Paving the way for clean energy.

Ensuring safe, secure and reliable products and components.

- Company overview
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- E-Mobility storage systems
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The Weiss Technik companies are part of the Schunk Group

Ludwig-Schunk-Stiftung e.V.

Schunk GmbH

Schunk Carbon Technology
4,457 employees
Sites in 27 countries

Weiss Technik
2,134 employees
Sites in 14 countries

Schunk Sinter Metals
1,064 employees
Sites in 2 countries

Schunk Sonosystems
213 employees
Sites in 2 countries

The Weiss Technik companies are split in two business units

Weiss Technik

Business Units

Environmental Simulation

Air Solutions

Business unit Environmental Simulation

Climatic test chamber for li-Ion batteries

Climatic test chamber

Hephaistos microwave system

Space simulator

Weiss develops and manufactures complete environmental simulation solutions from a single source, from consulting to after sales service, e.g.

- drive-in test chambers for the automotive industry,
- temperature and climatic test chambers for environmental testing,
- heat technology solutions for industrial production,
- plant growth chambers and
- climatic test chambers for stability tests on pharmaceutical products.

Business unit Air Solutions

Cleanrooms for industrial applications

Hygiene air conditioning for hospitals

Deltaclima® cooling system for data centres

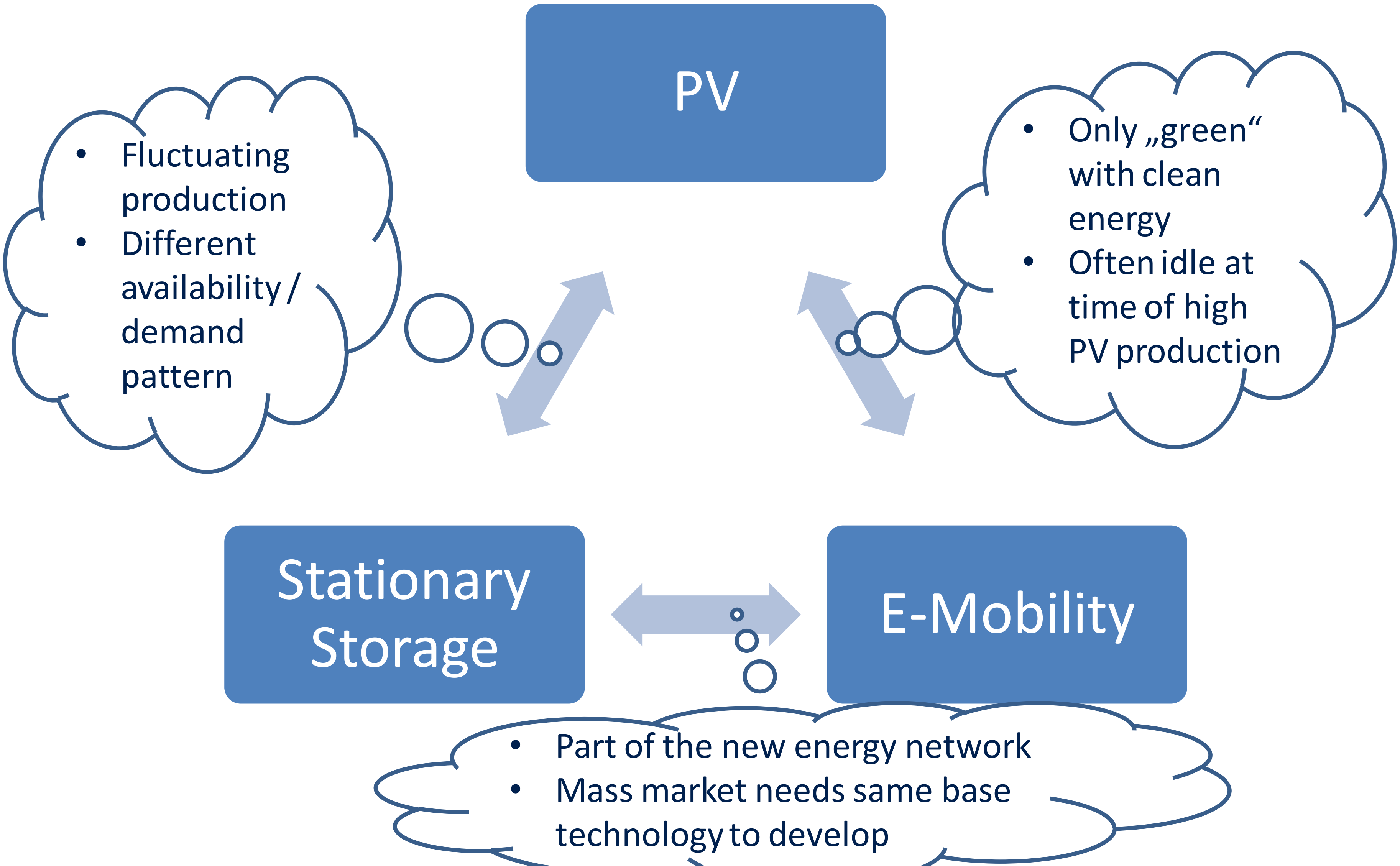
Weiss develops and manufactures air conditioning systems for the most demanding applications, e.g.

