

SUSTAINABLE BATTERY INDUSTRY:  
HEALTH & SAFETY CHALLENGES BATTERY LIFECYCLE:  
FROM PRODUCTION & USE TO RECYCLING



Tjerk Raske  
Head of Marketing Europe

**Dräger**

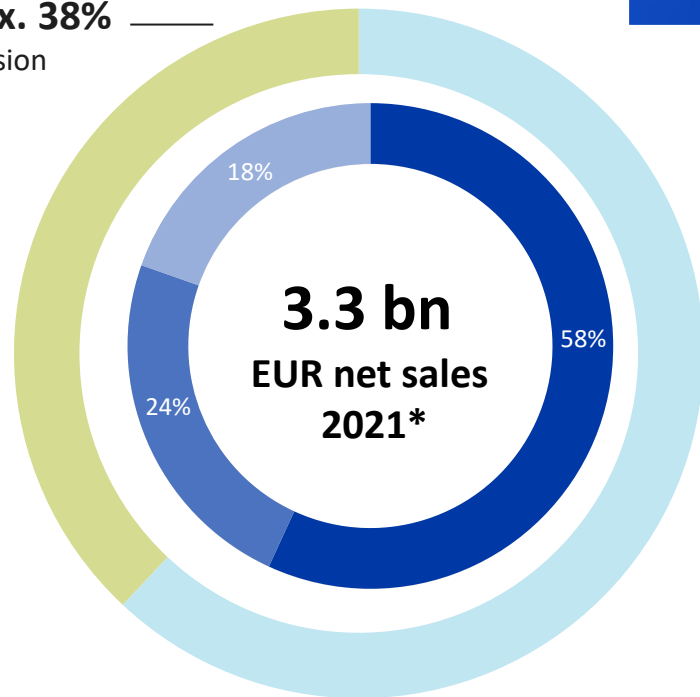
# Introduction Dräger



Technology  
for Life



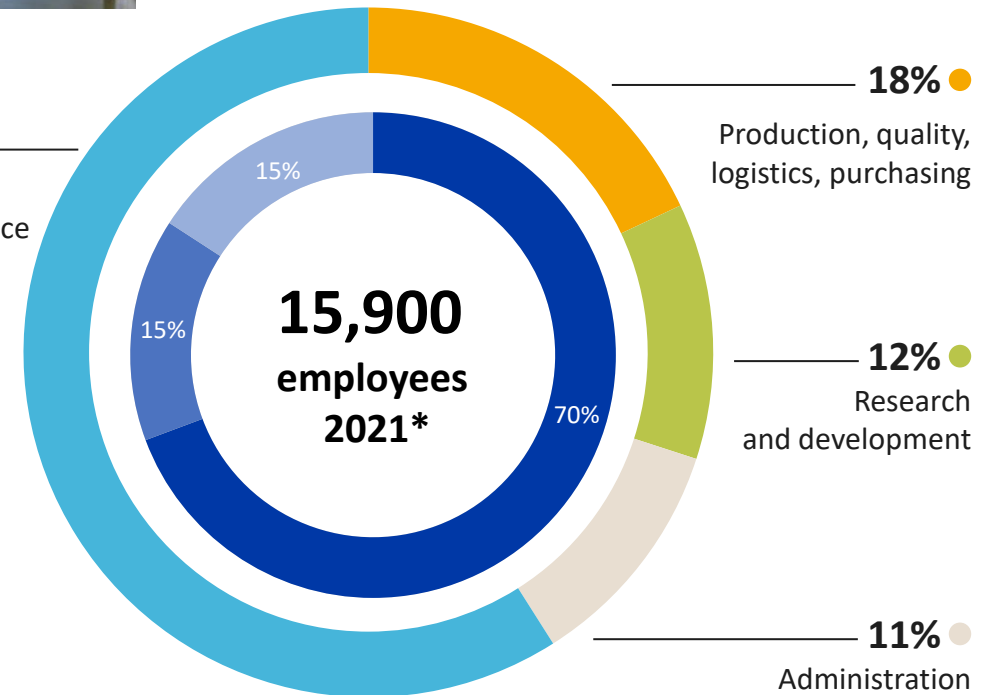
● **approx. 38%**  
Safety Division



● **59%**  
Sales,  
marketing, service

● **approx. 62%**  
Medical Division

- Europe
- Africa, Asia, and Australia
- Americas



\* As of December 31, 2021

# UN Global Goals for Sustainable Development & Importance of Batteries

Battery Technology is indispensable to deal with fluctuating nature of RES\* and store electric energy for mobile and stationary applications, as well as required services to stabilize the electric grid.

