsequent pop up boxes to guide a discussion on how to assess this problem.



A line drawing of an industrial facility, likely a battery energy storage system (BESS) site. In the foreground, there are several large, rectangular battery racks or containers supported by concrete pillars. A walkway with a metal railing runs along the racks. In the background, there are more industrial structures, including a large container with smoke rising from it. The scene is set outdoors with trees in the distance.

2pm, You arrived at a known Energy Storage Facility and Observed a smoke coming from a container.

Do you consider this an exterior or interior BESS location?

Following the Identify-Shutdown-Watchout process found in the NFPA BESS Curriculum, use the questions in the subsequent pop up boxes to guide a discussion on how to assess this problem.





2pm, You arrived at a known Energy Storage Facility and Observed a smoke coming from a container.

Do you consider this an exterior or interior BESS location?

Exterior BESS location

Following the Identify-Shutdown-Watchout process found in the NFPA BESS Curriculum, use the questions in the subsequent pop up boxes to guide a discussion on how to assess this problem.



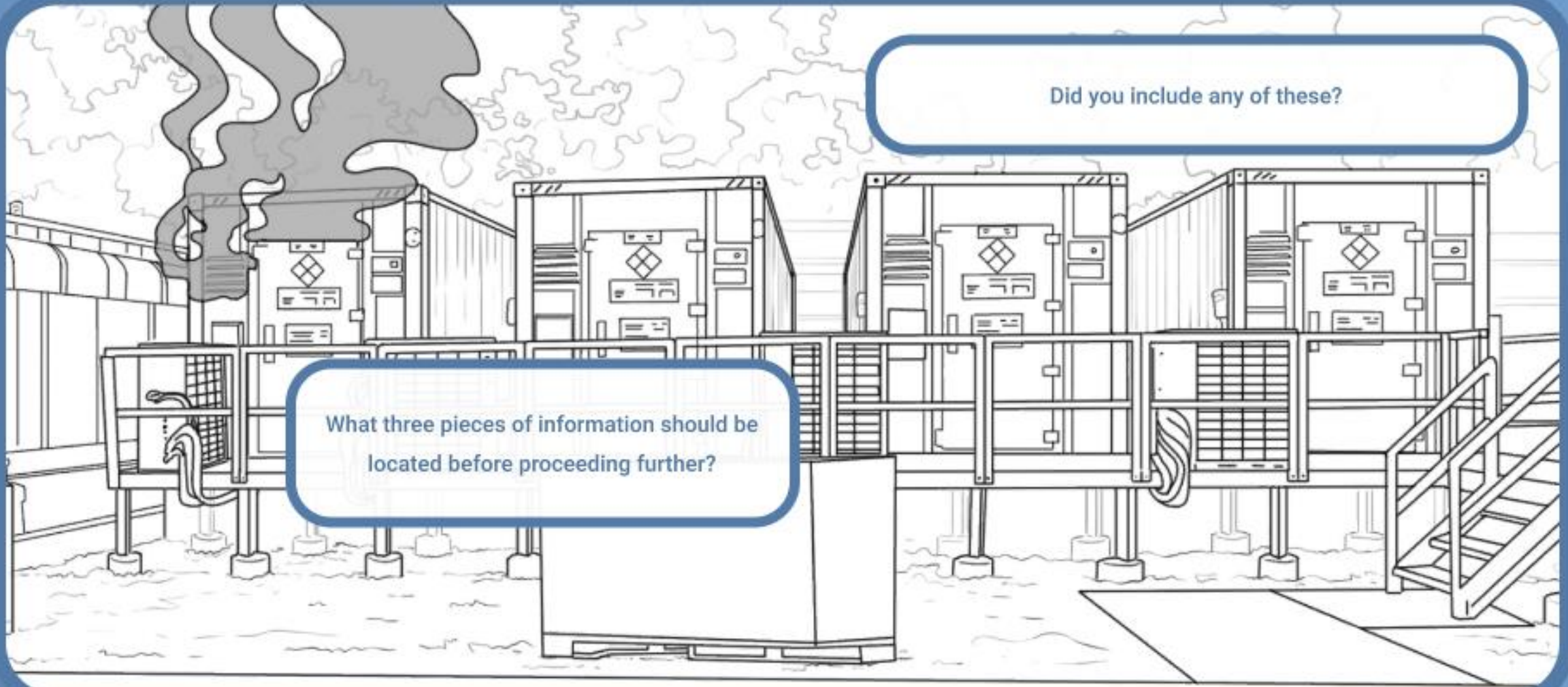




What three pieces of information should be located before proceeding further?

Following the Identify-Shutdown-Watchout process found in the NFPA BESS Curriculum, use the questions in the subsequent pop up boxes to guide a discussion on how to assess this problem.