- cleanrooms and measuring rooms,
- clean workplaces,
- operating theatres,
- data centres and
- mobile air conditioning.

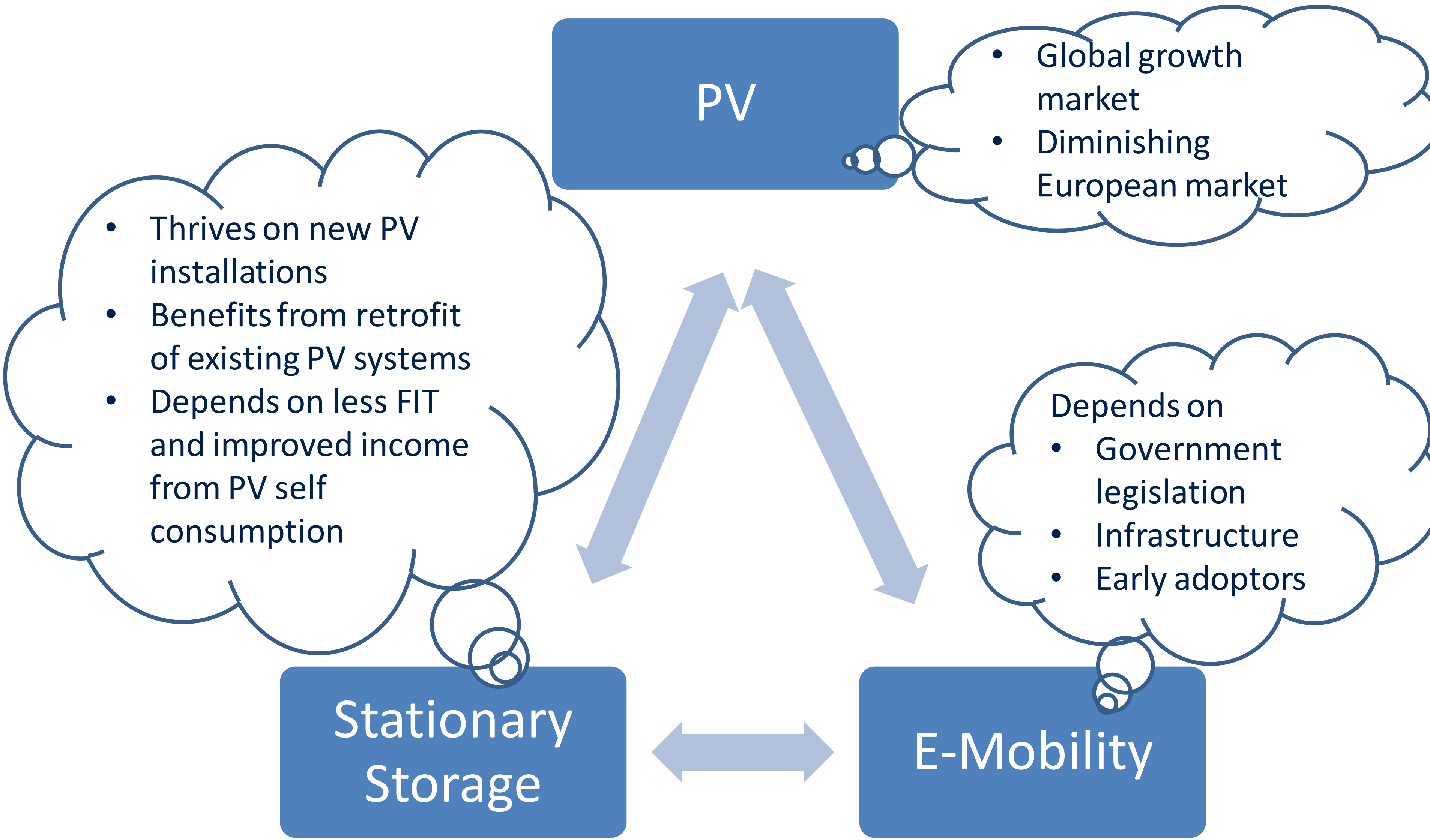
Climate protection agreements reached in Paris require renewables

