EVENT SUMMARY REPORT

Process Safety in the Electrification of Industry

New Energy, New Hazards?

30th September 2026
Online Webinar

ORGANISED BY

IChemE NL Members Group

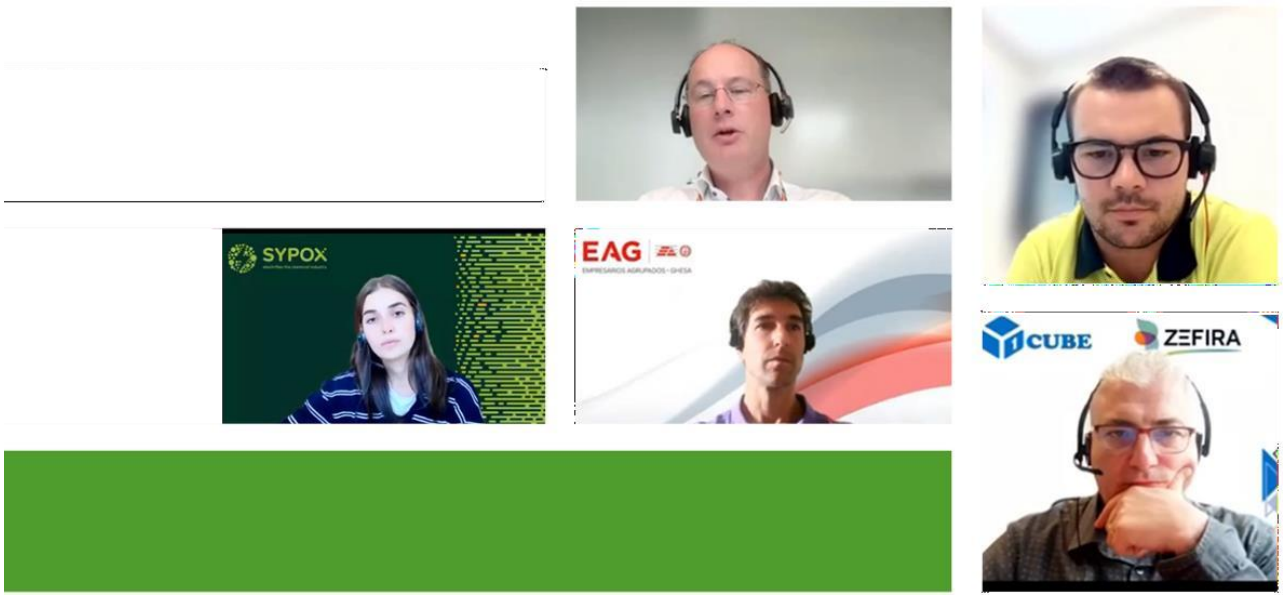
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AUTHORS

MEng AMIChemE Christian Liggett ·
Ir. Jebin James EngD ·

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Electrifying Industry: Why the Safety Case Has to Move With the Energy Source

Electrification is now a standard line in every industrial decarbonisation roadmap. e-furnaces, electric steam crackers, electrified reformers, induction-heated reactors, heat pumps and e-drives are all moving from concept to pilot and, in many cases, to commercial operation. The usual discussion is about emissions, energy efficiency and grid capacity. The process industry has learnt through painful experiences that safety must be proactively considered and consciously managed. As we propose to electrify industry, essentially changing how energy enters a process, what happens to the safety cases built around old safety scenarios?

The purpose of the webinar held on 30 September 2026 was to consider exactly this. The webinar was jointly organised by the IChemE Netherlands Member Group and the ELEKTRA project (Horizon Europe Project). Three speakers from the operator, engineering and technology-developer sides of the industry addressed the question from three angles.

For those who were not on the call, this report is a record of that conversation. For those who were, it is a synthesis of what the afternoon collectively surfaced, including two points on which the speakers did not, on closer reading, agree.

Shell: Electricity Is Invisible Until It Comes Out

Govert van der Ploeg, Senior Electrification Technologist at Shell Global Solutions, opened with two live polls. The first asked how fast electrons travel through a copper wire carrying direct current. Most of the audience answered "the speed of light". The drift velocity is, in fact, of the order of centimetres per hour, slower than a snail! It was a useful reminder that the field, not the electrons, carries energy in a conductor (see side bar).

