



Overview of PV + BESS technology and use cases

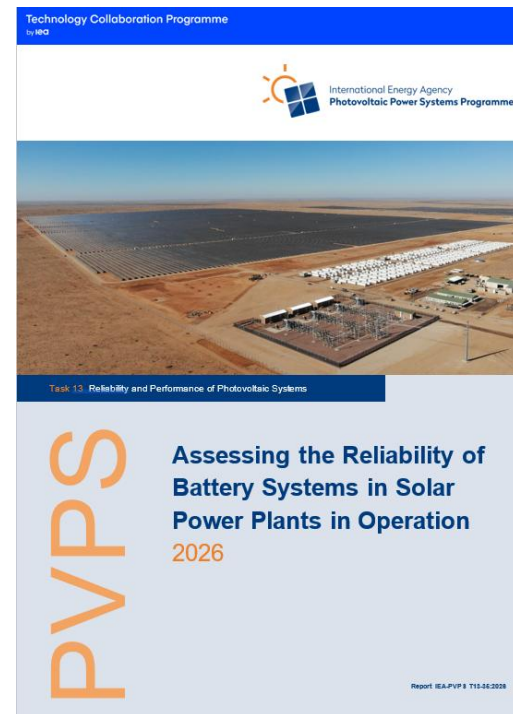
Erik Stensrud Marstein, Institute for Energy Technology (IFE)

EU PVSEC, Rotterdam, 17/9 2026

Rapid growth in PV is accelerating demand for BESS



- Global annual BESS additions surpassed **100 GW** in 2025, growing **~40%** from 2024.
- Most new capacity was **utility-scale BESS**.
- Industry moves towards increasingly long duration BESS
 - 1h and 2h BESS standard, 4h+ BESS increasingly common.
- PV + BESS no longer a niche configuration!
 - PV + BESS is now a mainstream power-plant architecture.



Lithium ion (Li-ion) the dominant technology



- Lithium Iron Phosphate (**LFP**) the by far largest in stationary BESS
 - Competitive cost, good cycle life and established manufacturing at scale.
 - Good fit with daily cycling, energy shifting and frequency services.
 - Lower energy density, not the major concern for stationary energy storage
- Many other technologies in the market, more being developed
 - Ensuring long-term efficient, reliable and cost effective BESS operation crucial!
- Learning from operational PV + BESS an important opportunity!



- We know **a lot** about battery cell behaviour!
- Performance and reliability depend on many factors
 - Chemistry (anode, cathode, electrolyte)
 - Cell design
 - Operating environment (Temperature, humidity)
 - **Duty cycle**
- Battery ageing modelled as sum of calendar and cyclic aging