<p><b>TARGET 7.1</b></p> <p><b>UNIVERSAL ACCESS TO MODERN ENERGY</b></p> <p>By 2030, ensure universal access to affordable, reliable and modern energy services.</p>	<p><b>TARGET 7.2</b></p> <p><b>INCREASE GLOBAL PERCENTAGE OF RENEWABLE ENERGY</b></p> <p>By 2030, increase substantially the share of renewable energy in the global energy mix.</p>
<p><b>TARGET 7.3</b></p> <p><b>DOUBLE THE IMPROVEMENT IN ENERGY EFFICIENCY</b></p> <p>By 2030, double the global rate of improvement in energy efficiency.</p>	<p><b>TARGET 7.4</b></p> <p><b>PROMOTE ACCESS TO RESEARCH, TECHNOLOGY AND INVESTMENTS IN CLEAN ENERGY</b></p> <p>By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology.</p>

\* RES = Renewable Energy Sources such as Solar PV, Windturbines ...



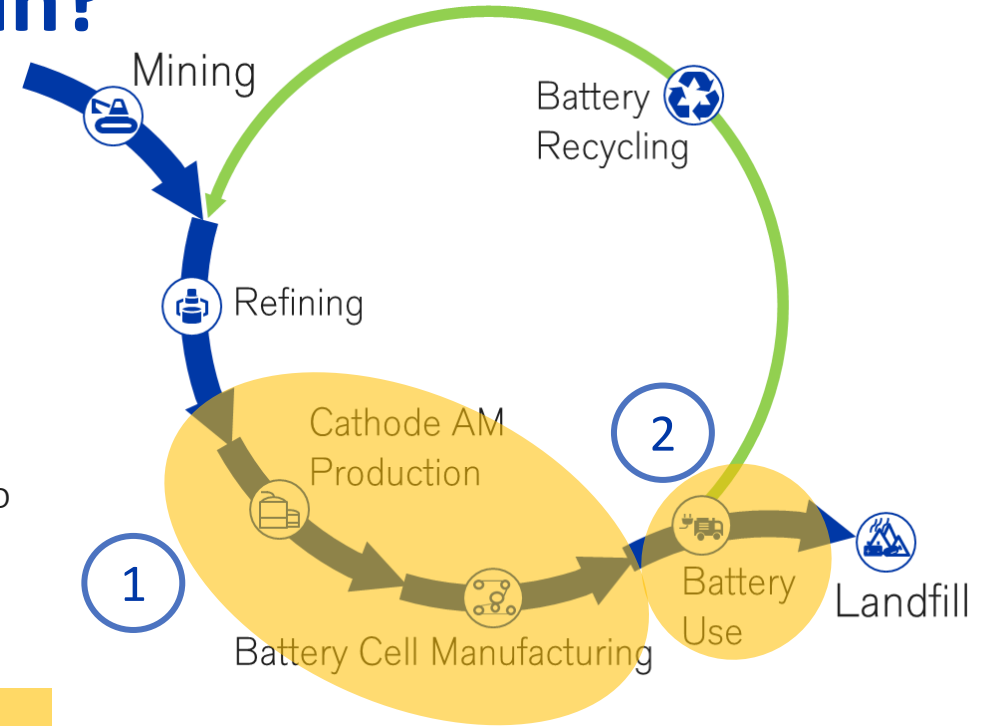
Self-sufficiency is desirable for reliability of supply and welfare of society

<p><b>TARGET 9.4</b></p> <p><b>UPGRADE ALL INDUSTRIES AND INFRASTRUCTURES FOR SUSTAINABILITY</b></p> <p>By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities.</p>	<p><b>TARGET 9.7</b></p> <p><b>SUPPORT DOMESTIC TECHNOLOGY DEVELOPMENT AND INDUSTRIAL DIVERSIFICATION</b></p> <p>Support domestic technology development, research and innovation in developing countries, including by ensuring a conducive policy environment for, inter alia, industrial diversification and value addition to commodities.</p>
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# Environmental, Health & Safety hazards: Why, how and what in Battery Value Chain?