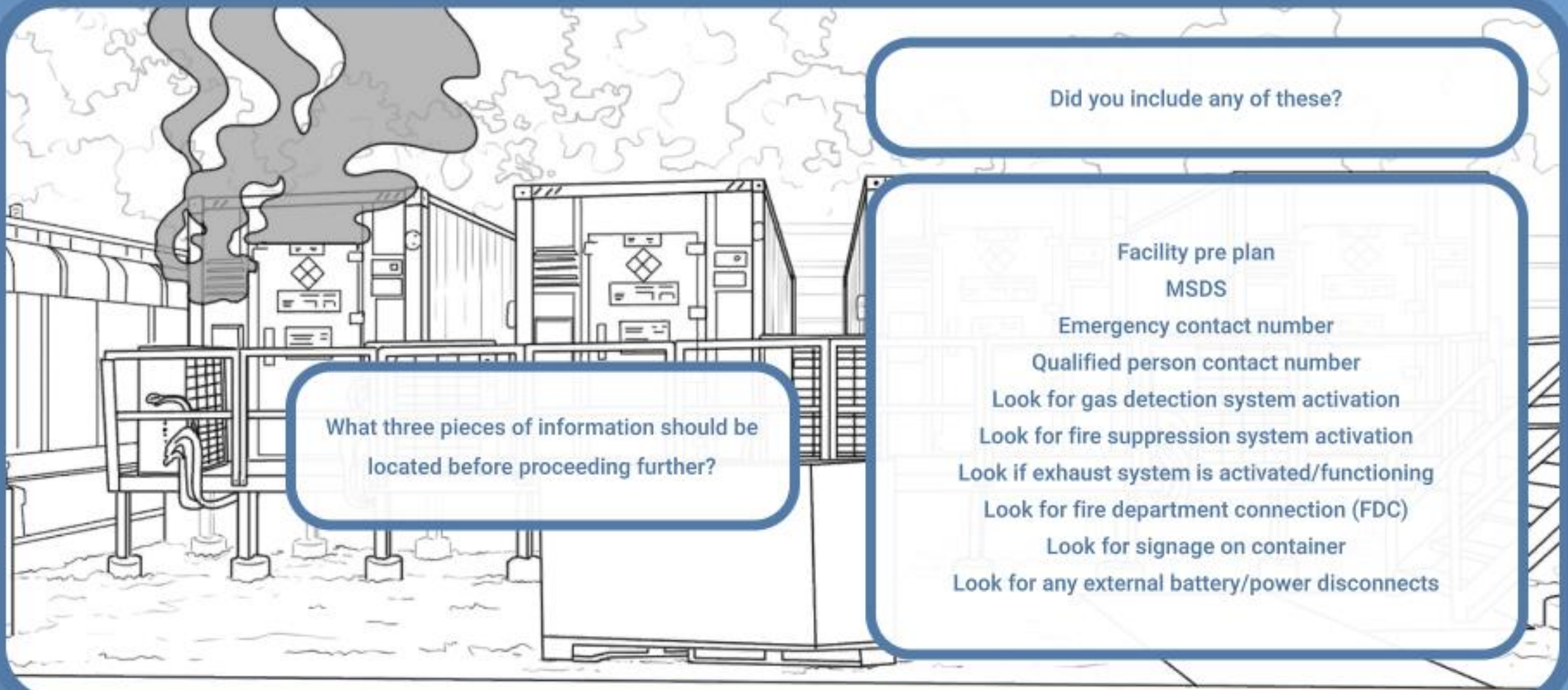


Did you include any of these?

What three pieces of information should be located before proceeding further?

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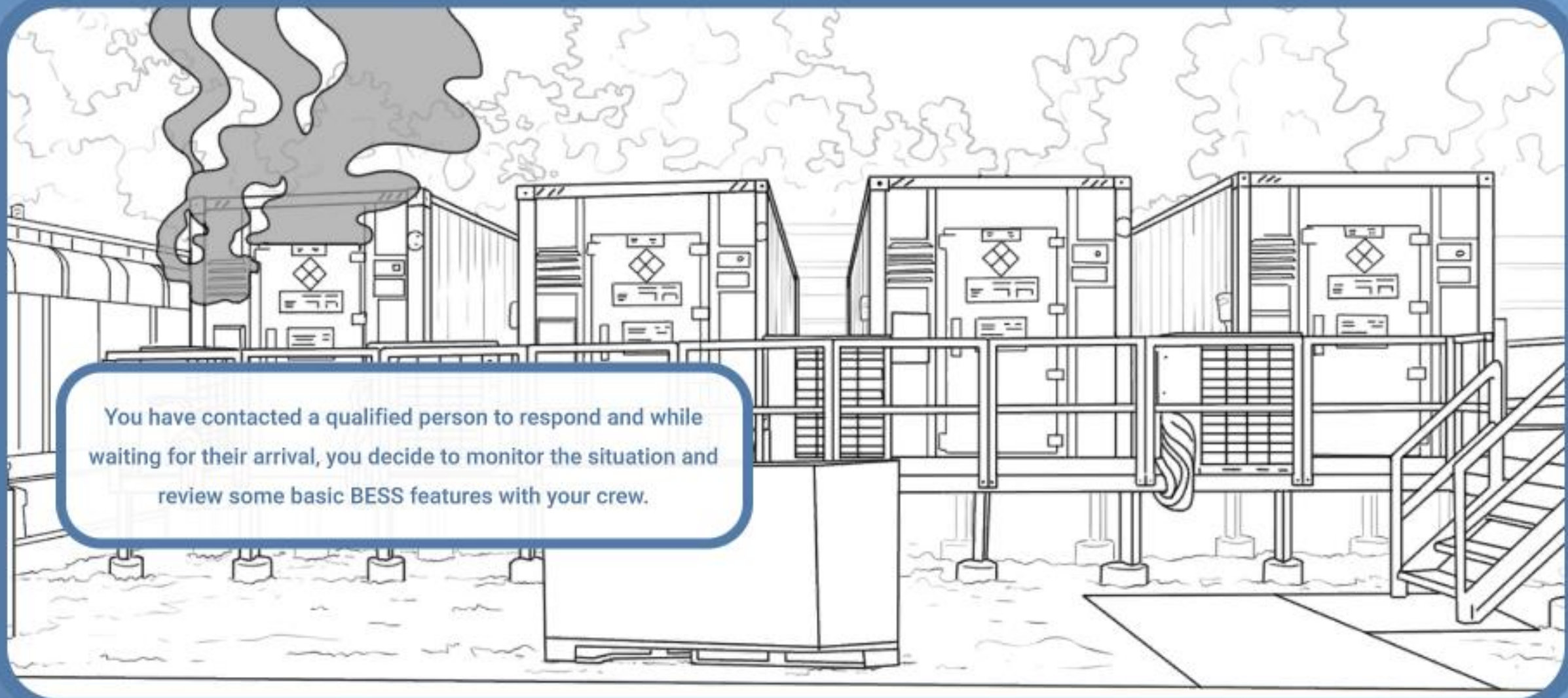
What three pieces of information should be located before proceeding further?

