



Powering a clean future

## Maritime Batteries & Sumbat

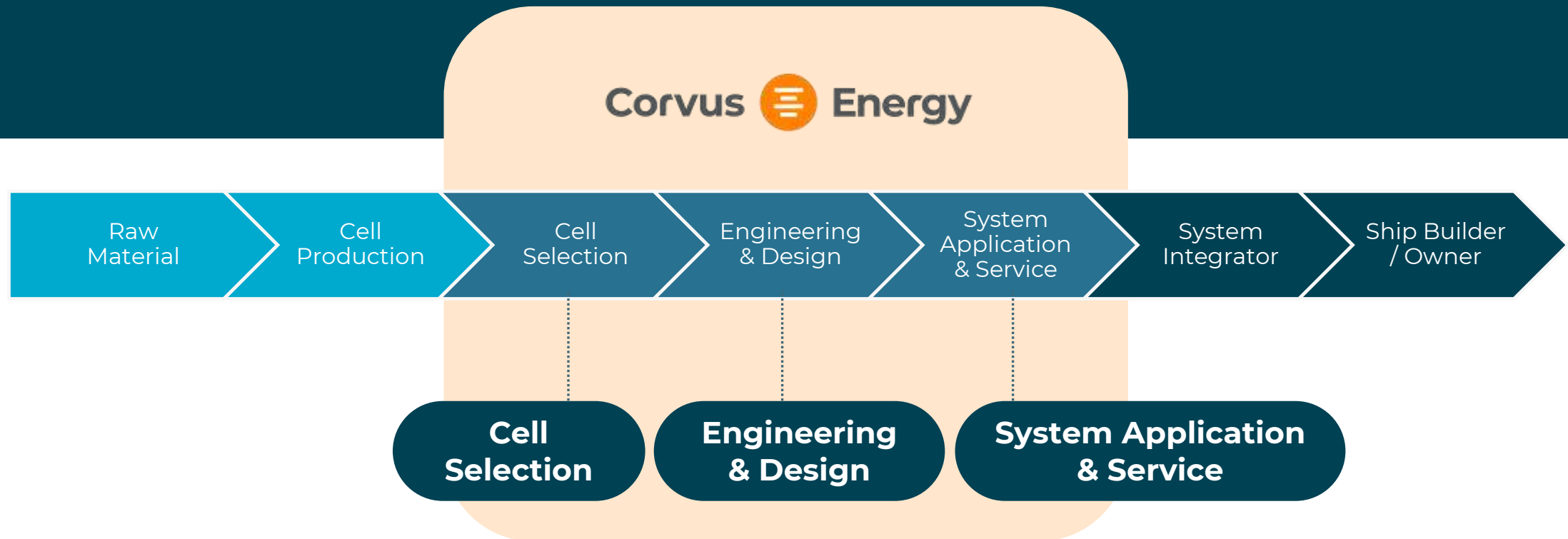
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# Our Role

How Corvus Energy is positioned in the value chain



## World largest battery electric vessel



Ro-Pax catamaran ferry  
Length: 130 m  
Passengers: 2100  
Vehicles: 225  
Hull: Aluminum  
Route: Argentina ⇌ Uruguay  
Vessel name: China Zorilla

- Corvus Dolphin Energy
- 42 MWh/~250 tons
  - ~2.3M 21700 cells
  - ~5200 battery modules
- Full battery system performance and life time model developed largely with the help of the Sumbat project

