

ELEKTRA

PROCESS SAFETY IN THE ELECTRIFICATION OF INDUSTRY

Industrial Electrification and Safety: New Energy, New Hazards?

Juan Carlos Marugán Peñas | ELEKTRA webinar



Funded by
the European Union

Funded by the European Union (grant agreement No 101294850, ELEKTRA project). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor HaDEA can be held responsible for them.

Disclosure or reproduction without prior permission of ELEKTRA project is prohibited



Agenda

01 The hazard landscape

Why electrical energy changes the process-safety picture

02 Interfaces and examples

Heating and battery energy storage

03 Risk assessment and safeguards

HAZID, HAZOP, LOPA and the loss-of-flow case

04 Safe delivery over the lifecycle

A practical framework and three takeaways



The hazard landscape

Why electrical energy changes the process-safety picture



Funded by
the European Union

Funded by the European Union (grant agreement No 101294850, ELEKTRA project). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor HaDEA can be held responsible for them

Disclosure or reproduction without prior permission of ELEKTRA project is prohibited



Why electrification changes process safety

Two concepts, connected by a changed energy pathway

PROCESS SAFETY

Prevent and mitigate major accidents from uncontrolled hazardous materials or energy.

Focus: containment, escalation and safe states.

INDUSTRIAL ELECTRIFICATION

Use electricity for industrial heat, motion or reaction energy.

Resistance, induction, electric drives and plasma; often with power electronics.

CONVENTIONAL

Fuel → Combustion → Heat → Process

ELECTRIFIED

Electricity → Power conversion → Heat → Process

New initiating events and consequence pathways call for reassessed safeguards.



Funded by
the European Union

ADVANCED ELECTRIFICATION OF KEY INDUSTRIAL REACTIONS

From conventional to electrified processes

CONVENTIONAL



HAZARD PROFILE

- Fuel supply
- Combustion
- Flame control
- Fuel isolation
- Thermal inertia

Combustion, fuel leaks and hot surfaces

Source: ELEKTIRA proposal extract, p. 5, Fig. 3A–B (reactor details)

ELECTRIFIED



HAZARD PROFILE

- High-power supply
- Electrical heating
- Power and temperature control
- Electrical isolation
- Potentially faster response

Electrical, thermal and control interactions



The new hazard landscape

Four hazard families to screen at concept and design

ELECTRICAL



Arc flash · high voltage
Short circuits · loss of power

THERMAL



Overheating · loss of cooling
Hot surfaces · thermal excursions

PROCESS SAFETY

STORED ENERGY



Batteries · capacitors
Residual energy after shutdown

CONTROL & AUTOMATION



Sensor or logic failure
Power-control interaction · common cause



Interfaces and examples

Heating and battery energy storage



Funded by
the European Union

Funded by the European Union (grant agreement No 101294850, ELEKTRA project). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor HaDEA can be held responsible for them

Disclosure or reproduction without prior permission of ELEKTRA project is prohibited



The process–electrical–control interface

The central safety question sits between engineering disciplines

PROCESS

Temperature
Pressure
Flow
Reaction

ELECTRICAL

Voltage
Current
Power
Stored energy

CONTROL

Instrumentation
Automation
Protection
Safety functions

PROCESS SAFETY

HAZOP EXAMPLE: H₂ release + electrical ignition source → potential fire/explosion

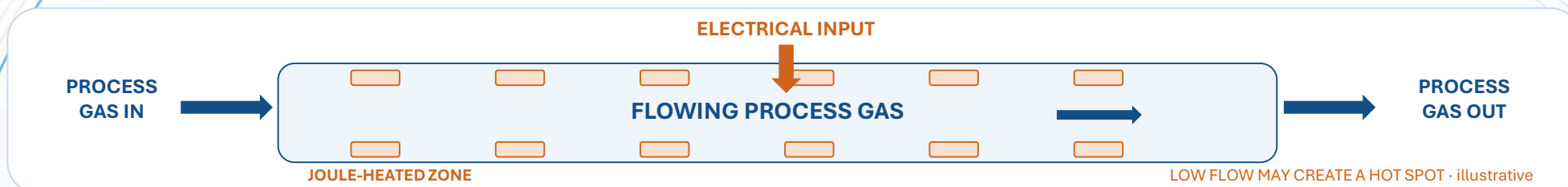


Funded by
the European Union

ADVANCED ELECTRIFICATION OF KEY INDUSTRIAL REACTIONS

Electrified heating: a practical example

Replacing a burner with a powered heater changes initiating events



POTENTIAL INITIATORS

- Loss of process flow
- Heater control failure / excess power
- Cooling failure or electrical fault