Did you include any of these?

- Facility pre plan
- MSDS
- Emergency contact number
- Qualified person contact number
- Look for gas detection system activation
- Look for fire suppression system activation
- Look if exhaust system is activated/functioning
- Look for fire department connection (FDC)
- Look for signage on container
- Look for any external battery/power disconnects

Following the Identify-Shutdown-Watchout process found in the NFPA BESS Curriculum, use the questions in the subsequent pop up boxes to guide a discussion on how to assess this problem.

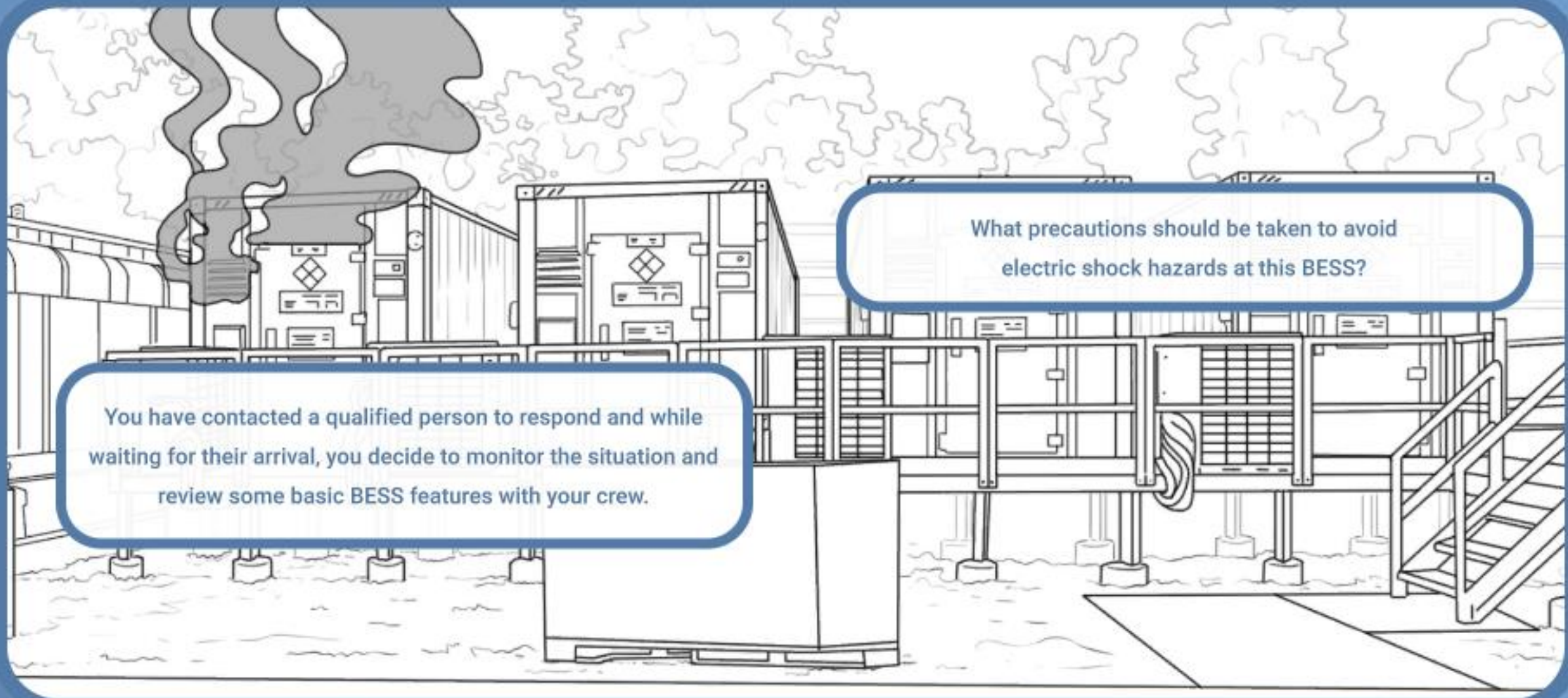




You have contacted a qualified person to respond and while waiting for their arrival, you decide to monitor the situation and review some basic BESS features with your crew.

Following the Identify-Shutdown-Watchout process found in the NFPA BESS Curriculum, use the questions in the subsequent pop up boxes to guide a discussion on how to assess this problem.