The second poll asked whether electrification will improve or worsen process safety. A clear majority said it will improve, and the speaker agreed, on the condition that it is implemented properly. Govert has led Shell's development of the electric steam cracker and electric steam methane reforming, and holds 11 patents on electrical process furnaces.

Electricity moves fast, electrons move slowly

Think of a long incompressible fluid pipeline. Change the feed composition at the inlet and the outlet analyser sees nothing until one residence time has passed. Change the inlet pressure and the outlet responds almost at once, because the pressure wave travels at the speed of sound while each parcel of liquid barely moves.

A copper wire behaves the same way. It is already full of free electrons, about 8.5×10^{28} per m^3. For 1 A in a 1 mm^2 conductor, their net drift is about 0.07 mm/s, roughly 25 cm/h. Closing the circuit established the electro-magnetic wave at a speed approaching that of light, the electric field causes a small net drift of the free electrons along the wire which we record as current: In the hydraulic analogy, current corresponds to flow rate and voltage to pressure difference.

The analogy with liquid holds for the behaviour of electricity but breaks on energy. In a pipe the fluid carries the energy, as pressure x flow. In a wire the energy travels with the electromagnetic field at almost the speed of light.

Three Inherent Hazards

Govert named three inherent hazards:

Arc flash: Current conducting through air reaches extreme temperatures (up to 20,000◦C and produces a pressure wave and molten or vaporised metal. Even with PPE, injury is likely; without it, survival is unlikely.

Electrocution: The common belief that 30 mA, the typical earth-leakage trip setting, is a safe current is wrong. People survive it only because exposure is usually brief. At that current, the muscles lock, making it hard to let go, and sustained exposure can be fatal.

Electrical shorts: Uncontrolled current releases heat without limit, and electricity can drive a material to almost any temperature.

Electricity is invisible until it comes out: A short video of a low-voltage switchgear test at 25 kA, which failed to contain the short circuit fault, made the point vividly, see Figure 1.



Figure 1 *Heat exchange explosion following powerwful electrical short.*

Mitigation & the Opportunities Electrification Can Unlock

His counterweight was more than 140 years of standardisation, engineering and operational practice. German statistics show a steady decline in fatal electrical incidents. **The framework exists; using it requires chemical engineers to build electrical competence.**

The key example provided was a comparison of a fuel gas fired furnace with a radiant electrical furnace, See Figure 2.

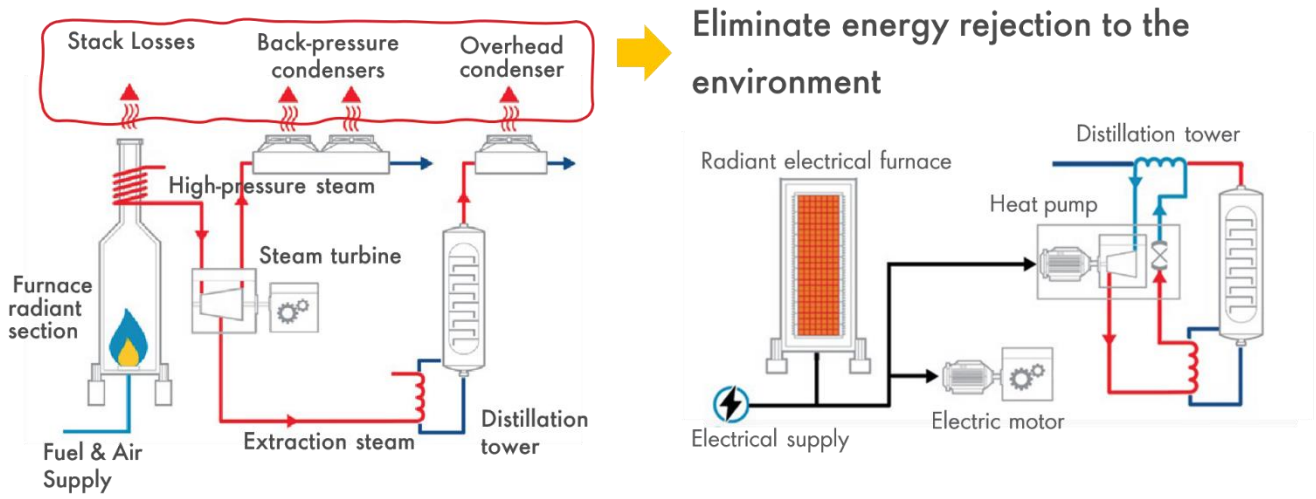


Figure 2 *Comparison of heating technologies showing that electrification reduces emissions and can potentially result in large efficiency improvements*