- Wind, solar, biomass, hydropower need to be combined
- E-mobility is only „green“ if fed by renewable energy
- Fluctuating energy production levels need to be balanced by storage solutions
- Decentralized solutions play an important role in the future energy network
- Solar, stationary and mobile storage are a natural combination

A joint market



Growth of markets is interdependent



Stakeholder, requirements, questions

- Manufacturer
- System integrator
- User
- Bank
- Insurance
- Government

- Economic viability
- Safety
- Durability
- Performance
- Compatibility

- Material selection
- Behaviour under normal operating conditions
- Behaviour under extraordinary conditions
- Development over a systems life time
- Interaction between components in a system

Influencing environmental factors

Normal Operating Conditions, e.g.

- Temperature
- Relative humidity
- Sun light / UV
- Ozone / air pollutants / dust
- Rain / hail / snow
- Salt spray from ocean sides or winter roads
- Movement during transportation
- Intrinsic risk potential (inflammable, explosive)

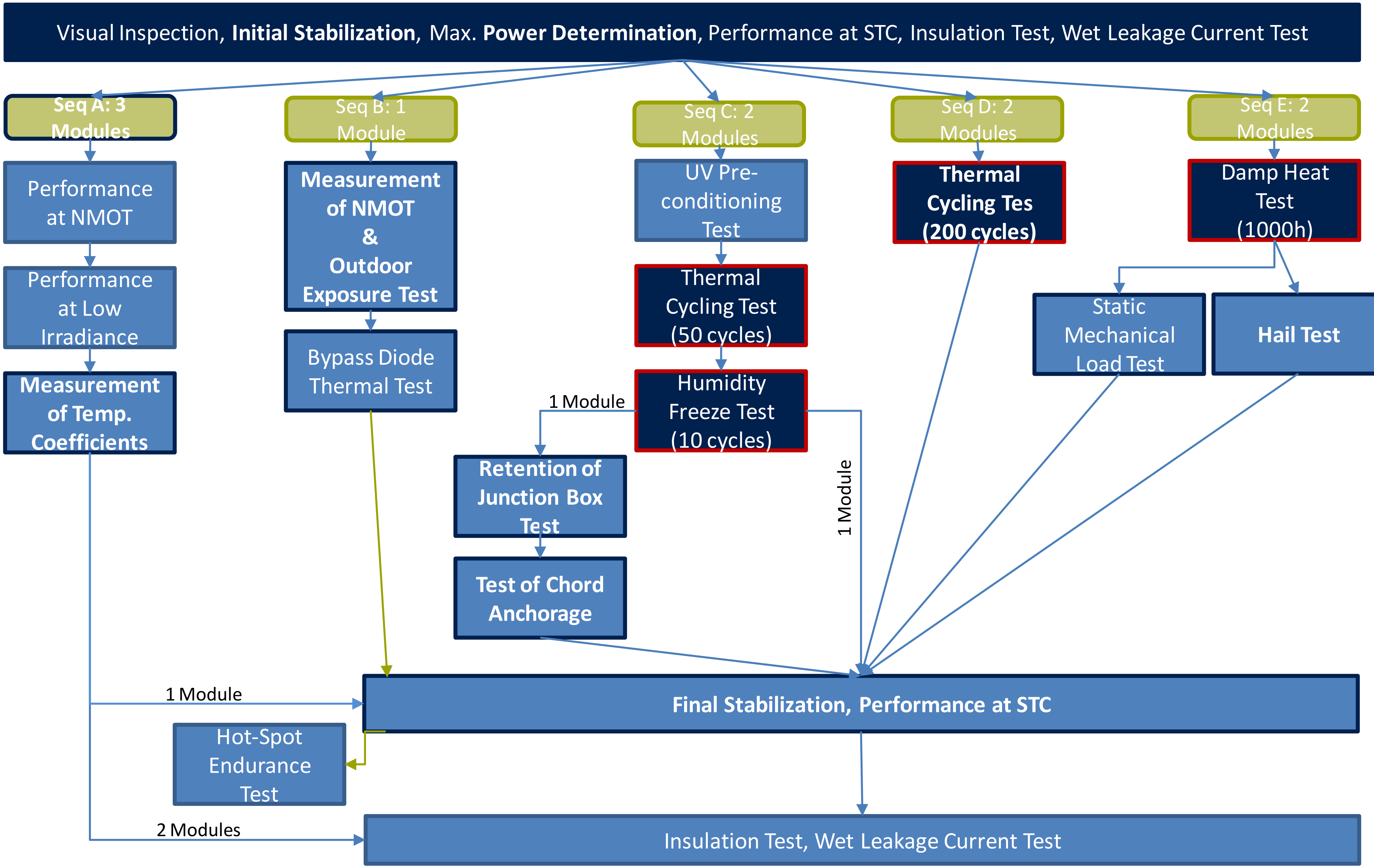
- Economic viability
- Safety
- Durability
- Performance
- Compatibility