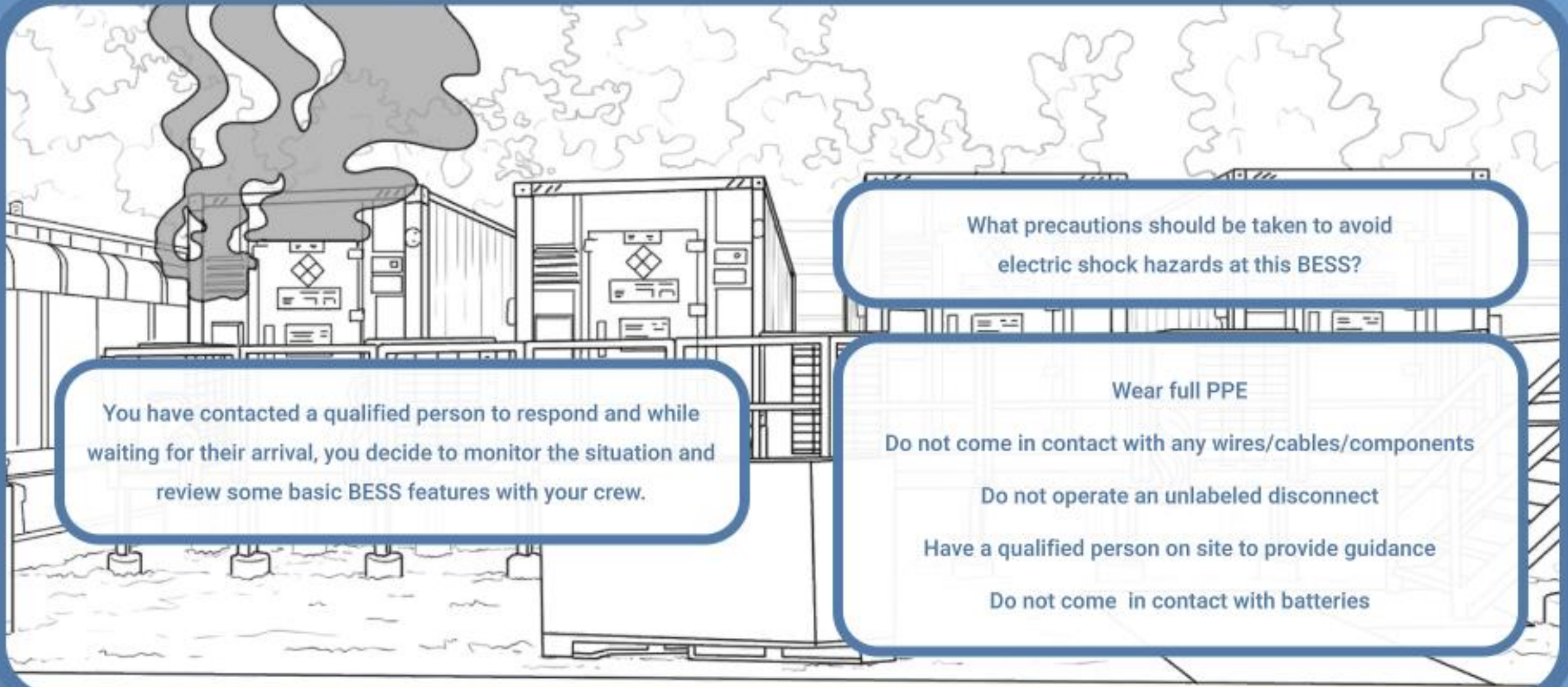


You have contacted a qualified person to respond and while waiting for their arrival, you decide to monitor the situation and review some basic BESS features with your crew.

What precautions should be taken to avoid electric shock hazards at this BESS?

Following the Identify-Shutdown-Watchout process found in the NFPA BESS Curriculum, use the questions in the subsequent pop up boxes to guide a discussion on how to assess this problem.





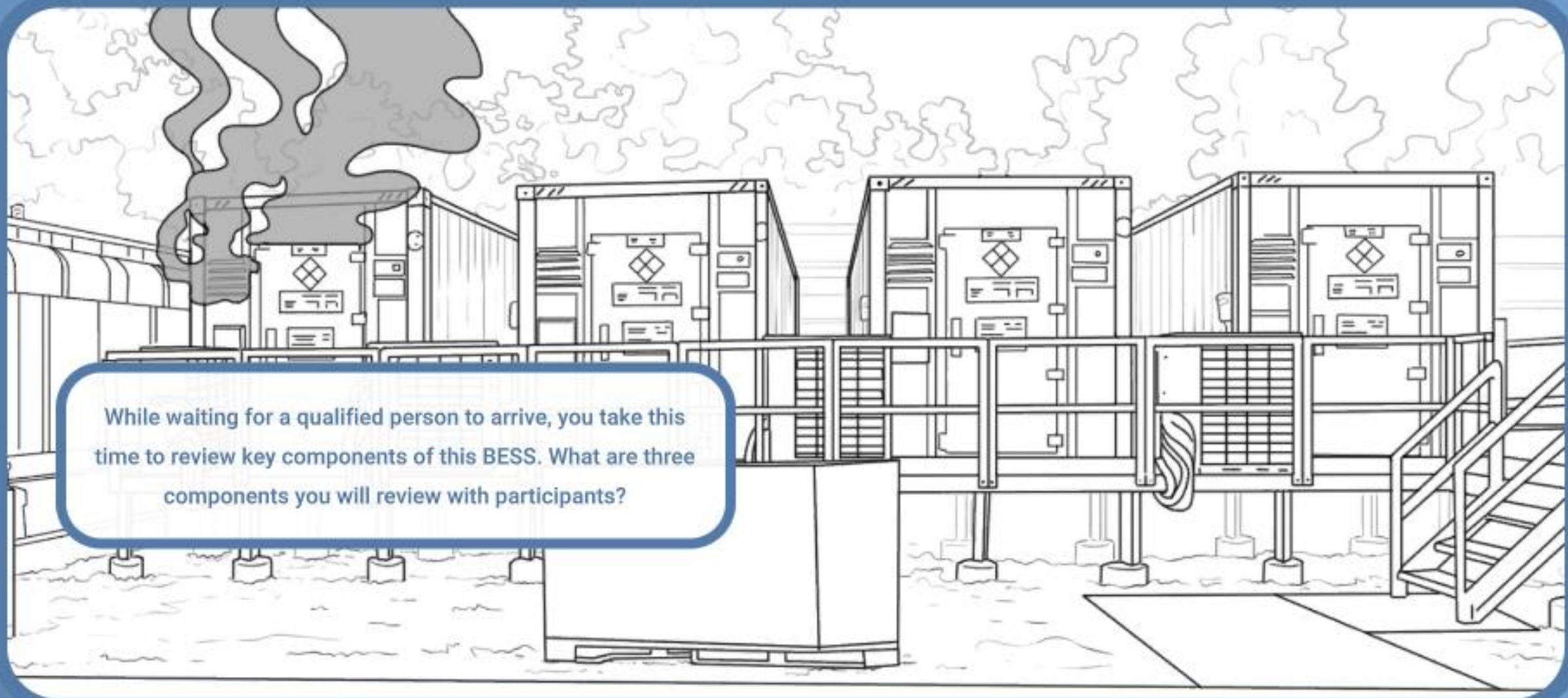
You have contacted a qualified person to respond and while waiting for their arrival, you decide to monitor the situation and review some basic BESS features with your crew.

