STORED ELECTRICAL POWER AND POTENTIAL TO CHANGE SUBSEA SYSTEM POWER DISTRIBUTION

Presentation of Subsea Engineering Project Findings

Image: SWE SeaSafe

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Safety Moment

- Explosion in Battery Room

Figure 1 – First entry into the battery room post incident.

Figure 2 – Battery cabinet with doors removed. Damage within left cabinet.

Source: NOPSEMA

- Key Learnings

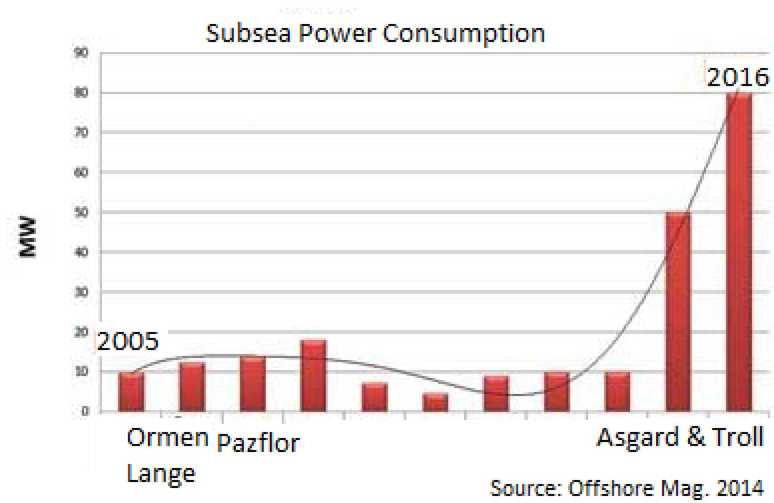
1. Hydrogen gas
2. Dedicated Battery Room
3. Modules should be fixed

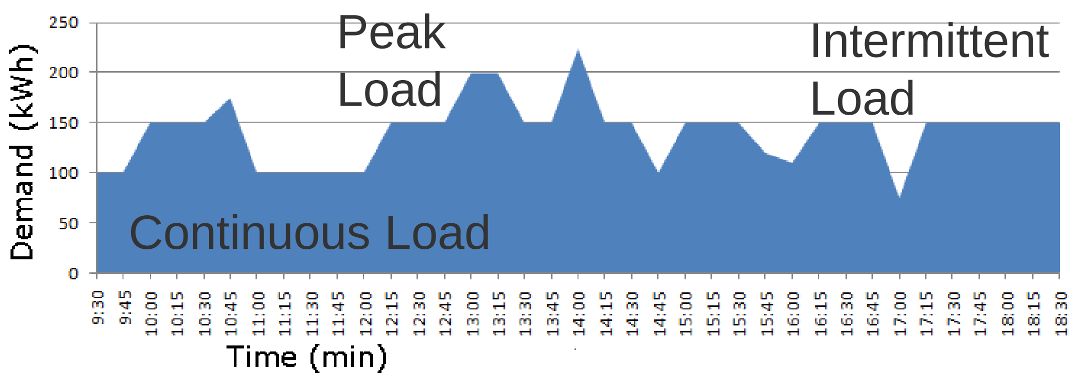
Agenda

- Overview
  1. Problem definition
  2. Purpose and objective
  3. Background
- Scope
  1. Method
  2. Assumptions, Constraints and Exclusion
- Main Findings
  1. Battery Technology for Subsea Use
  2. Case Study