Extraordinary conditions

- Floods
- Hailstorm
- Fires
- Earthquake
- Accidents

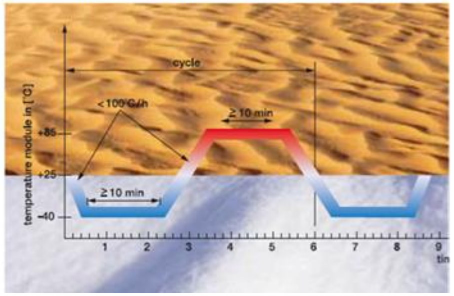
- Criteria particularly for durability are defined in IEC 61215 and IEC 61464
  - Application during product development and qualification:
    - change in materials to optimize cost and / or performance
    - Understand the impact of components on newly identified risk factors, such as PID (potential induced degradation) or LID (light induced degradation)
  - QC at manufacturers end or partially through institutes as requested by banks / customers as acceptance criteria for delivered batches
  - Particularly changes in environmental conditions effect the durability (10.10, 10.11, 10.12, 10.13)
    - Impact on cost through lower performance or higher O&M costs (customer side)
    - Impact on potential warranty costs (manufacturer side)
    - Impact on brand ranking in relevant overviews (Bloomberg, PV-Magazine etc.)
- Criteria particulary for electrical safety are defined in IEC 61730
  - Changes in environmental conditions are tested under MST 51 a/b, MST 52 and MST 53
- Usually the tests for IEC 61215/61464 and IEC 61730 are conducted in one run.

The new IEC 61215 type approval test method (published March 2016)

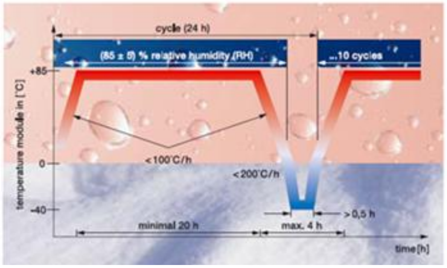


- Environmental tests can be combined with
  - UV testing
  - Irradiation unit between 800 to 1200 W/m²
  - Spectral radiation distribution – global radiation 280 to 3000 nm
- Durability requires
  - Lasting bonds between all materials including adhesives, encapsulation, back sheet etc.
  - Particularly important for flexible thin-film modules to avoid humidity entrance leading to destruction of cell chemistry.