What precautions should be taken to avoid electric shock hazards at this BESS?

- Wear full PPE
- Do not come in contact with any wires/cables/components
- Do not operate an unlabeled disconnect
- Have a qualified person on site to provide guidance
- Do not come in contact with batteries

Following the Identify-Shutdown-Watchout process found in the NFPA BESS Curriculum, use the questions in the subsequent pop up boxes to guide a discussion on how to assess this problem.

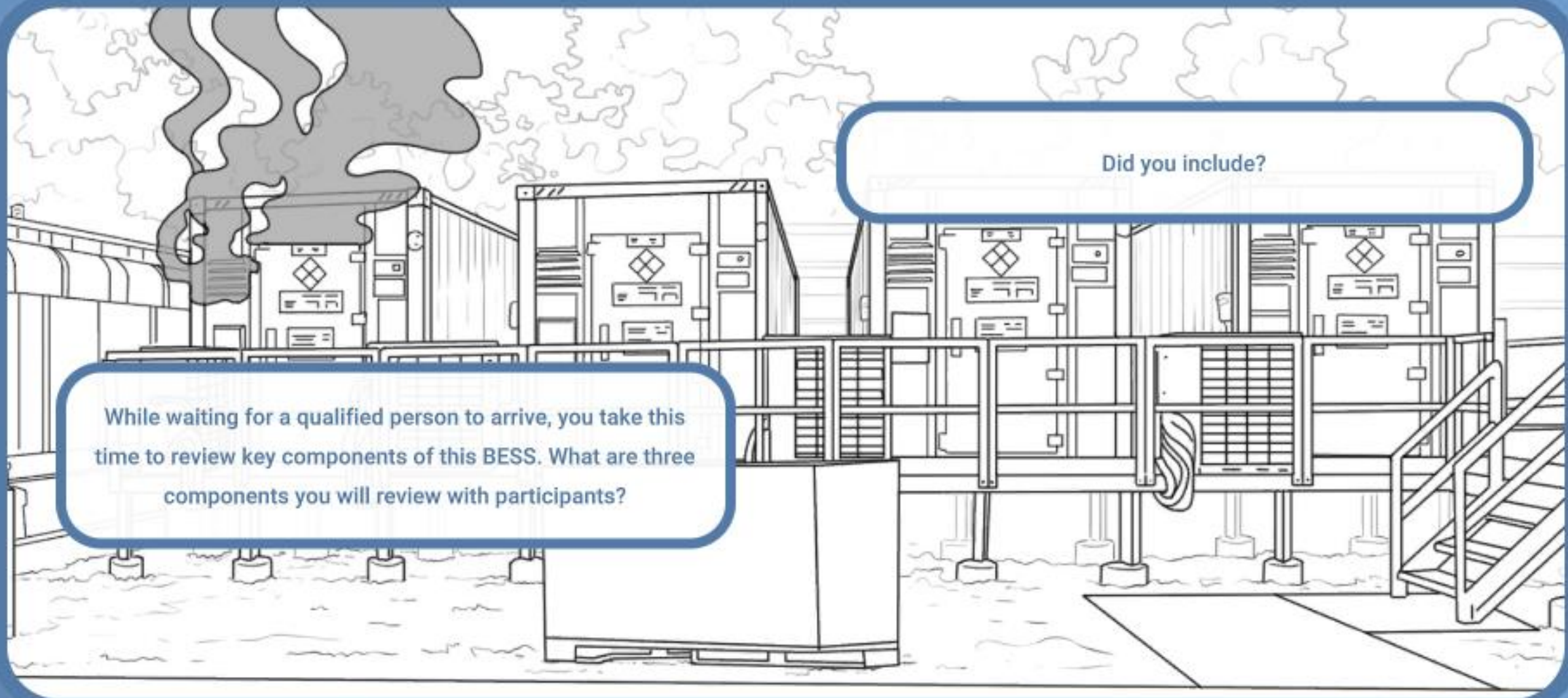




While waiting for a qualified person to arrive, you take this time to review key components of this BESS. What are three components you will review with participants?

Following the Identify-Shutdown-Watchout process found in the NFPA BESS Curriculum, use the questions in the subsequent pop up boxes to guide a discussion on how to assess this problem.