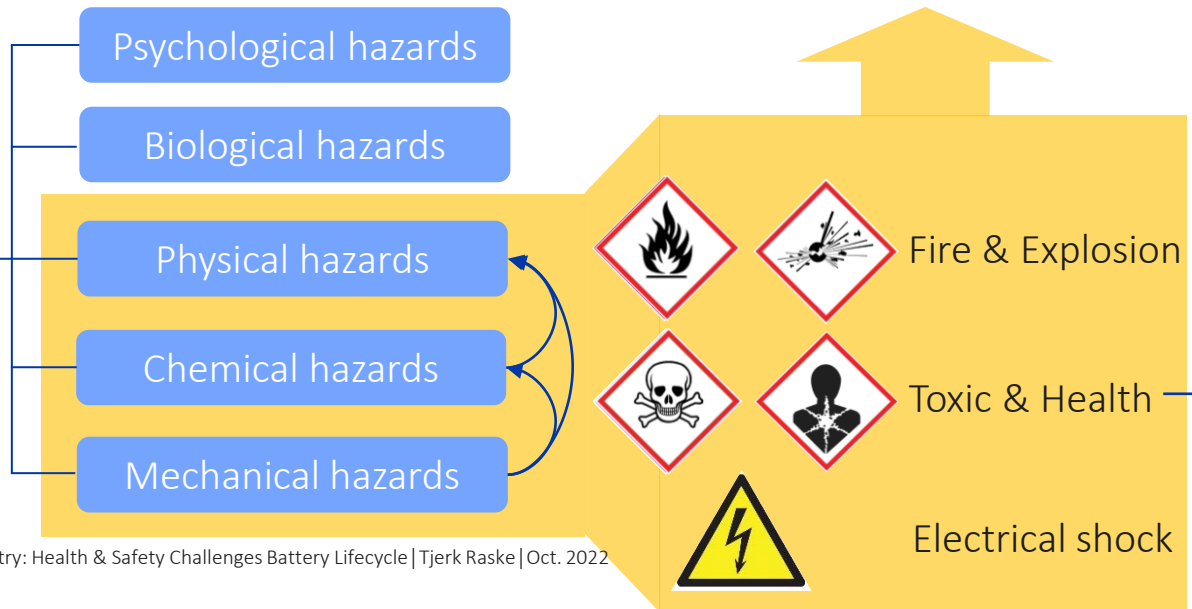
<p><b>3 GOOD HEALTH</b></p>	<p><b>TARGET 3.9</b> REDUCE ILLNESSES AND DEATH FROM HAZARDOUS CHEMICALS AND POLLUTION</p> <p>By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination.</p>
<p><b>8 DECENT WORK AND ECONOMIC GROWTH</b></p>	<p><b>TARGET 8.8</b> PROTECT LABOUR RIGHTS AND PROMOTE SAFE WORKING ENVIRONMENTS</p> <p>Protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment.</p>

- Plant safety & protection of production assets
- OHS – reduce risk from exposure to toxic substances
- OHS – prevent long-term health effects from exposure to carcinogenic substances