The efficiency argument was the strongest part of the talk:

- A radiant electric furnace produces no flue gas, so heat release stops the moment it is no longer needed. That can cut the energy used for the fired duty by up to 50%.
- Replacing a condensing steam turbine with an electric motor removes the latent heat rejected at the condenser.
- A heat pump on a distillation column upgrades overhead heat to drive the reboiler, reducing the energy needed by a factor of up to about four.

The gains, he argued, are not 2–3% but in the range of 10–50% for the same process duty. His reference case was Shell's Moerdijk chemical complex. There, 115 MW of thermal steam-turbine drives were replaced by 28 MW of electric drives. That allowed a gas-fired boiler to be taken out of service, removing a combustion hazard along with the fuel and the emissions.

> *Final takeaway: electricity is inherently hazardous and requires competent people, but the standards to manage it already exist. Once the hazard is controlled, the efficiency case is large enough that every project should assess it.*

Empresarios Agrupados: New Energy, New Hazards?

Juan Carlos Marugán, Head of the Safety Department at Empresarios Agrupados, brought more than 15 years of experience in industrial safety engineering, specialised in the nuclear-sector, to this discussion. He examined how industrial electrification changes process-safety hazards and the safeguards needed to control them.

His starting point was the change in the energy pathway, i.e., that electrification changes how energy reaches the process and leaves the chemistry alone. Hydrogen, carbon monoxide and ammonia are as hazardous as before. What changes is the path: fuel, burner and flame supervision give way to power conversion, cabling, heating elements and power control (Figure 3).

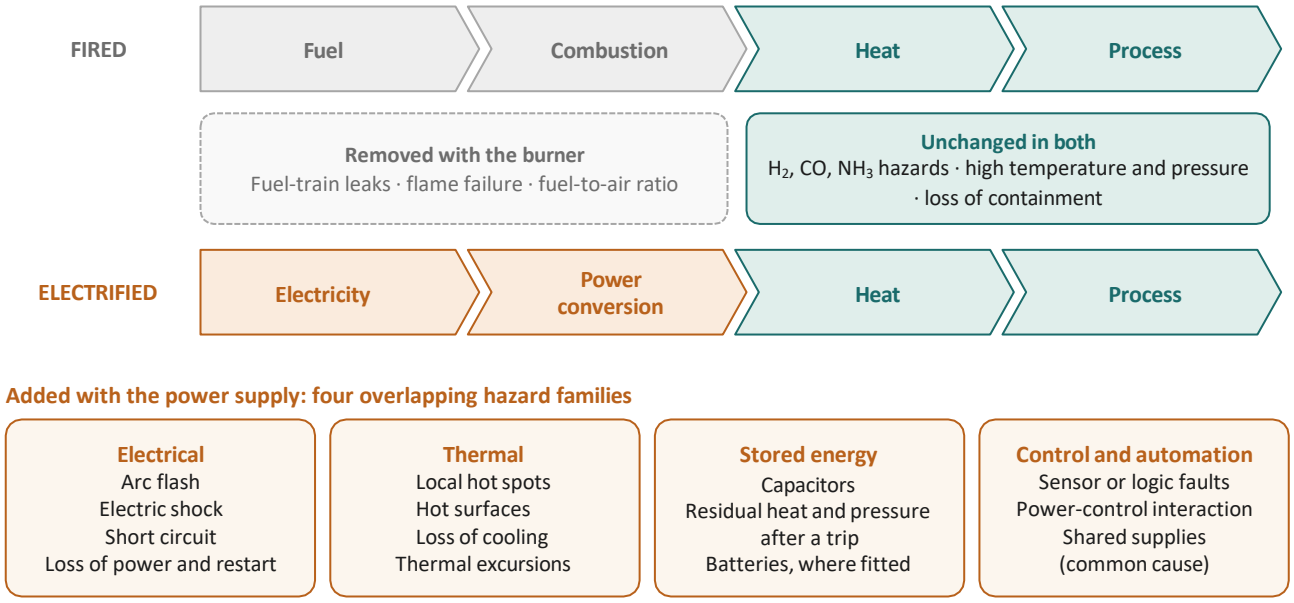


Figure 3: *Same chemistry, different route in. Taking out the burner removes the fuel-train and flame scenarios; the power supply brings four overlapping families of hazard: electrical, thermal, stored energy, and control and automation. The process chemistry and its hazards are unchanged. Adapted from Marugán's presentation*