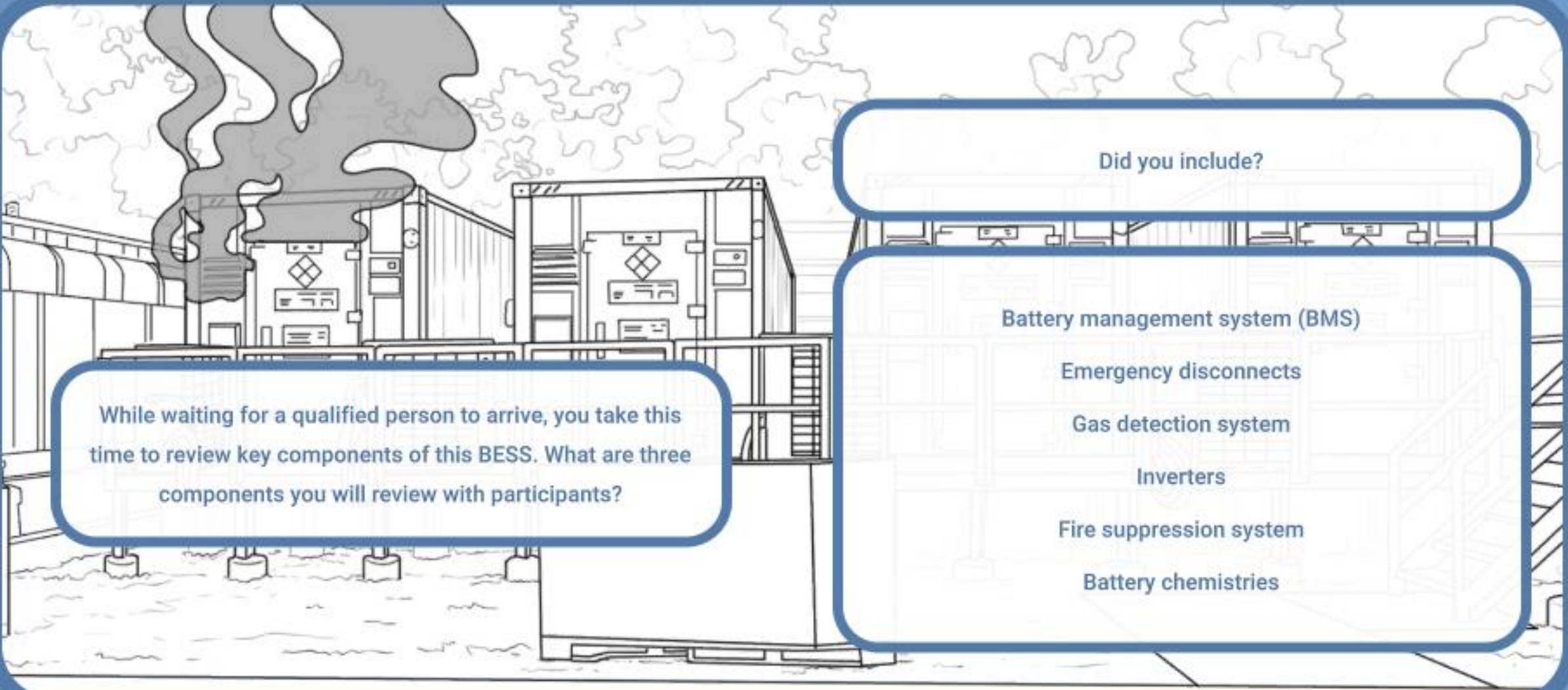
Did you include?

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While waiting for a qualified person to arrive, you take this time to review key components of this BESS. What are three components you will review with participants?

Did you include?

Battery management system (BMS)

Emergency disconnects

Gas detection system

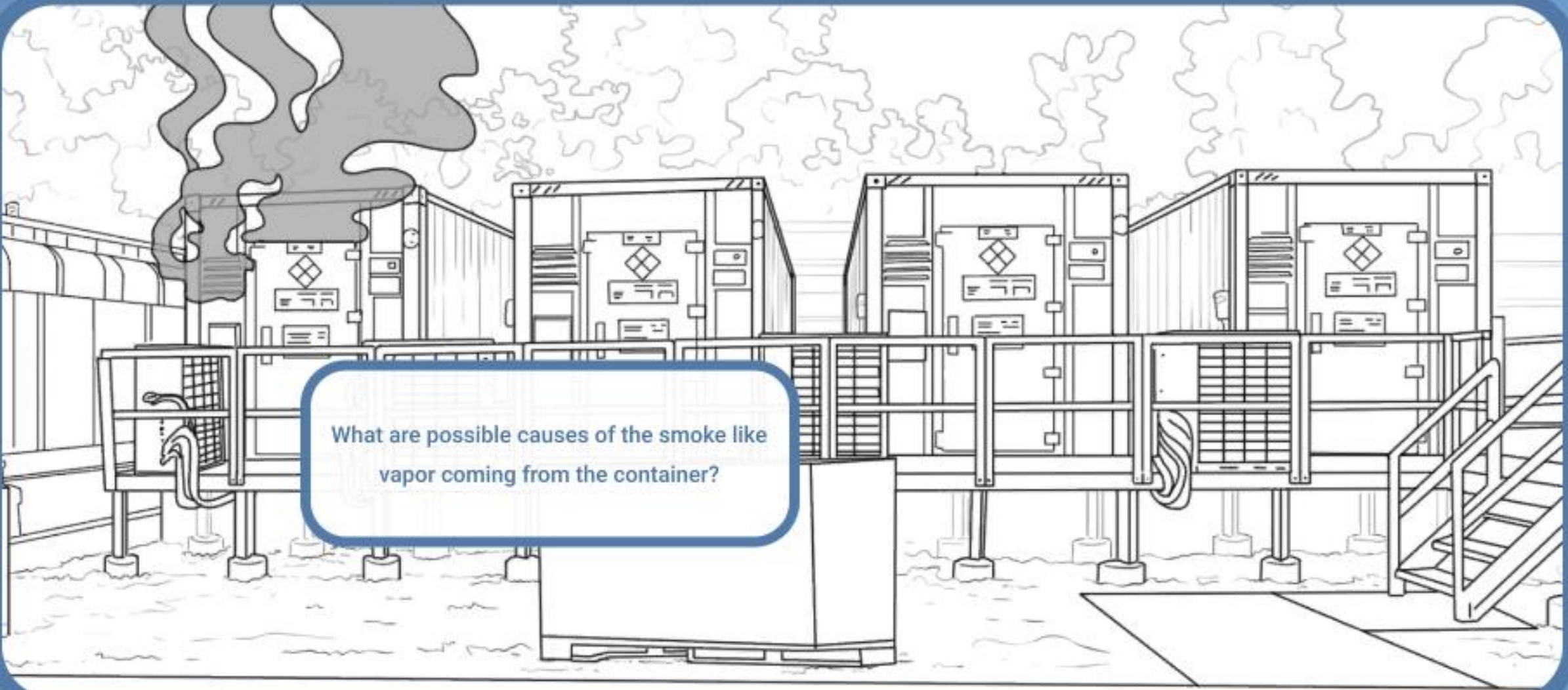
Inverters

Fire suppression system

Battery chemistries

Following the Identify-Shutdown-Watchout process found in the NFPA BESS Curriculum, use the questions in the subsequent pop up boxes to guide a discussion on how to assess this problem.