POTENTIAL CONSEQUENCES

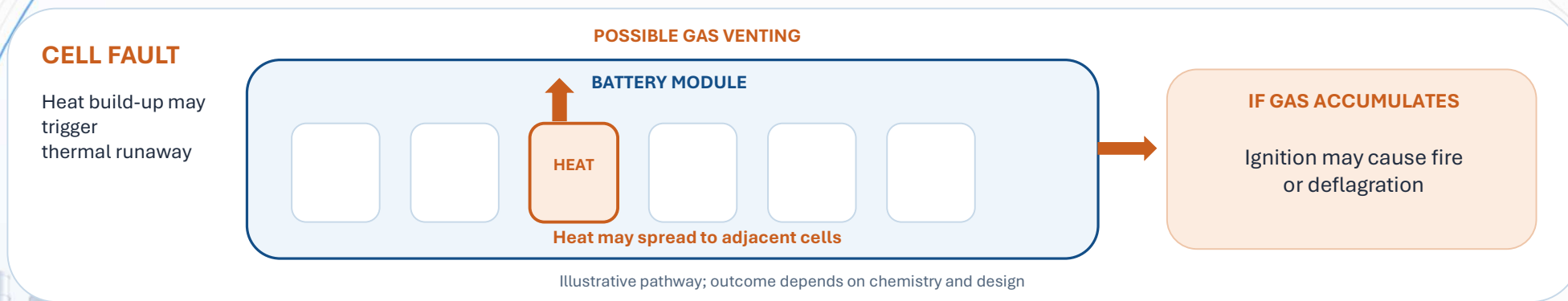
- Local overheating
- Material degradation / abnormal reaction
- Potential loss of containment

What happens when the heater fails, or fails to switch off?



Batteries & energy storage

Illustrative battery energy-storage scenario outside the ELEKTRA pilots



Can it be detected early enough?

Can propagation be prevented?

What happens after shutdown?



Funded by
the European Union

ADVANCED ELECTRIFICATION OF KEY INDUSTRIAL REACTIONS

Risk assessment and safeguards

HAZID, HAZOP, LOPA and the loss-of-flow case



Funded by
the European Union

Funded by the European Union (grant agreement No 101294850, ELEKTRA project). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor HaDEA can be held responsible for them.

Disclosure or reproduction without prior permission of ELEKTRA project is prohibited



How should we reassess the risk?

Start with what changes in the design; use HAZID, HAZOP and LOPA where appropriate

01 What energy source is changing?

02 What new equipment is introduced?

03 Which hazards are reduced or removed?

04 Which initiating events appear?

05 Which safeguards lose validity?

06 Which protection layers are needed?

Revalidate the old assessment against the new design basis.



Protection layers & functional safety

A protection claim needs independence, response time and a defined safe state

INITIATING EVENT



PROCESS DEVIATION



POTENTIAL CONSEQUENCE

CANDIDATE SAFEGUARDS • credit depends on the scenario

BASIC CONTROL

Evaluate the failure mode

ALARM + OPERATOR

Action must be timely

OTHER IPL

Independent protection

SIF

One possible IPL

Can the system reach a safe state before an unsafe condition develops?

IEC 61511 applies when a safety instrumented system is used for process risk reduction.



Funded by
the European Union

ADVANCED ELECTRIFICATION OF KEY INDUSTRIAL REACTIONS

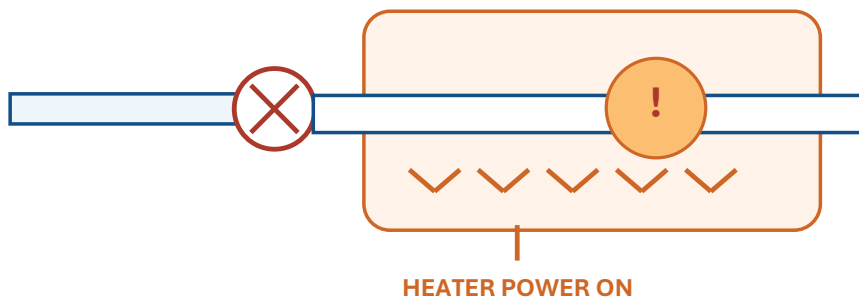
Case study: loss of flow with heater energised

Illustrative HAZOP scenario for an electrically heated reactor

EVENT PATH

LOW / NO FLOW

LOCAL HOT SPOT



Damage → possible loss of containment

CANDIDATE SAFEGUARDS

DETECT

Low flow / local high temperature

RESPOND

Alarm + action, or independent trip

SAFE STATE

Isolate heater; manage residual heat

Credit a safeguard only after checking independence and timing.