Problem Definition & Objective

- High Power Requirements
- Step-out Distances
- Cables
- CAPEX
- Complex

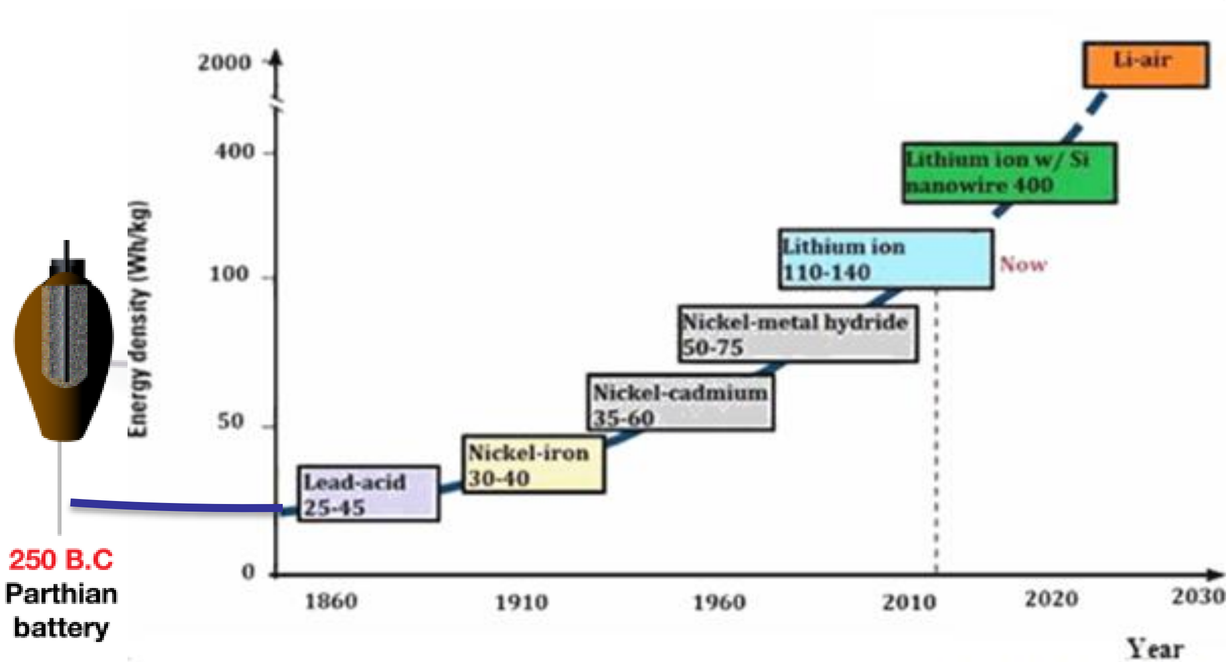




Source OG21 Report: Subsea Cost Reduction

Background

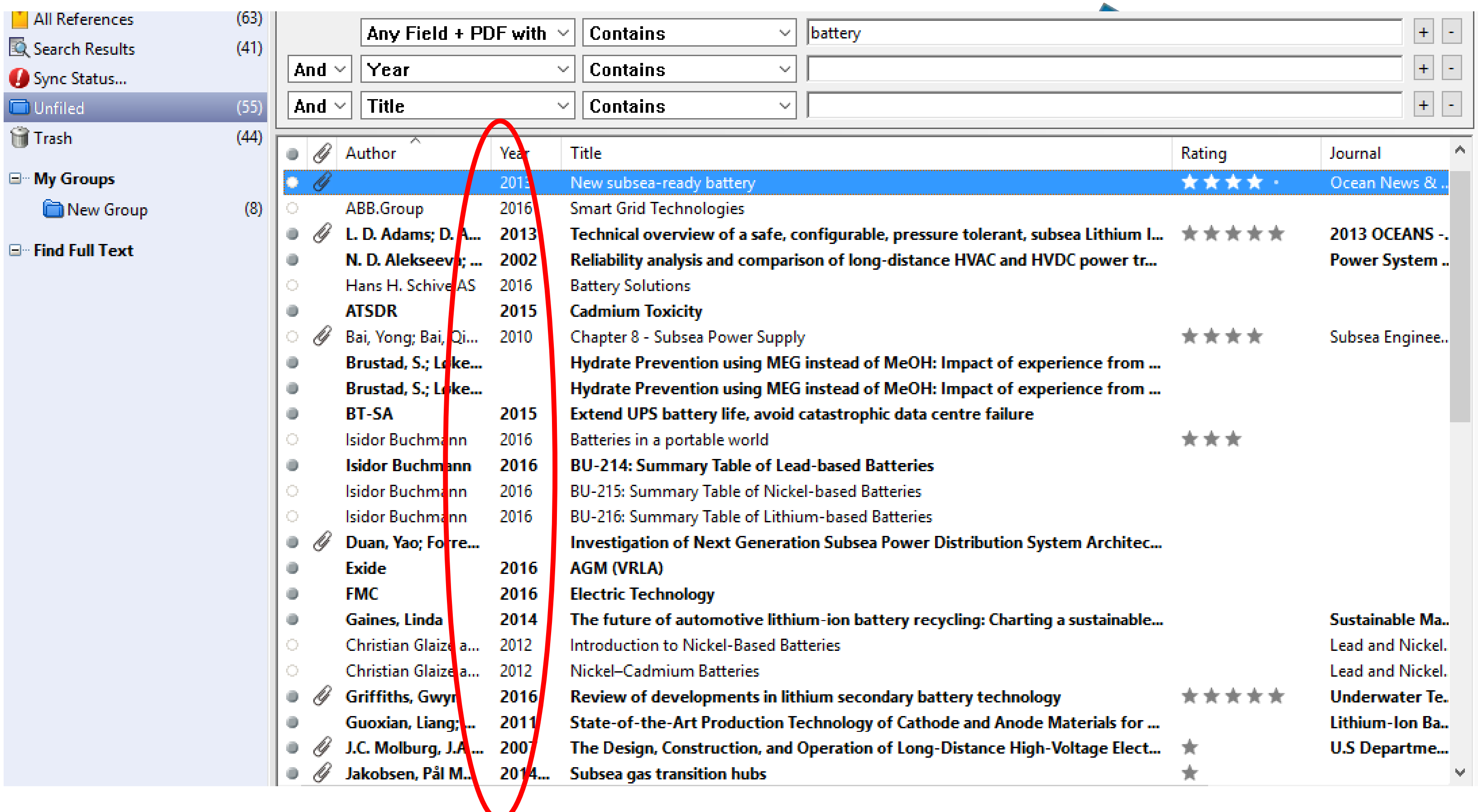
- Battery Technology
- Opportunity
- Current usage in Subsea



Source: ecotubetech.com

Part One: Selecting a Battery Technology

Society for Underwater Technology