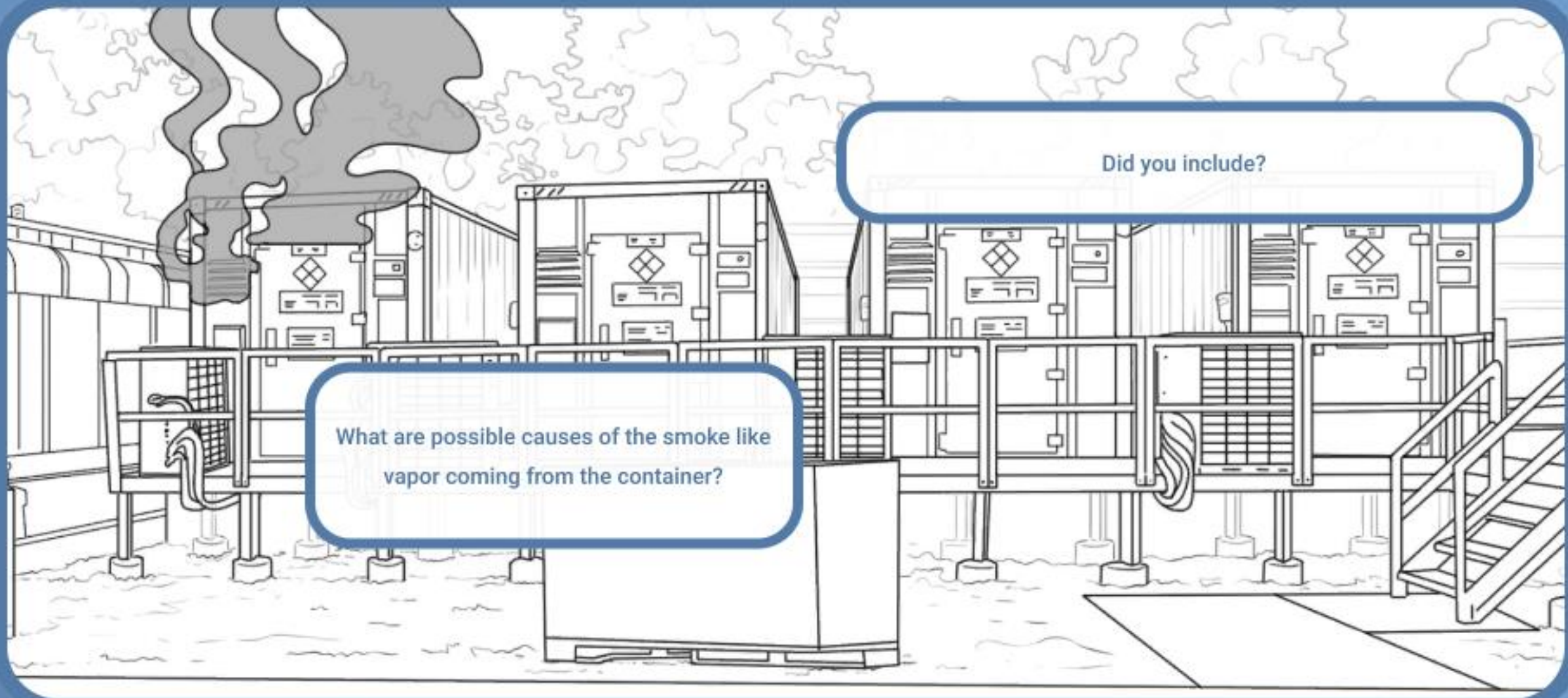




What are possible causes of the smoke like vapor coming from the container?

Following the Identify-Shutdown-Watchout process found in the NFPA BESS Curriculum, use the questions in the subsequent pop up boxes to guide a discussion on how to assess this problem.