Occupational Health & safety hazards

International Labour Organization



**6 CLEAN WATER AND SANITATION**

**TARGET 6.3** IMPROVE WATER QUALITY, WASTEWATER TREATMENT AND SAFE REUSE

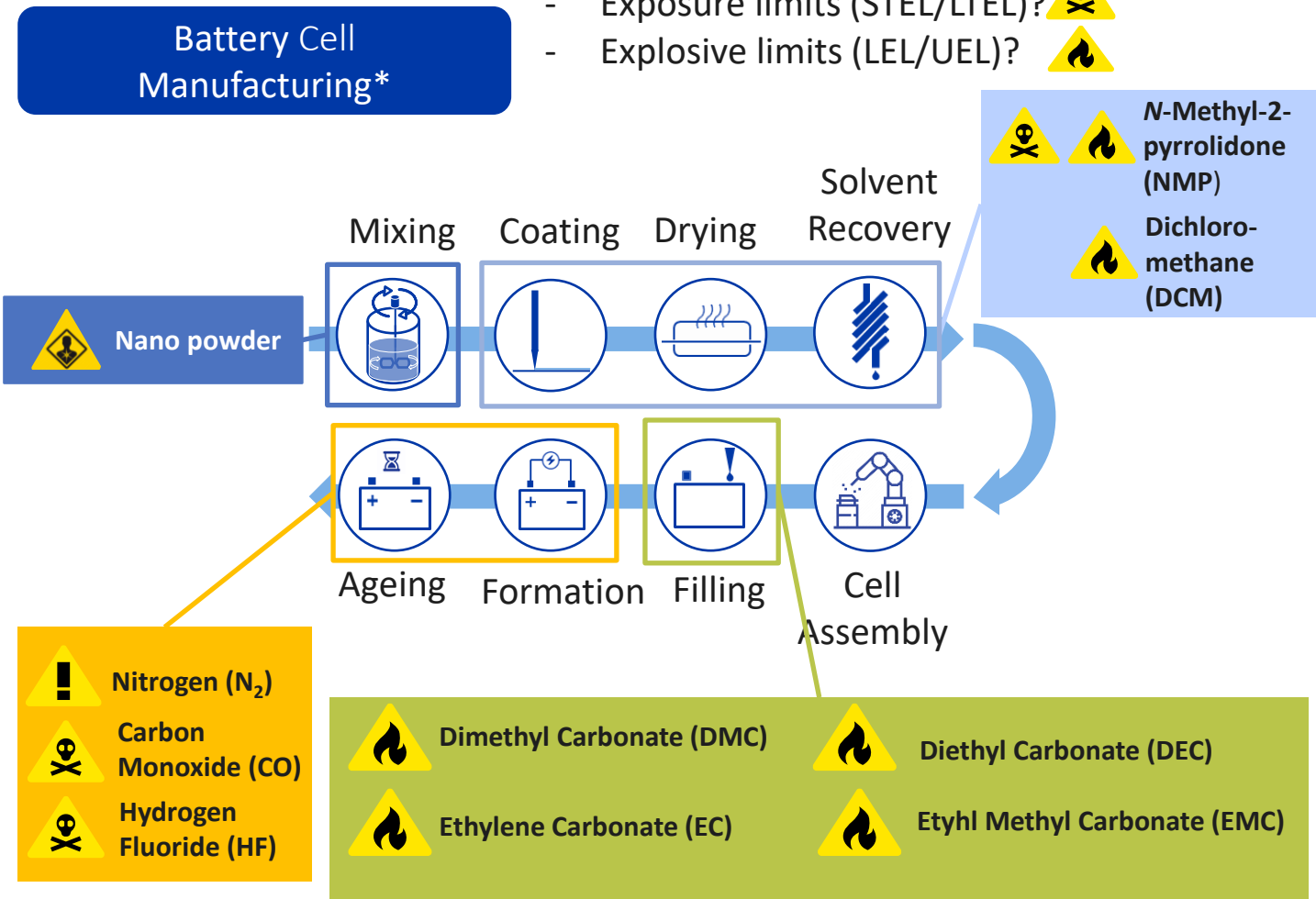
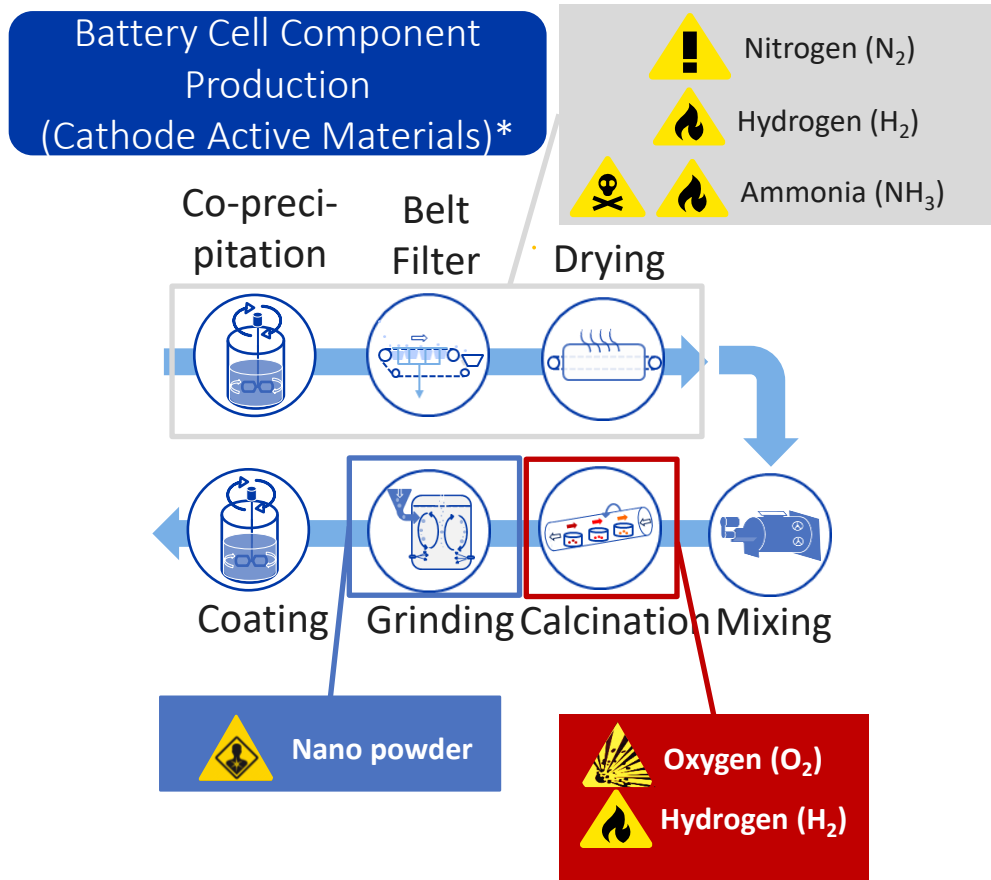
By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.