## SP 3 Digital Framework for Battery Degradation

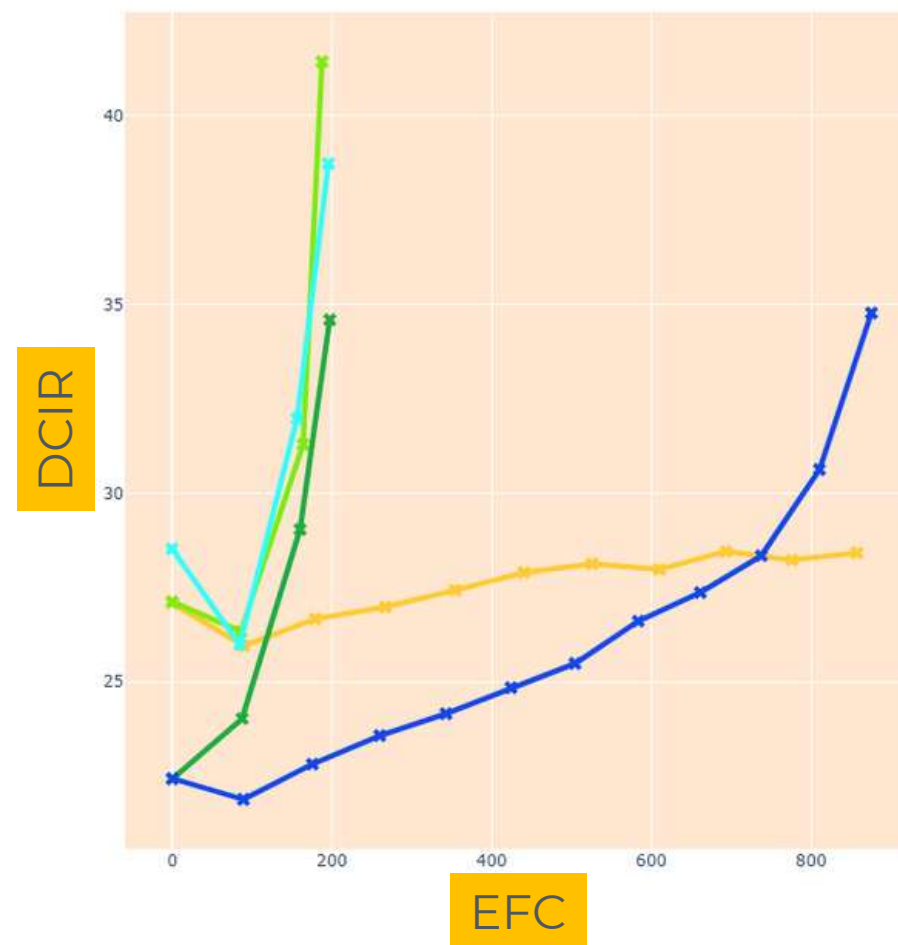
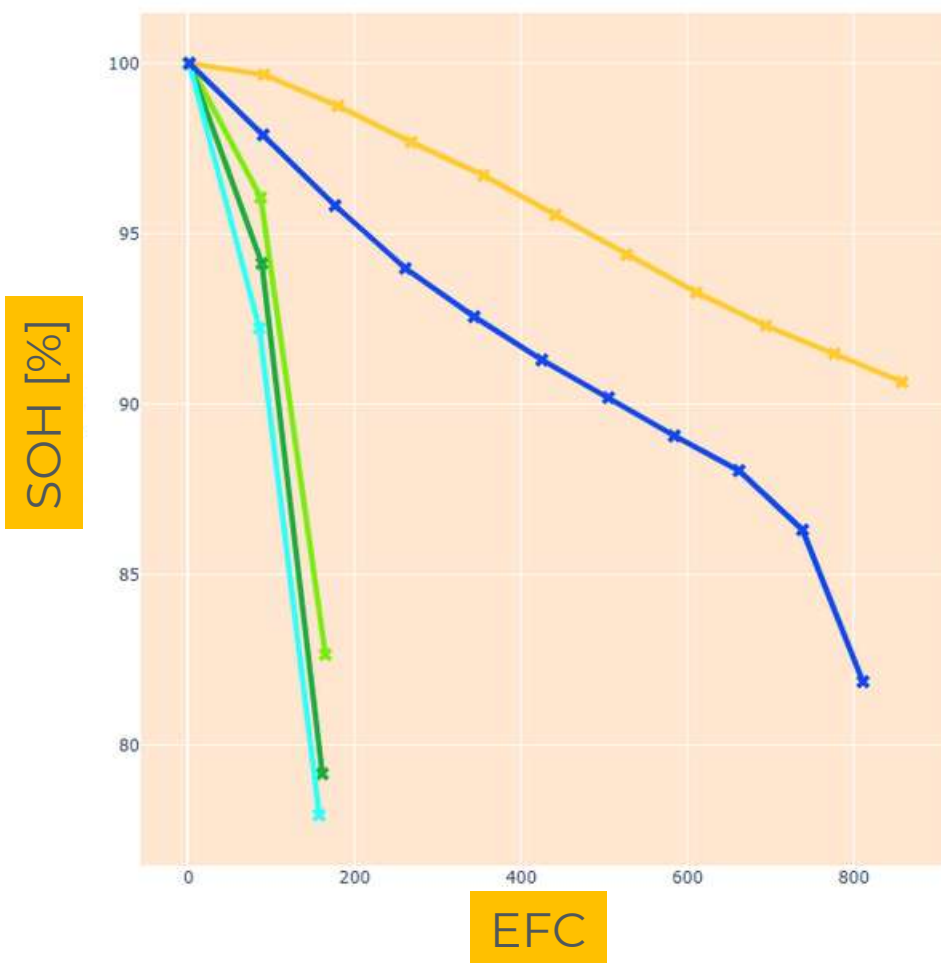
WP	What	Why?
3.1	Framework Development	Degradation models need a framework to ensure a systematic approach scalability and ability to keep the results up to date as new cell technologies become available
3.2	Non-invasive Model Parameterization	How far can we get without opening cells? Electrochemical information is often very abundant
3.3	Model Validation	No further explanation needed
3.4	Digital Design and Optimization Workflow	Throughout the life of a battery cell, every day (or even more often), cell properties changed permanently (usually for the worse)