Taking out the burner eliminates flame-failure and fuel-train scenarios, and he said that gain should be counted. The job is to keep the safeguards that still work, retire the assumptions that no longer hold and assess the new failure modes on the actual design, and then to keep the safety case valid through testing, operation and later modification.

The gaps, he argued, open between disciplines. The process engineer knows the safe flow and temperature limits, the electrical engineer knows what the supply and converter will do in a fault, and the control engineer knows what the instruments will see and which device will actually trip. They need one analysis boundary covering the power equipment, reactor, inventory and the utilities that keep it safe, and someone has to own the assumptions where a vendor package meets the host plant.

He illustrated this with a hydrogen release (Figure 4). A credible release near an electrical ignition source is handled through hazardous-area classification and equipment selection. The harder question is whether one electrical fault, through a shared feeder, motor control centre or location, could both ignite the release and disable the ventilation or gas detection meant to mitigate it. Most study teams would record that as two events and screen it out as double jeopardy. It is one common-cause failure, and it only shows up if the electrical single-line diagram is part of the hazard study. Where ventilation availability was used to set the hazardous-area zone, the same fault undermines the classification as well.

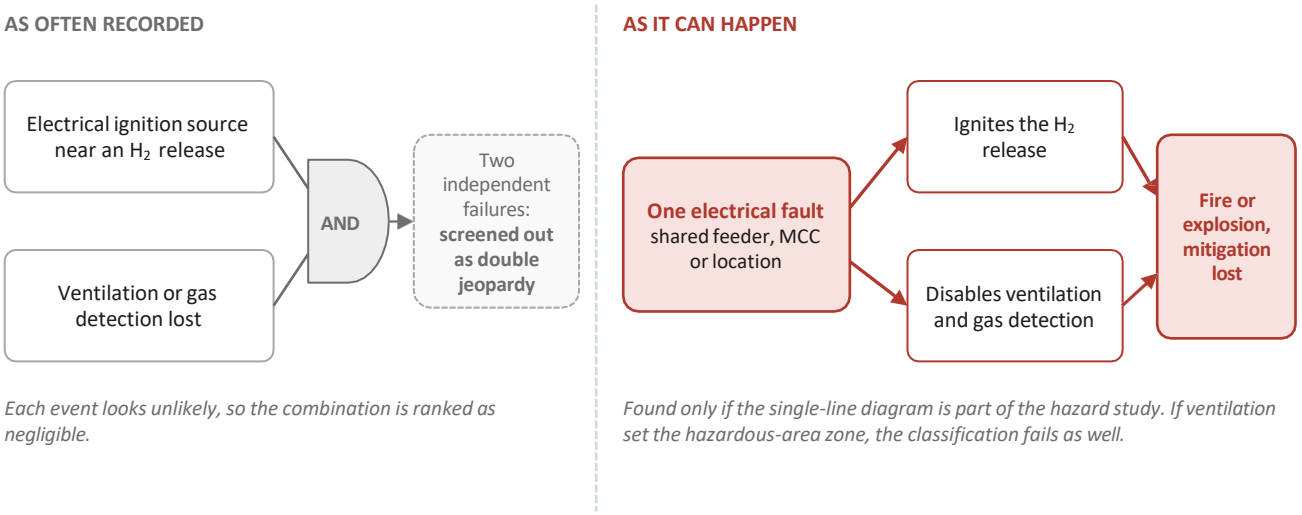


Figure 4: *One fault, two failures. Logged as independent events, ignition and loss of detection look too unlikely to matter. Traced through the single-line diagram, they can share a single cause.*

His worked example was loss of flow with the heater still energised, which leaves a local hot spot while the bulk temperature looks normal, a pattern familiar from fired-heater low-flow trips. Electrification adds its own ways for protection to fail. The power controller and the low-flow trip may share a transmitter, the temperature element may not sit at the hottest point, and the converter may restart by itself after a brief power dip. He stressed that the scenarios were illustrative and that none was a failure reported by ELEKTRA.