Temperature shock cycling test (10.11)



Humidity freezing test (10.12)



- No clear norm for stationary home storage systems defined yet
- German institutional organisations have defined guidelines, which may become standards
- Other norms that need to be taken into consideration
  - UN 38.3: Requirements for the safe transport of lithium batteries
  - DIN EN 62281 Safety of primary and secondary lithium batteries during transport
  - IEC 62619 / 62620 for cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for lithium cells and batteries
  - IEC 62485-2/5 (under development) Safety requirements for secondary batteries and battery installations
  - VDE AR-E 2510-2/-50 for stationary energy storage systems planned for network integration / safety requirement for systems with lithium batteries
  - BATSO 02 2014: Manual of evaluation of energy systems
  - IEC 61427-1 for rechargable cells and batteries for storage of renewable energy – general requirements and test methods – part 1: PV off-grid applications
  - DIN EN 61508-1 Funktional safety or related electric / electronic / programmable electric systems – part 1: general requirements

Source: TÜV Rheinland, DKE, VDE 2015, SGS

Purpose of environmental tests of stationary home storage systems

Transport	Operation	Storage
Altitude simulation for air transportation	Definition of optimal operating temperature (dry and damp)	Definition of optimal storage temperature
Thermal test to test battery integrity	Determination if the set contact disruption works (temperature protection BMS)	
Vibration to simulate vibration stresses during transport	Determining of consequences if temperature is lower or higher	
External short circuit at 55°C	Support of development of heat generators inside the battery	
	Combination with emission tracking to idenity gas development	
	Avoidance of unsafe operating conditions due to dust / dirt / liquids	
	Control of pressure release operation	
	Pressure test of cooling system	

Source: interal evaluation of the guideline versus product portfolio, aforementioned norms

For batteries and their cells in e-mobility applications harsher standards currently apply

- UN 38.3: Requirements for the safe transport of lithium batteries
- DIN EN 62281 Safety of primary and secondary lithium batteries during transport
- IEC 62619 / 62620 for cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for lithium cells and batteries
- IEC 62485-2/5 (under development) Safety requirements for secondary batteries and battery installations
- IEC 62660
- ISO 12405
- ISO 18243
- prEN 506041
- UN ECE R 100
- NHTSA – working draft 2015

Source: TÜV Rheinland, DKE, VDE 2015, SGS

Environmental test on e-mobility storage systems

Transport	Operation	Storage
Altitude simulation for air transportation	Vibration	Definition of optimal storage temperature
Thermal test to test battery integrity	High temperature resistance from room temperature to 130°C with 5K/min holding 30 min	
Vibration to simulate vibration stresses during transport	Temperature cycling out of operation 30 times 25°C / 2x -40°C / 25°C / 2x 85°C / 25°C	
External short circuit at 55°C	Temperutre cycling in operation 30 times each 480 min = 8h 25°C / 2x -20°C / 25°C / 2x 65°C / 25°C	
	Dewing	
	Avoidance of unsafe operating conditions due to dust / dirt / liquids	
	Corrosion – salt and gases	
	Dust	

Source: SGS, VDE, aforementioned norms

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a schunk company

Overview of main norms for transport of batteries, e-mobility and stationary storage applications