**12 RESPONSIBLE CONSUMPTION AND PRODUCTION**

**TARGET 12.4** RESPONSIBLE MANAGEMENT OF CHEMICALS AND WASTE

By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment.

# Hazards in Battery Manufacturing Upstream & Downstream\*

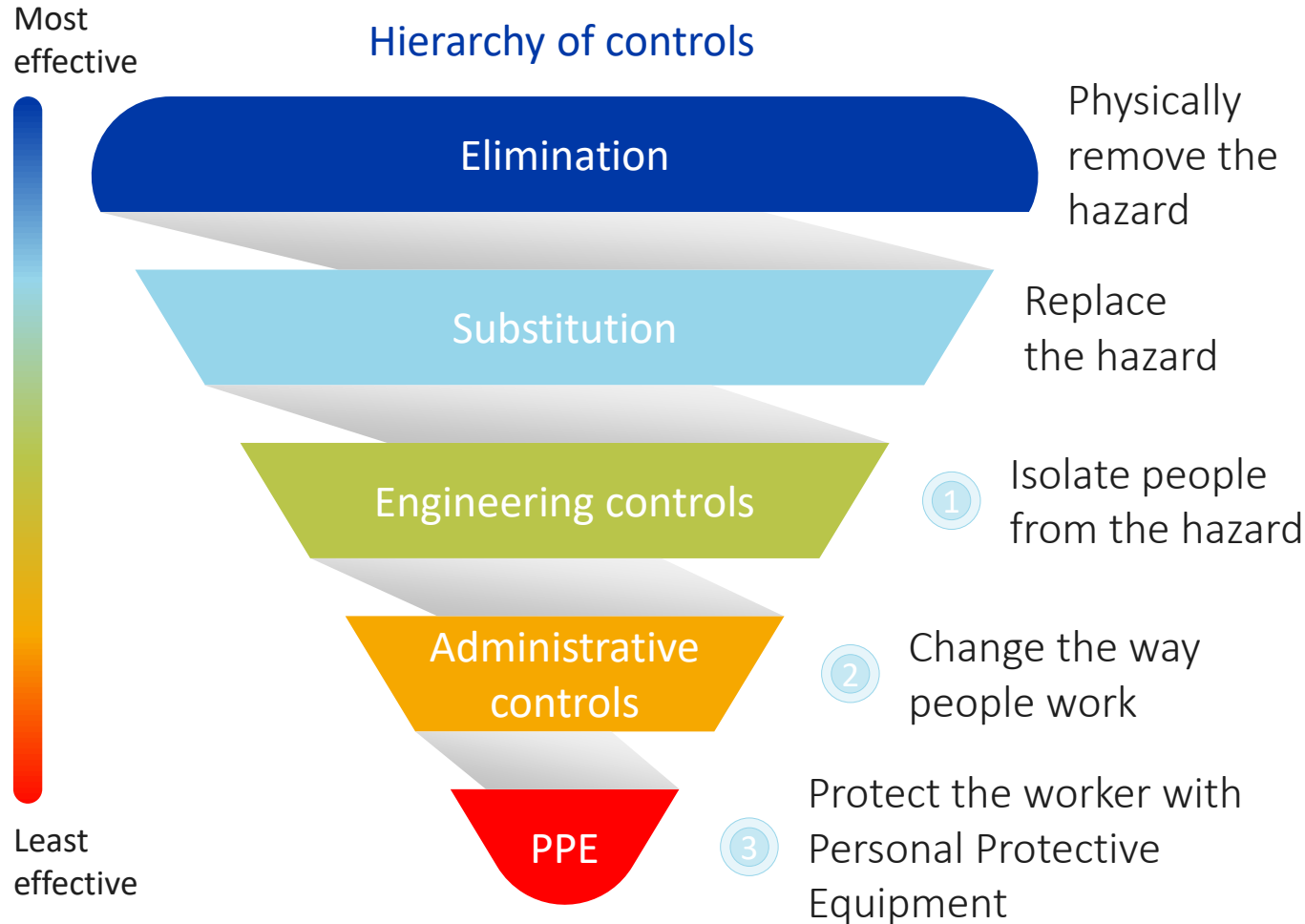


- Factors to consider:**
- Process temperature & vapor pressure?
  - Behavior of gas in air?
  - Exposure limits (STEL/LTEL)? ☠️
  - Explosive limits (LEL/UEL)? 🔥

\* exemplary based on NMC cell chemistry – actual hazards change with cell chemistry and also processing/production route