In our reading, heating has one particular trap. The power controller can be the control element, the initiating cause and a candidate trip path at once. A power semiconductor (thyristor or IGBT) that fails short delivers full power, so it cannot also be credited as an independent protection layer, and packaged heaters with power control and over-temperature cut-out in one panel, or on one sensor, deserve the same scrutiny. The safe state must be defined too, he said, because isolating the power can leave residual heat that still needs cooling or a controlled gas flow to remove.

Asked whether new standards are needed, he said no, in principle. Existing regulatory requirements and standards (e.g. ATEX, PED, IEC) provide a framework for addressing these new hazards, but their applicability and coverage must be checked against the installation. He also said that he had not noticed clients asking for more safety studies on electrified systems.

> *Final takeaway: electrification changes how an accident can begin and how energy moves through a plant. The safety case has to remain valid from design through testing, operation and later modification.*

Sypox: Shutting Off 100 MW Safely

Angela Lotti, Project Manager at Sypox, wrapped up the talks by applying the principles to one specific technology. Sypox is a German start-up scaling up electrically heated reformers. As part of ELEKTRA it is tailoring its electrified steam methane reformer for a Direct Reduced Iron (DRI) process.

She compared the two designs:

- Conventional reformer. A fired box roughly 20 m high and up to 10 m wide for a 20 MW unit, containing catalyst-filled vertical tubes about 10 m long. Burners heat the tube walls, and the heat must conduct inward to the gas. Thermal efficiency is limited because the burners also heat the entire firebox and the flue gas generated.
- Sypox reformer. A refractory-lined pressure vessel with a cold outer skin, about 2 m diameter for a 10 MW unit. Its core is a structured ceramic catalyst with resistive heating wires running through its channels. Gas flows in the narrow gap between wire and catalyst, so it is in direct contact with the heat source and the catalyst.

In hazard terms, the two share high-temperature, high-pressure, flammable-gas scenarios. Each also has its own issues such as: Flame instability and fuel-to-air ratio for the fired unit. Electrical arcing, loss of insulation resistance and short circuits belong for the electric equivalent. In both, the most serious scenarios end in a safety-system shutdown of the heat source, independent of the basic process control system.

For a fired reformer that means isolating the fuel, which is mature practice. A burner management system closes two block valves in series and opens the bleed between them, with position feedback and specified closure times. For an electrically heated reformer, a conventional approach to safety-related power isolation uses redundant contactors to interrupt the electrical supply. SYPOX used this arrangement as an illustrative reference and noted that its practical implementation may become more demanding at high heating powers.

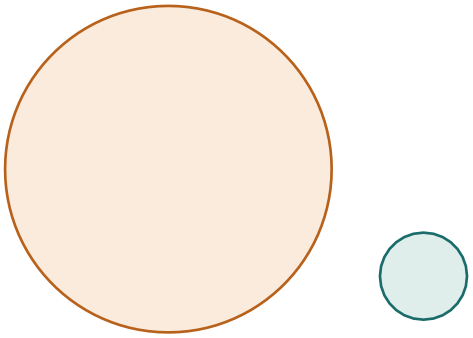


Figure 5: *Switching off 100 MW. Sypox's comparison of a fuel line and the equivalent electrical conductor, drawn to scale. Dimensions are calculated based on specific assumptions.*

As an illustrative scale-up example, SYPOX compared the equipment required to interrupt a large fuel-fired heat supply with the equipment needed for high-power electrical heating. At 100 MW, a duty not unusual for large ammonia plants or refineries, the fuel line is about 200 mm in diameter, while Sypox put the equivalent conductor cross-section at about 750 mm in diameter (Figure 5). That means very large contactors, expensive switchgear and big cabinets.

The presentation raised the question of how a reliable and economically practical safety-related shutdown function should be implemented at industrial scale. The relevant solution depends on the voltage level, power electronics, process hazards and required safety integrity.

Large motors have been here before. Their protection also began with double contactors and evolved towards safety functions integrated directly into the motor drive. Safe Torque Off, standardised in IEC 61800-5-2, prevents the motor from generating torque without opening the main power circuit and can therefore avoid the need for external double contactors. Heating loads currently have no recognised equivalent.

