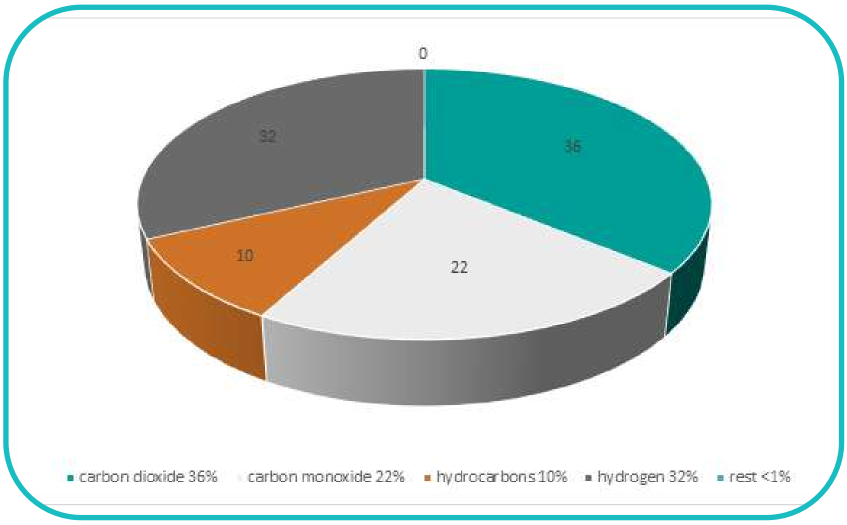

Fig. 4: Representative gas composition for thermal runaway

	Hydrogen H2	Carbon monoxide CO
Lower explosion limit LEL	4.0 Vol%	10.9 Vol%
Upper explosion limit UEL	75.6 Vol%	76 Vol%
Minimum ignition energy MIE	0,016 mJ	< 1mJ
Ignition tempera-ture IT	560 °C	605 °C
Temperature class	T1	T1
Explosion group	IIC	IIA
Density	0,09 kg/m^3	1.25 kg/m^3
Max. explosion pressure	8.0 bar	8.2 bar

Fig 5: Explosion parameters of hydrogen and carbon monoxide. BG RCI Magazin – Ex-Zonen für Wasserst-off-Elektrolyseanlagen – 2014 .

GESTIS Stoffdatenbank – Kohlenmonoxid

well as toxic flue gases (see figure 4).

ISHPMIE - Explosibility Properties of Gases from Lithium-Ion Energy Storage Battery Thermal Runaways, Adam Barowy – Braunschweig 2020

Hydrogen and carbon monoxide are gases that can form explosive mixtures with oxygen from the air over wide concentration ranges (see figure 5). Both gases have low minimum ignition energies, meaning that even small electrostatic charges or hot surfaces are sufficient to ignite this mixture. There is a risk of gas explosion when unburned gas accumulates in the environment.

The use of GSME gas sensors is a proven method of identifying thermal runaway. The simultaneous monitoring of numerous pyrolysis gas concentrations, such as carbon monoxide, hydrogen and hydrocarbons, in the parts per million range offers a detailed insight into the process status. If previously set limit values for the pyrolysis gas concentrations are exceeded, the GSME gas sensor emits an electrical alarm signal, which can be used as a warning and to initiate further measures.

Benefits of REMBE GSME fire gas detectors for BESS at a glance

•Monitoring of gas concentrations (e.g. hydrogen and carbon monoxide) in the case of thermal runaway

•Multi-component detection with sensitivity in the ppm range

•Early alarm to initiate countermeasures

•Compact construction, robust design and simple installation

A major challenge in practice is that thermal runaway cannot be stopped or extinguished using classic fire protection measures. It must, therefore, be expected that the explosive gases can ignite outside of the battery cell/housing and lead to an explosion.

If hydrogen-air mixtures ignite in closed systems, explosion pressures of up to 8 bar can occur (see figure 7). These pressures exceed the strengths of the containers and battery rooms in which the battery energy storage systems are located. In particular, doors have low pressure shock resistance and can represent dangerous weak points.

To prevent bursting or flying debris with explosive flames, explosion vents have proven of use as predetermined breaking points, which vent the explosion pressure into the environment in a controlled manner. Extensive explosion vents that are ready for series production have been developed that also open safely and completely at low burst pressures. This solution offers the advantage that the strength of the housing and doors can be much lower, which brings with it huge cost savings. Explosion vents are recommended as protective measures in many standards and are explicitly required by law in certain regions.

The benefits of REMBE explosion vents for battery energy storage systems at a glance

•Passive, mechanical and autonomous protective systems made from stainless