Transportation	Road Vehicles Traction Battery				Stationary Storage	
UN 38.3	CDV IEC 62660-3	ISO 12405-3	UN ECE R 100 (Rev 2)	NHTSA	D IEC 62619	IEC 61427-2
UN 38.1 -Transportation Testing for Lithium Batteries	Lithium-Ion Secondary Cells for the Propulsion of Road Vehicles -Part 3 Safety Requirements	Elektric Propelled Road Vehicles – Test-Specification for Lithium-Ion Tractionbattery-Systems – Part 3: Safety Requirements	Typeapproval of Electric Propelled Road Vehicles and their Batteries	Working Draft 2015 National Highway Traffic Safety Administration (Doughty, August 2015)	Lithium Cells and Batteries for Industrial Applications	Secondary Cells and Batteries for Storage of Renewable Energy - Part 2 Grid-Integrated Applications
Altitude						
T 1 Altitude Simulation						
Mechanical Impact						
T3 Vibration	Vibration (O)	Vibration (O)	Vibration (O)			
T4 Mechanical Shock	Mechanical Shock (O)	Mechanical Shock (O)				
		Crash-Shock (A)	Crash-Shock (A)			
T6 Crush (C) (Cyl>20mm)	Crush	Crush (A)	Crush (A)	Pack Level Crush		
(drop test see ADR)					Drop (C, BS)	
T6 Impact (C)					Impact (C)	
Thermal Influence						
	Elevated temperature	Loss of cooling	Overtemperature		Elevated Temperature (C)	
T2 Extreme Cykles	Extreme Cycles	Extreme Cycles	Extreme Cycles (O)	Extreme Cycles		
	Funktion Cycles (O)					
Electric Influence						
T6 External Short Circuit	External Short Circuit	External Short Circuit (P)	External Short Circuit (P)	Wide Range Impedance Short Circuit	External Short Circuit	BS Behaviour after SC (P)
T7 Overcharge	Overcharge	Overcharge (P)	Overcharge (P)	Overcharge	Overcharge (C)	BS Behaviour after OC (P)
T8 Forced Discharge (C)	Forced Discharge	Forced Discharge (P)	Forced Discharge (P)		Forced Discharge (BS, C)	BS Behaviour afer OD (P)
		Isolation	Isolation			
Internal Short Circuit						
	Ni-Particle Test				Ni-Particle Test	
	Under discussion: partial special nail	Under discussion: propagation in a pack	Under discussion: propagation in a pack (BS)	Single Cell TR Initiation	Propagation (BS)	
Funktional Safety						
			(see ISO 26262)		Over V, I, T control (BS)	
				BMS Performance DC Level 3 Charging		
Fire resistance						
			Fuel Fire	Fuel Fire		
Water and Humidity						
		Immersion, Dewing		Vehicle Immersion		

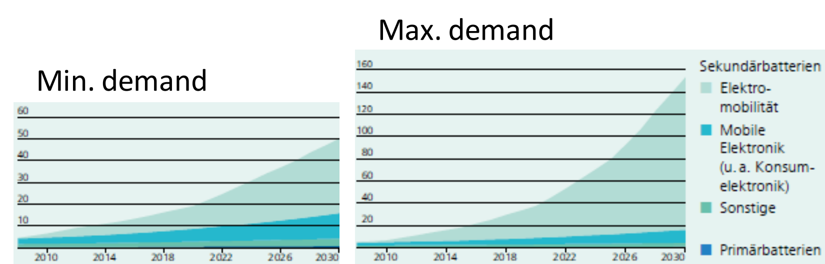
C=Cell, BS=Battery System, O=(normal) operation, A=Accident, SC=Short Circuit, OC=Overcharge, OD=Overdischarge, P=Protection Test, V=Voltage, I=Current, T=Temperature

Source: SGS

Potential Trends

Battery cells are the base for both storage applications

- Mass market for storage only possible by combining stationary and mobile applications
- The demand for cells for mobile applications will be higher long-term
- Batteries sytems for stationary and mobile storage solutions are based on cells
- The number of cell technology able to become a mass market solution is limited
- The same cells will be used in both applications
- The higher quality standard needed to achieve qualification for the tougher application will prevail
- i.e. all cells will have to be suitable for e-mobility application, even when used in stationary applications to allow greates flexibility and hence market share