SYPOX discussed whether such safety-related electronic functions established for electric motor drives, could inspire corresponding solutions for electrically heated industrial processes. Such solutions could reduce the required equipment footprint and potentially lower implementation costs. Their development and recognition would require cooperation with power-supply manufacturers, certification bodies and standards organisations.

> *Final takeaway: safely shutting down a high-power electric heating load is the gap. Closing it needs power-supply manufacturers, notified bodies and standards committees to develop and recognise an equivalent approach for heating applications.*

Audience Question & Closing Discussion

Audience questions during the presentation

The questions after each talk sharpened several points the presentations had left open.

Heat pumps, efficiency against inherent safety. Richard asked how widely heat pumps are applied to distillation outside steam-cracker separations. Govert's's answer was that the case comes down to operating cost, reliability and integration. Brownfield retrofits are hard because of plot space and because they shift the energy balance of a well-integrated site. On greenfield assets, heat pumps should be on the table by default.

How ready is the process engineering community? Jebin asked how mature the process engineering community is in recognising and assessing electrification risks. Govert described himself as a chemical engineer still learning the electrical dimension. He said maturity is hard to generalise, and that the disciplines will have to learn to speak to each other as electrification spreads.

Are the existing standards enough? The moderator asked whether new standards are needed. Mr Marugán's view was that they are not. Electrification introduces new hazards relative to combustion, but not unknown ones, and the existing frameworks (ATEX, hydrogen standards, the Pressure Equipment Directive, IEC 61511) already cover them. Asked whether clients are requesting more safety studies for electrified systems, he said he has not yet seen a noticeable rise.

ATEX and hot surfaces. Aritz asked Sypox how a reformer running at reforming temperatures can comply with ATEX in a hydrogen zone, where surface temperatures must stay below 450 °C. The answer had two parts. The refractory lining keeps the vessel skin within the allowable range. Additional safeguards, for example infrared temperature monitoring, could be considered to detect abnormal vessel temperatures and initiate an appropriate protective response. On certification for CE marking, the answer was that the conformity route depends on the risk assessment and design. That determines whether a notified body must be involved or self-declaration is sufficient.

Size versus capacity. The moderator noted that the size comparison between the two reformers partly reflects capacity. Sypox confirmed the figures: the conventional example was a 20 MW unit and the Sypox unit is 10 MW. Two Sypox units would match the conventional unit's hydrogen output with a much smaller footprint.

The Closing Discussion

What is holding back electrification of the process industry? All three agreed it is not primarily technology. Govert pointed to the grid as the main bottleneck in the Netherlands. It also pointed to the supply-demand balance: the more is electrified, the more generation is needed, and day-ahead price swings complicate the picture. The direction of travel, reflected in the European Electrification Action Plan, is nevertheless clear. Juan ranked three barriers: electricity price competitiveness, grid access and connection capacity, and capital investment. Electrification affects the entire industrial ecosystem, not just the unit being converted.

Do faster electrified systems carry more risk?

This produced the most interesting exchange of the afternoon, and a disagreement that was presented as agreement. Govert's view: no. Fired, steam-integrated plants are slow and tightly coupled; heat moves around the site through the steam system. Electrified systems are less coupled, respond faster and are easier to control and start up. Shrinking the delay between action and process response is a control advantage.

Mr Marugán's view: speed cuts the other way. He opened by agreeing, but argued that many electrical fault scenarios develop much faster than combustion-driven ones. That leaves less time for detection, diagnosis and operator intervention. Combustion systems store large amounts of chemical energy and can produce large-scale accidents. Electrified systems often store less energy locally but can release it at a much higher power density and rate.

Both points are true, and they are about different things. Faster response improves control in normal operation. Faster fault development erodes the process safety time that protection layers, and especially operator action, depend on. That is precisely the response time vs. process safety time available check from Mr Marugán's own talk. Christian Liggett's closing remark captured the balance: faster actuation may improve reliability, but it changes how operators interface with the hazard.

Reflection and Conclusions

Beyond the significant efficiency gains and the rapidly increasing technology readiness of industrial electrification, the afternoon highlighted three takeaways that may at first appear contradictory.