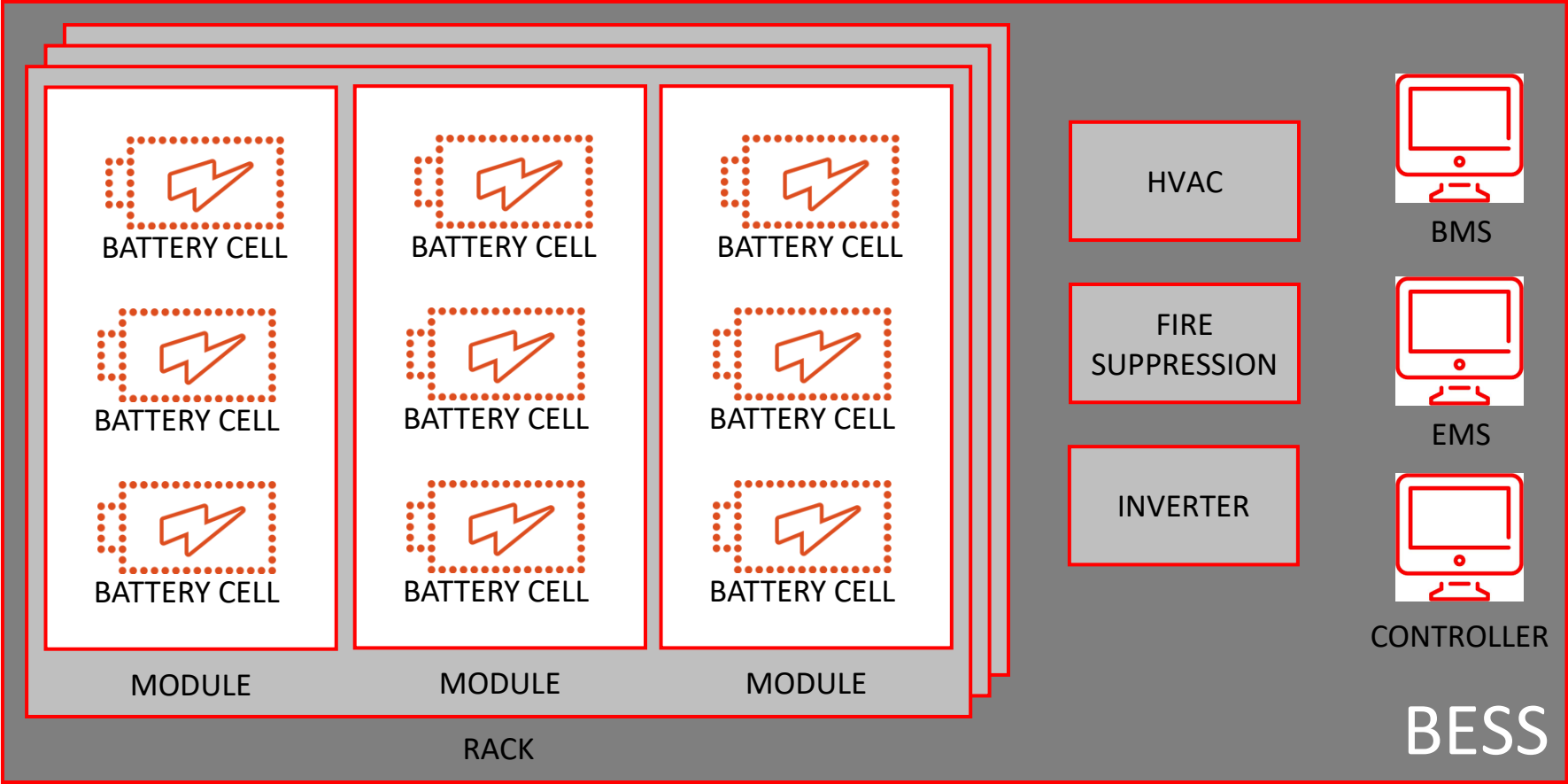


$$Q_{loss}^{total} = Q_{loss}^{cal}(t, SOC, T) + Q_{loss}^{cyc}(cycles, C - rate, T, SOC, DOD)$$

BESS



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Large variety in use cases and duty cycles



- Cyclic ageing depends on use case
- Value stacking adds complexity

$$Q_{loss}^{total} = Q_{loss}^{cal}(t, SOC, T) + Q_{loss}^{cyc}(cycles, C - rate, T, SOC, DOD)$$

Use cases for PV + battery systems			
Time shifting	Peak shaving and time shifting	Avoid/reduce clipping losses Avoid/reduce curtailment losses Increase utilization of infrastructure Reduce energy costs of operation	Daily/few deep cycles
	Self-consumption and self-sufficiency	Maximize share of self-consumed PV power	Daily/few deep cycles
Market operations	Spot market	Energy arbitrage	Frequent cycles of varying depth
	Capacity market	Profitability based on ability to supply firm power (W_p) in accordance with contract (PPA)	Daily/few deep cycles with frequent smaller corrections
	Day ahead and intra-day bidding	Reduction of production forecast uncertainty Reduction/avoidance of imbalance fee	Variable
Resilience	End user energy resilience	Energy resilience for end users Power back-up Black start capabilities	Few deep cycles
System services	Capacity firming and smoothing	Capacity firming Smoothing Ramp rate control	Frequent shallow cycles (firming, smoothing), few deeper cycles (ramp rate control)
	Ancillary services	Provision of frequency reserves Provision of voltage support	Frequent fast and potentially deep cycles
Off-grid	Off-grid PV and appliances	Off-grid PV systems PV appliances	Large variation

The challenge



- Cell design, system topology, inverter behaviour, BMS and EMS controls, temperature and duty cycle **jointly determine** efficiency, ageing, safety and availability.

How can we ensure performance and reliability?



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RESIDENTIAL	Product specifications & warranties	
MEDIUM SIZE		
UTILITY		
		PROJ. DEV. EPC OPERATIONAL PHASE

How can we ensure performance and reliability?