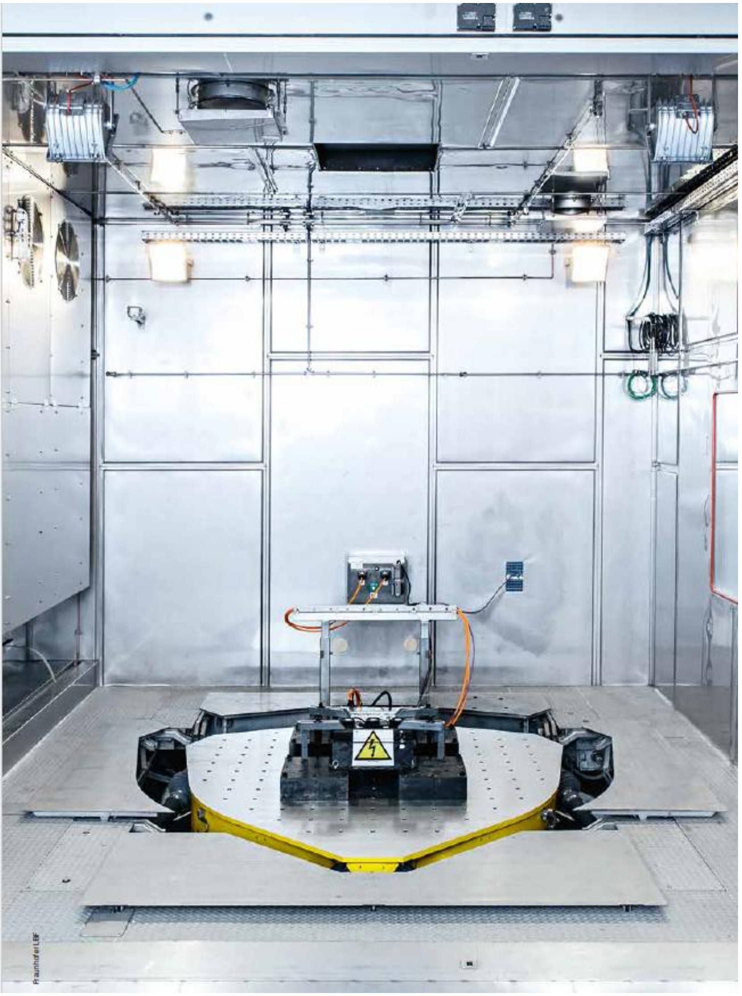
Source: Fraunhofer ISI – Product-Roadmap Lithium-Ionen-Batterien 2030

Example TÜV Rheinland Cologne
Testing of solar modules

- TUV Rheinland is a major player in PV product testing, with > 30 experience, testing PV products since 1982, today in 6 PV test centers across the globe

- Climate chambers from Weiss / Vötsch play a major role in durability testing of PV modules
- Temperature and climate tests are the main parameters to confirm long-term functionality and performance under operating conditions.

Example Fraunhofer LBF, Darmstadt, Germany
Testing of e-mobility energy storage solutions



- High-performance chamber with multi-axis vibration table
- Volume 56m³ / Load capacity 1t
- Temperature range -40°C to +80°C
- Temperature change rate: 4K/min
- MAVT table allowing movements about the three spatial axes (acceleration, movement and vibration)
- High-performance battery tester 8-800V, up to 600A, bi-directional
- Particularly for HV battery systems for electric vehicles
- Measuring mechanical, electrical and thermal factors determining reliability
- Safety devices installed
  - Possibility of complete nitrogen inertion
  - Pressure relief
  - Sensor controlled gas warning system
  - Water mist extinguisher system
- R&D test will allow cost savings in material development and production processes

Conclusion

- The markets for PV, stationary home storage systems and e-mobility storage are interlinked and drive each other
- Norms for the PV sector are mainly developed with upcoming issues being addressed (PID / LID)
- Norms for the stationary home storage sector are currently under development and will require meeting demands of all stakeholders
- Norms for e-mobility are embeddes in general automotive norms plus specifc regulations for battery safety, which are clearer defined as for stationary applications but are not completed yet due to the ongoing development
- Assuming that e-mobility will become the largest market for battery storage solutions, battery cells quality standards are likely to be set by the respective harsher requirements as the general standard for all cells independent of their final application
- Testing during R&D to define best materials / cost solutions as well as part of the QC procedure during production is mandatory to fullfill norms and safety requirements and install trust in the new technology
- Weiss Technik supports manufacturers, OEMs and industry institutes with state-of-the-art climate testing solutions including a broad range of safety devices covering all Eucar hazard levels

Thanks for your kind attention

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