# Risk minimization

## Selection of protective measures



- 1
- Fixed gas detection system
  - Explosion-proof electrical equipment
  - Plant fire protection
  - Technical safety (e.g. rupture disk)
  - Ventilation equipment



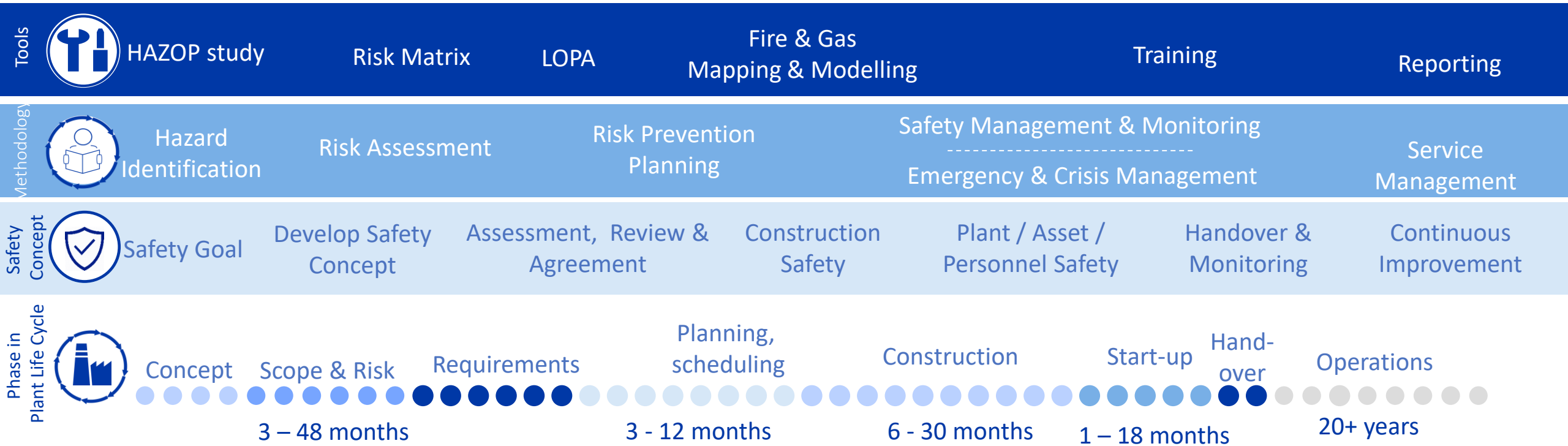
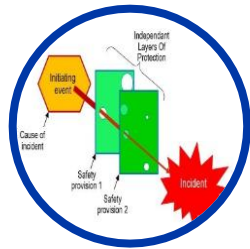
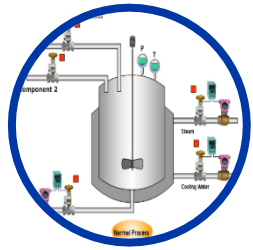
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- Safety matrix (If ..., then ...)
  - Emergency stop of electrical equipment
  - Emergency and hazard prevention & response management
  - Definition of permitted activities