For the world's largest battery powered vessel:

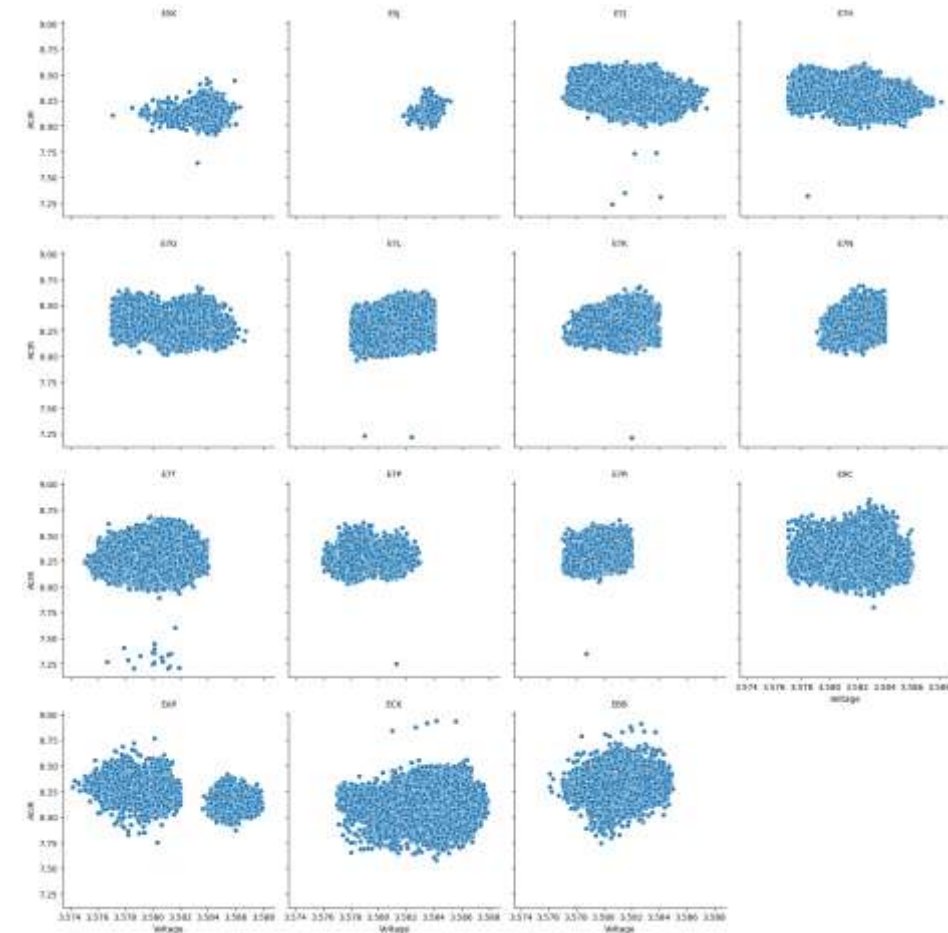
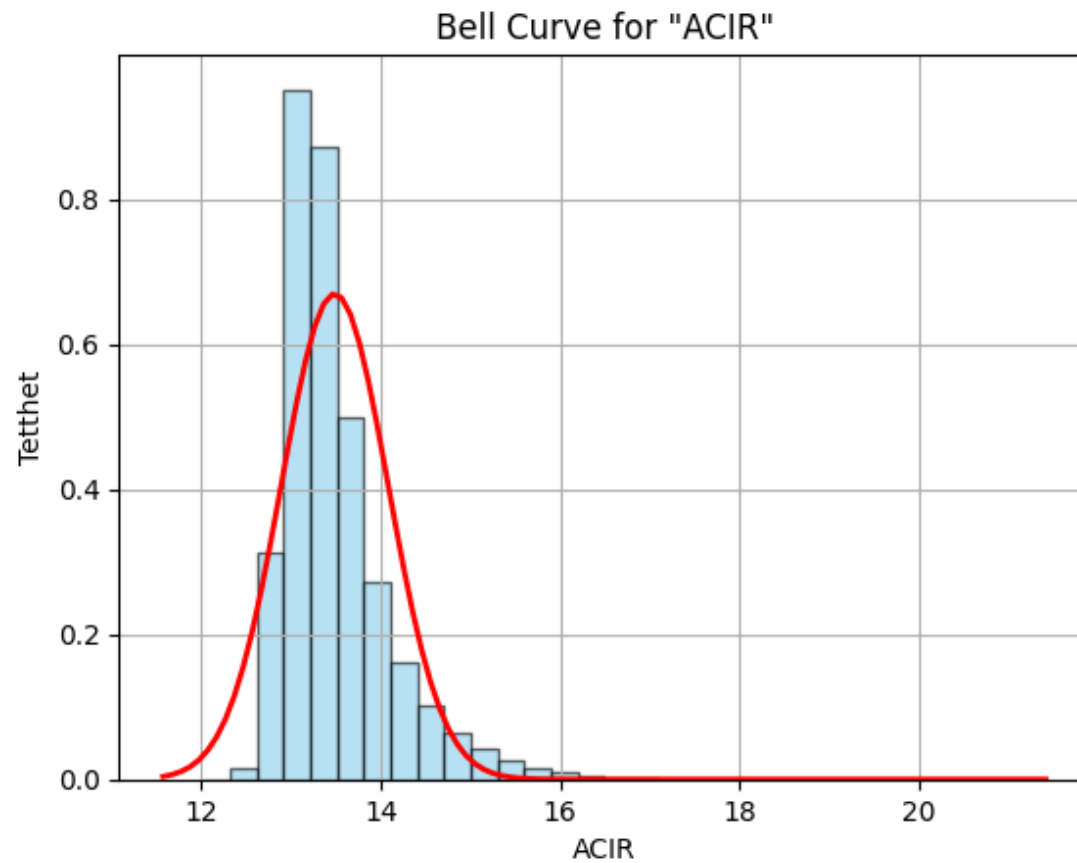
- Cell selection
- Cell degradation model vs operational profile and temperature