The first, voiced by Empresarios Agrupados and Govert van der Ploeg, is that the standards are already there: electrification introduces new hazards, but known ones. Second, once safety is managed, electrification enables large efficiency gains in the order of 10 to 50%. Third, from Sypox, is that a concrete standards gap exists. There is no recognised equivalent of Safe Torque Off for shutting down high-power heating loads. Unlike electric motor drives, heating applications do not yet have a widely recognised integrated safety function equivalent to Safe Torque Off, which could simplify the safety architecture.

They are not in conflict. They describe different levels of the safety framework. At the level of hazard identification, risk assessment, layers of protection and functional safety, the established methods remain applicable regardless of whether the heat is supplied by a flame or by electricity. However, at the level of the final element—the part that removes energy from the process—mature industrial practice exists for fuel isolation. For the new high-power heating applications emerging from the electrification of the chemical industry, comparable switching equipment exists, but recognised integrated safety solutions are still at a lower level of maturity. The methods are in place; what still needs to develop is the equipment architecture and recognised design basis for these emerging applications.

The same pattern runs through the speed question. Electrified systems are faster to control and faster to fail. The control advantage is real, but the benefit may not offset the reduced process safety time. Any credit taken for operator action in an electrified unit deserves particular scrutiny. Process engineers need to understand what a converter does in a fault, and electrical engineers need to understand what a loss of flow does to a hot spot. Mr Marugán's case study shows that the most dangerous scenarios sit between the disciplines rather than inside any one of them.

Conclusions from the presentations and discussion:

1. **Electrification moves the hazard; it does not remove it.** The chemistry and its inventory are unchanged. Fuel-train and flame-failure scenarios go; electrical, stored-energy and control-interface scenarios arrive. The prior hazard study is a starting point, never the answer.
2. **The gaps sit at the interfaces.** Process limits, electrical fault behaviour and control-system response have to be analysed together, within one agreed boundary, with explicit ownership of vendor-package assumptions.
3. **Independence must be demonstrated, not named.** Shared transmitters, power supplies and final elements can quietly collapse apparently separate protection layers, especially when the basic control system is part of the initiating failure, or when one electrical fault both ignites a release and disables its detection. That is common cause, not double jeopardy.
4. **The safe state needs a definition, not a label.** "The unit shuts down" is not enough. Power isolation may need to be combined with continued cooling or a controlled gas route to remove residual heat.
5. **Speed cuts both ways.** Faster dynamics ease normal control but shorten the process safety time. Response time has to be verified against time available, and operator credit treated with caution.
6. **Mature solutions are required for high-power electric heating.** The electrification of the chemical industry is creating new applications for which recognised equipment architectures and design approaches are still developing. Further progress could simplify the safety architecture and reduce equipment footprint and implementation costs.
7. **The efficiency case justifies the effort.** Reductions to the order of 10–50% in energy use for the same duty, even upto 75% in the Shell's Moerdijk drive replacement, are large enough that the developments in safety are worth pursuing rather than a reason to defer.

The conclusion, then, is not that electrification is safer or less safe than combustion. It removes a well-understood set of hazards and introduces another that is less familiar to process engineers. The safety framework to manage it is largely in place, but the discipline boundaries need to be respected to realise these huge efficiency benefits.

From the Organising Committee

We are most grateful to Prof. Fausto Galluci and Simona Scoppa of the 1 Cube B.V., representing the ELEKTRA project for organising the webinar and supporting a collaborative discussion. We are also grateful to the three speakers for bringing real engineering questions to an open audience: Govert van de Ploeg of Shell Global Solutions, Juan Carlos Marugán of Empresarios Agrupados, and Angela Lotti of Sypox. Thanks also to Christian Liggett for coordinating on behalf of the IChemE Netherlands Member Group, and to every participant who asked a question or answered a poll.

The recording and slides are available via the ELEKTRA project website: Webinar “Process Safety in the Electrification of Industry” – Elektra Project.

ELEKTRA's survey on the social acceptance of electrification remains open, and takes six to seven minutes: Expert Survey on the Social Acceptance of ELEKTRA Technologies.

IChemE Netherlands will continue to build on these conversations through future events and through written summaries for our members. If the challenges discussed here are relevant to your work, or you would like to contribute to a follow-up session, we would like to hear from you.

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