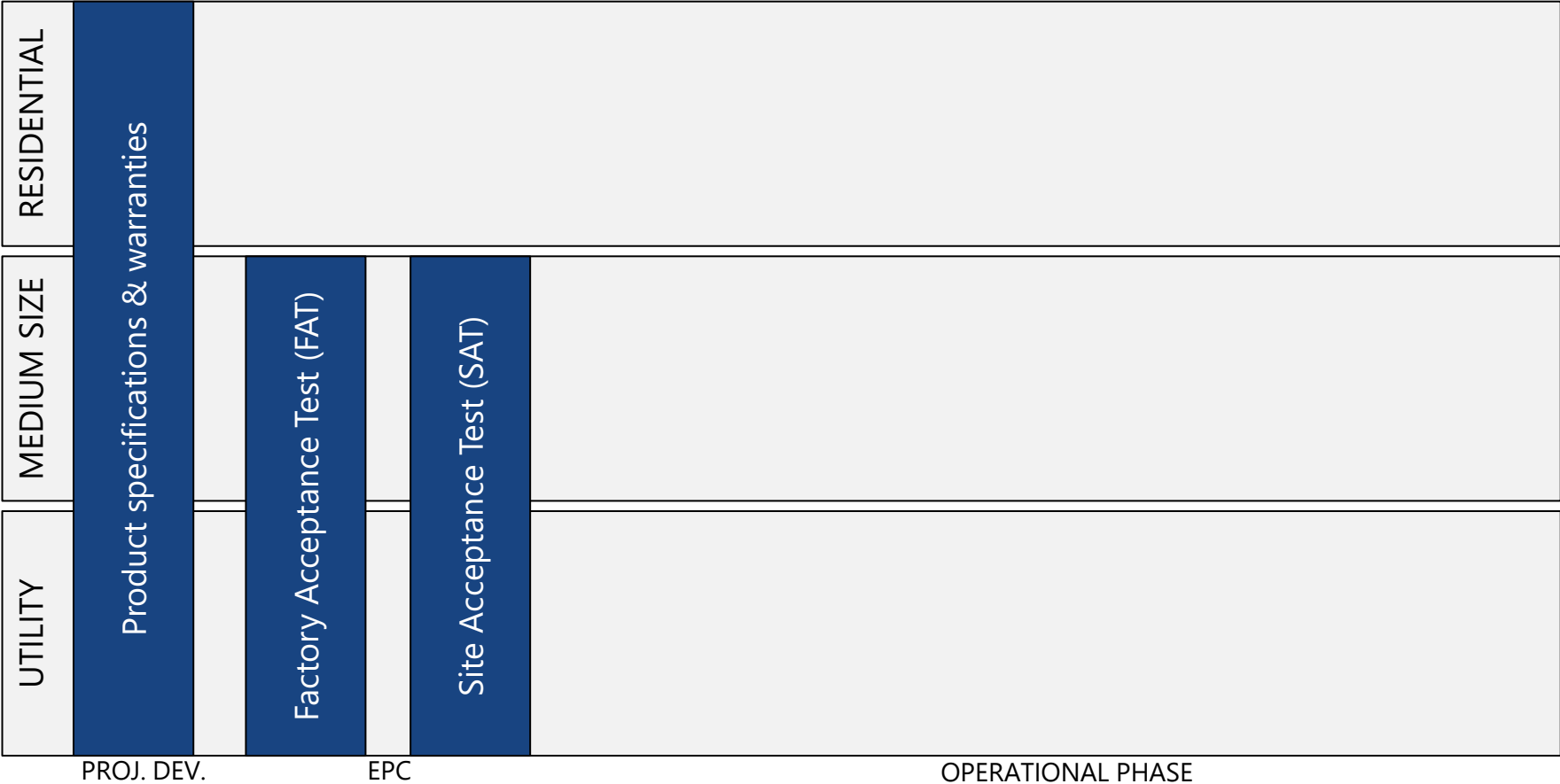
PVPS

UTILITY	Product specifications & warranties		Factory Acceptance Test (FAT)	OPERATIONAL PHASE	
MEDIUM SIZE					
RESIDENTIAL					
PROJ. DEV.		EPC			

How can we ensure performance and reliability?