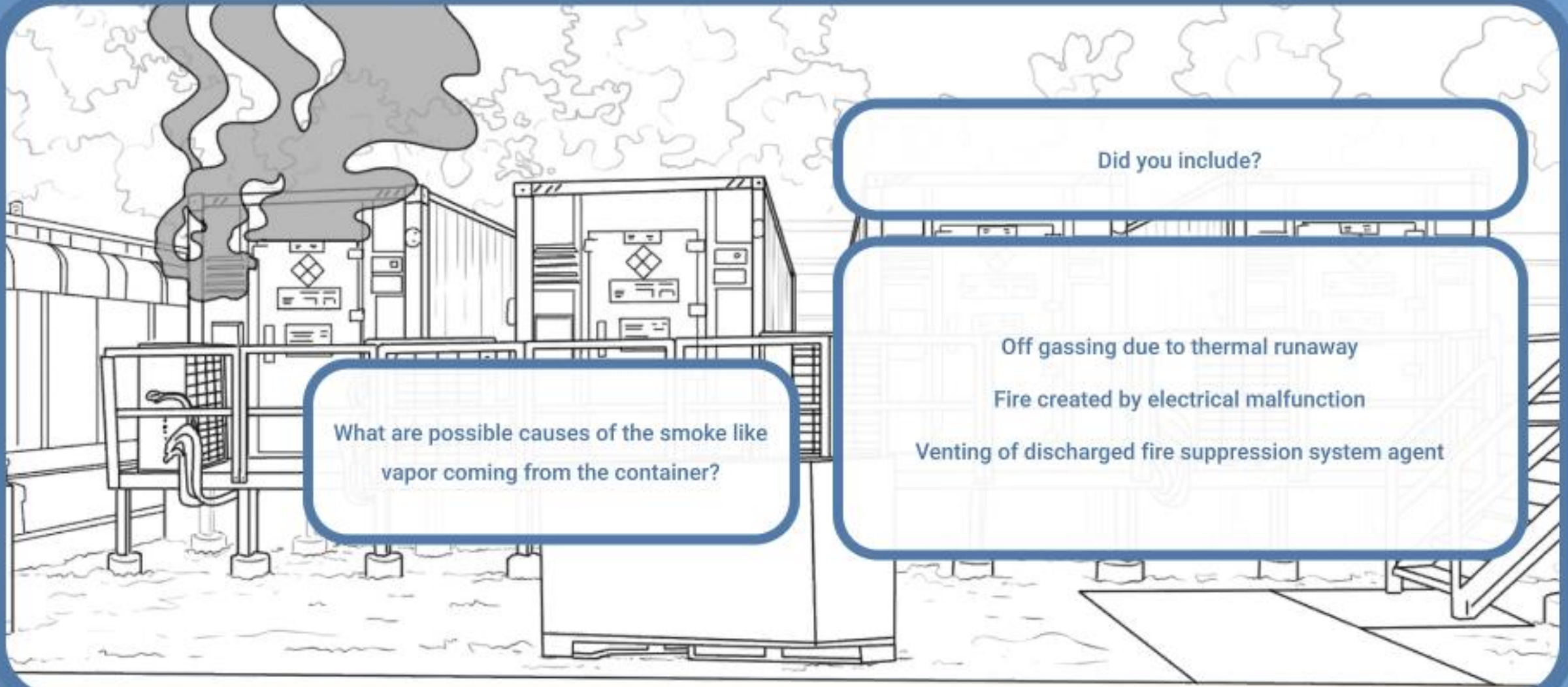


Did you include?

What are possible causes of the smoke like vapor coming from the container?

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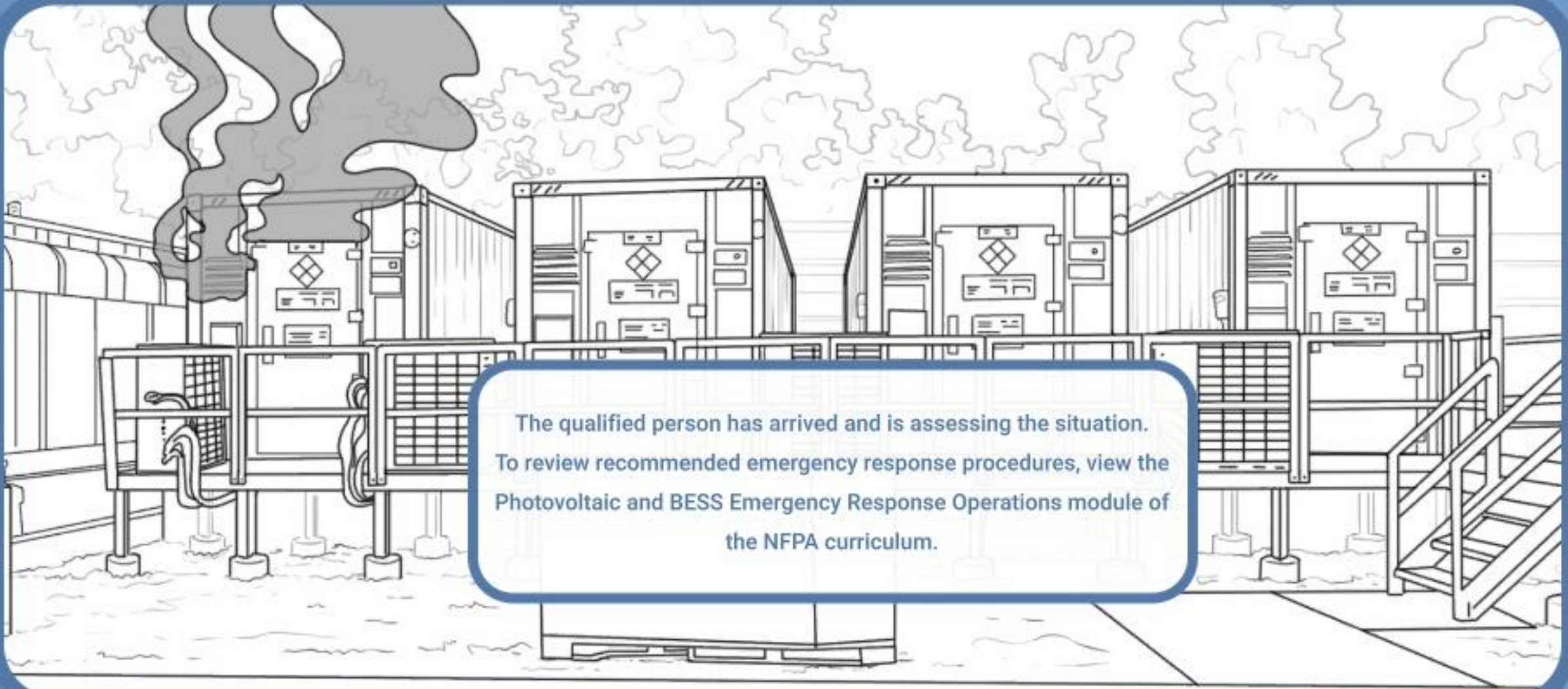
What are possible causes of the smoke like vapor coming from the container?

Did you include?

- Off gassing due to thermal runaway
- Fire created by electrical malfunction
- Venting of discharged fire suppression system agent

Following the Identify-Shutdown-Watchout process found in the NFPA BESS Curriculum, use the questions in the subsequent pop up boxes to guide a discussion on how to assess this problem.





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