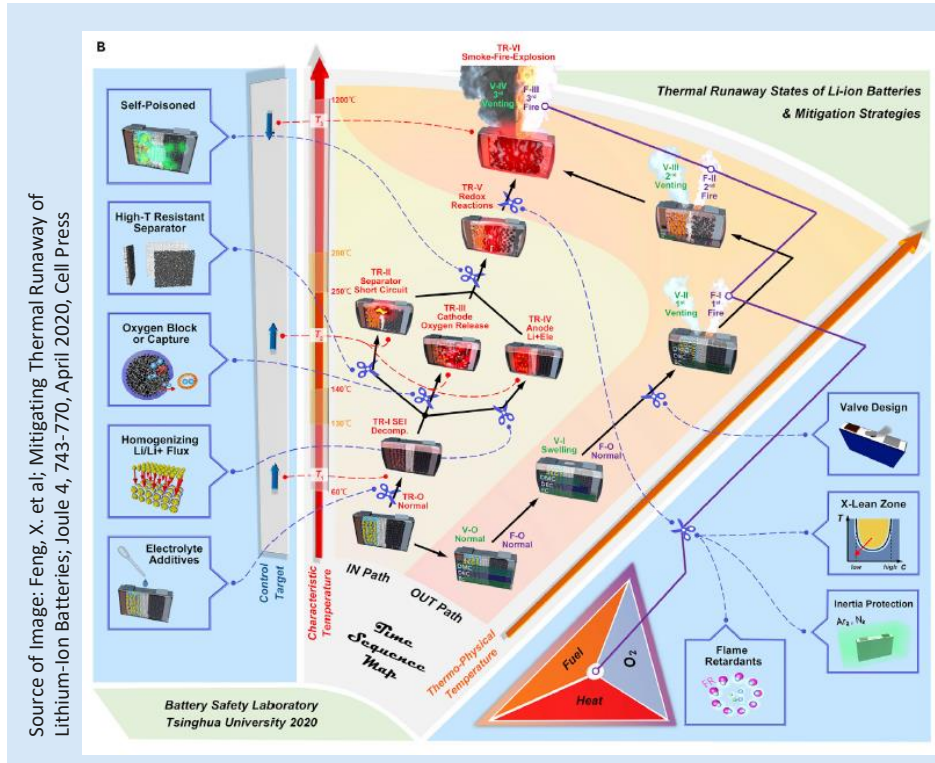
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- Mobile gas detection
  - Thermal imaging camera
  - ESD safety shoes
  - Instruction/Training



# Plant Lifecycle: Risk, Environmental & Health & Safety Management



# Plant Safety: Monitoring of Battery Energy Storage Systems (BESS)



Off-gassing occurs (depends on cell chemistry and other factors) in order of thermal stability of components:

- CO<sub>2</sub> from SEI layer\*
- HC\*\* from reaction between Anode & Electrolyte
- HC, HF, H<sub>2</sub> & CO<sub>2</sub> from Collapse of Separator & Decomposition of Electrolyte
- O<sub>2</sub> release from cathode
- Most of the associated reactions are exothermal and hence feed the process

**Off-gas typically prior to smoke & fire therefore still in prevention phase**






The "triangle of fire" components are present in the battery constituents itself:

- oxygen (present in the cathode materials),
- combustible substances (electrolyte, separator, anode material)
- heat (external or internal to the battery).