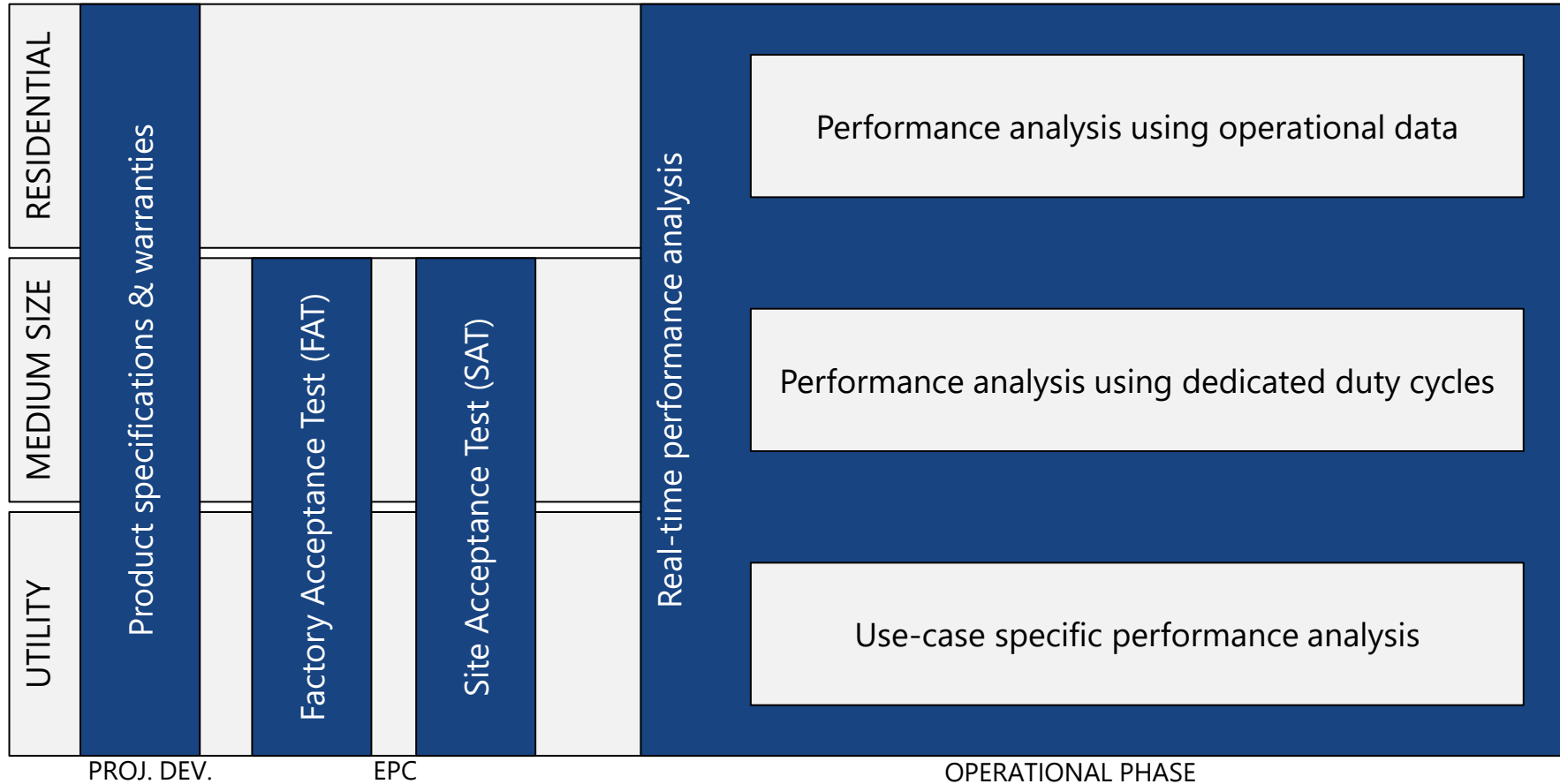
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How can we ensure performance and reliability?



PVPS



Future activities in Task 13



- We now have a framework for assessing performance and reliability of PV + BESS in operation
- Ahead, the focus will be on collecting and analysing data and experience from operational PV + BESS

Erik Stensrud Marstein, Task 13
eriksm@ife.no