# Accelerated testing of “equal” cells (selected results only)

Different cell types, same or similar spec



# But not all cells are created equal ...



## SP 4 - Battery Safety and Lifetime Assessment

WP	What	Why
WP 4.1	Assessment of seawater current flow	Safety - only basic modeling carried out
WP 4.2	Conceptual solution design	Seawater – replaced with IP 67 goal for all components
WP 4.3	Quantification of effects from preventive solutions	Seawater – IP robustness
WP 4.4	End-of-life assessment of battery cells	Cell change tremendously over their life time. Capacity, impedance, safety....
WP 4.5	Development of digital twin	Whole system including cell degradation
WP 4.6	Battery module thermal modeling	No twin without the thermal properties
WP 4.7	Tuning of the digital twin model	The proof of the twin is in the field response

For the world's largest battery powered vessel:

- Every day optimized operation



# Vessel & system – digital twins throughout the battery life time

Maritime requirements for battery modeling exceeds most other industries; at Corvus we have with the help of Sumbat developed leading battery cell & system modeling frameworks supporting quality and robustness throughout the full life of the battery system

- Battery dimensioning
- Battery cell properties monitoring & data exchange with cell manufacturer
- Battery module manufacturing QC – DCIR
- System commissioning and field trials
- System SOH test routines
- System continuous diagnostics
- System prognostics



# Digital Twin

A digital model of a physical battery system

## Given the operational profile, the digital twin model can:

- Simulate the electrical and thermal performances
- Simulate the degradation over time
- Takes BMS (Battery Management System) limits into account

### Configuration

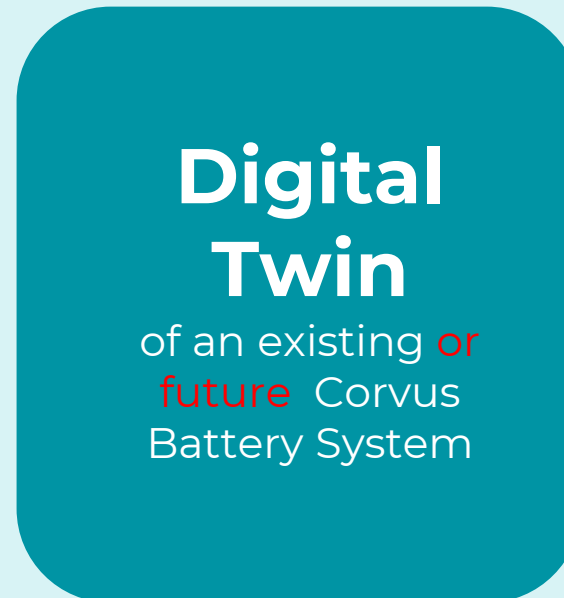
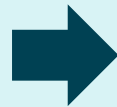
Product type, No. of modules and packs, SOC and SOH limits

### Operational Profile

Time vs. Power/Current

### Initialization

SOH, SOC, Temperature



### Performance

Electrochemical & Thermal Degradation

Repeat for different configurations

→ Trends & estimation of impact of future innovations

# Corvus Products

Multiple product families and safety approaches for a diverse maritime market

## Energy Storage Systems (ESS)

## Fuel Cell System (FCS)



**Corvus  
Orca**

High Performance  
Pouch Cells



**Corvus  
Blue Whale**

Large Systems  
Prismatic Cells



**Corvus  
Dolphin NxtGen**  
Energy

Light Weight  
Cylindrical Cells



**Corvus  
Dolphin NxtGen**  
Power



**Corvus Pelican**  
Hydrogen Fuelled

Long  
Range

Thank you



Thanks to RFF, NFR, IN & EU for assisting Corvus in developing world leading maritime zero and low emission technology and solutions already preventing more than 10 million tons of CO<sub>2</sub> emission as well as substantial amounts of NO<sub>x</sub>, PMs etc literally saving the planet and saving lives