**Therefore fire events are likely to occur upon Thermal Runaway**

- toxic gases such as HF, HCl, HCN once there is a fire and plastics burn further

**Inert atmosphere can prevent fire & explosion**

<p>HC &amp; H2 Flammable Detection</p> 	<p>HF, HCl, HCN Toxic Detection</p> 	<p>Smoke &amp; Flame Detection</p> 	<p>O<sub>2</sub> rich atmosphere Detection</p> 	<p>N<sub>2</sub> or CO<sub>2</sub> rich atmosphere Detection</p> 
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\* SEI = Solid Electrolyte Interphase  
 \*\* HC = Hydrocarbons (e.g. CH<sub>4</sub>, C<sub>2</sub>H<sub>4</sub>, C<sub>2</sub>H<sub>6</sub>,...)

# Risk Response: Detection & Protection Solutions

**All Manufacturing / Production Areas**  
 Potential explosive environment with Nano-particles

- ▶ First responder equipment, SCBA + MGM

## Accidents/Thermal Runaway

Highly toxic HF, CO, CO<sub>2</sub>, HCN and others are generated

- ▶ + TIC, X-am 5100 HF, Parat 5500

## Nano-particles in Ex-Environment

- ▶ PAPR ATEX with P-filter

In case of existing solvents or paint:

- ▶ combined ABEK- P-Filter with TH3/TM3 headpiece

## Toxic Solvents - VOC's

DMC ▶ Half mask/FFM with A-Filter, in case of possible decomposition ▶ ABE or AX-Filter

NMP ▶ higher boiling point

- ▶ Half mask/FFM with A-Filter

## Escape Accidents/Thermal Runaway

Highly toxic HF, CO, CO<sub>2</sub>, HCN and others are generated

- ▶ Escape Devices, Filtered (HF stays on the filter surface) ▶ SCSR & ERBD

Emergency Response



Fire & Gas Detection & Monitoring



## Stationary Fire & Gas Detection Systems Area Monitoring & Sampling Systems

- ▶ Point Gas VOCs solvents (e.g. NMP) - PID
- ▶ Flammable Detection – solvents (e.g. DMC, EC, DEC,...)
- ▶ Toxic Detection – O<sub>2</sub> depletion to N<sub>2</sub>, ageing & testing (CO, HF, HCN)
- ▶ Control system, Integration & Visualization of Alarms



## Laboratory quality measurements for low-concentrations of carcinogens

- ▶ VOCs solvents (selective PID gas measurement)

## Spot Measurements/Leak Detection

- ▶ VOCs solvents (e.g. NMP)
- ▶ Flammable Detection – solvents (e.g. DMC, EC, DEC,...)
- ▶ Toxic Detection – O<sub>2</sub> depletion to N<sub>2</sub>, ageing & testing (CO, HF, HCN)

## Personal & Area Monitoring

- ▶ Flammable Detection – solvents (e.g. DMC, EC, DEC,...)
- ▶ Toxic Detection – O<sub>2</sub> depletion to N<sub>2</sub>, ageing & testing (CO, HF, HCN)



Safety Goals



PPE



Mobile Gas Detection



# Risk Response: Dräger Services

- ▶ Software tool for positioning of flame and gas detectors
- ▶ Optimize the F&G design while still maintaining system performance targets
- ▶ Follows best practices: e.g. BP GP 30-85 (2013) / Shell DEP 32.30.20.11-Gen and standards: BS660080:2020
- ▶ Provide a percentage coverage
- ▶ Volumetric design cloud is used to represent gas clouds
- ▶ Both 2D and 3D modelling can be utilized

- ▶ Online Trainings for Health & Safety Awareness / Vision zero
- ▶ User Training for PPE & Detection equipment
- ▶ Alarm & emergency drills
- ▶ Life Emergency Response Training
  - Fire Fighting
  - Dealing with Chemical hazards
  - Escape & Rescue



- ▶ Risk analysis & definition of protection goals improvement and to establish sustainable safety
- ▶ Alarm & emergency planning
- ▶ Crisis Management
- ▶ Safety Management systems
- ▶ Drills & exercises

- ▶ Data collection and analysis for connected systems, enables reporting on:
  - Efficient use of systems and devices
  - Uptime/downtime analysis
  - Early identification of potential issues
  - Fault patterns
  - Asset management

- ▶ Integration of Measurement Results in electronic workflows and documentation, e.g. permit handling for CSE
- ▶ Workforce Health & Safety: Documentation of short & long-term exposure
- ▶ Full & instant Data availability for Emergency Response Services

# Thank you

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