Independent? Safe state? Time available?



Safe delivery over the lifecycle

A practical framework and three takeaways



Funded by
the European Union

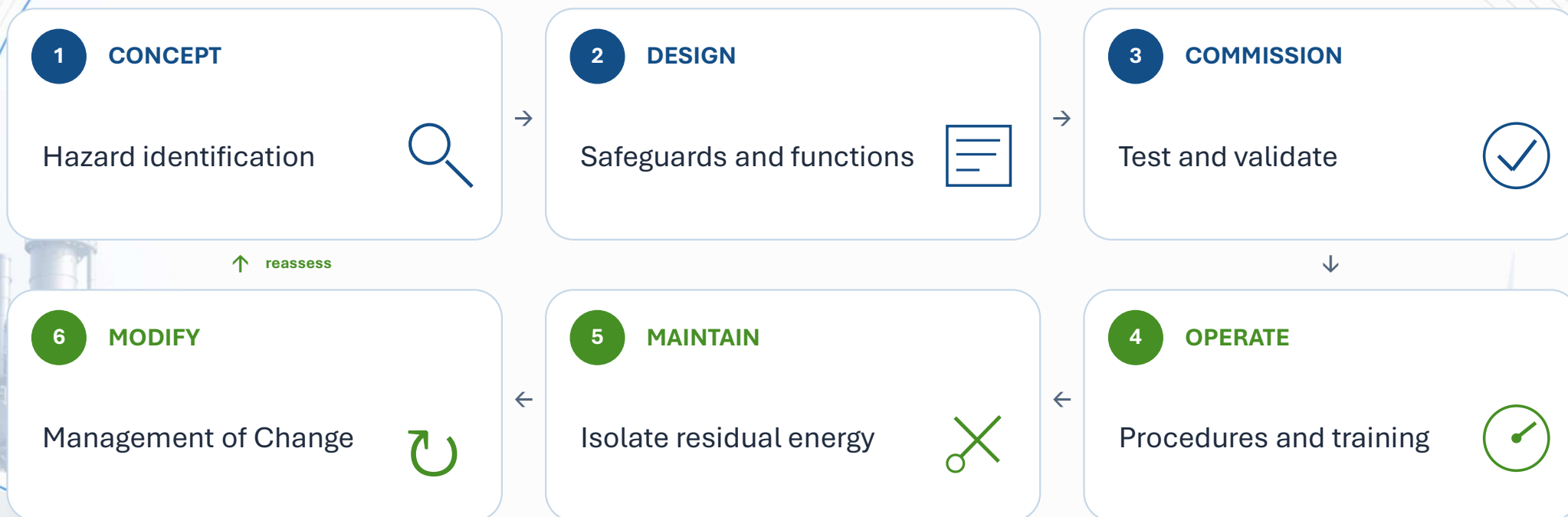
Funded by the European Union (grant agreement No 101294850, ELEKTRA project). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor HaDEA can be held responsible for them

Disclosure or reproduction without prior permission of ELEKTRA project is prohibited



What changes across the lifecycle?

Electrical and process-safety decisions must remain linked after installation



Electrification changes the plant lifecycle, from concept through modification.



A practical framework for safe electrification

Use this sequence as a review checklist at each project gate

01 **MAP** THE ENERGY

☐

Locate electrical, thermal and stored energy.

02 **REASSESS** HAZARDS

☐

Find new causes and consequence paths.

03 **REVIEW** SAFEGUARDS

☐

Check validity, independence and coverage.

04 **DEFINE** THE SAFE STATE

☐

Specify actions after each critical failure.

05 **VERIFY & VALIDATE**

☐

Test process, power, control and trips together.

06 **MANAGE** THE LIFECYCLE

☐

Keep procedures, maintenance and MOC current.



Three key takeaways

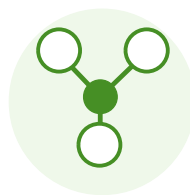
01 NEW ENERGY, NEW HAZARDS

Electrification changes initiating events and energy pathways.



02 INTERFACES MATTER

Assess process, electrical and control interfaces together, including H₂ release and ignition.



03 SAFETY BY DESIGN

Integrate process safety from concept through operation.



Electrification is an energy transition and a process-safety transformation.



Thank you

Industrial Electrification and Safety: New Energy, New Hazards?

Juan Carlos Marugán (jcmarugan@empre.es)

<https://www.elektraproject.eu/>

Questions & discussion



Funded by
the European Union

Funded by the European Union (grant agreement No 101294850, ELEKTRA project). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union . Neither the European Union nor HaDEA can be held responsible for them

Disclosure or reproduction without prior permission of ELEKTRA project is prohibited