Curtin University

Selecting a Battery Chemistry

- Feasibility Table

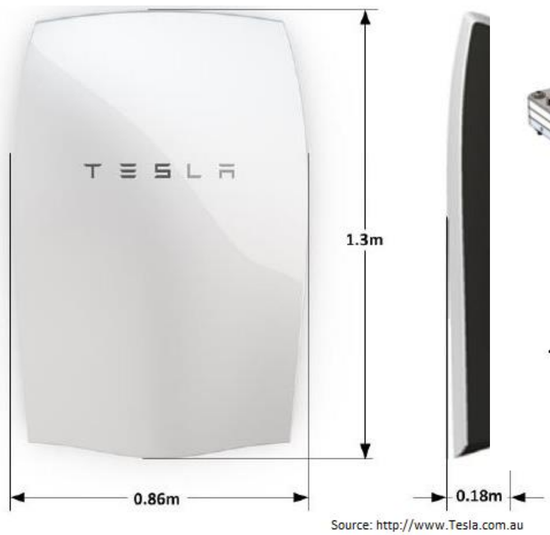
Criteria	Lithium-ion	Lead-acid	Nickel-based
Thermal Stability	Requires protection circuit	Thermally stable	Fuse protection required
Potential toxicity	Low	Very High	Very high
Spark Hazards	Due to high energy density	Low	Low
Maintenance	Potentially maintenance free	3-6 months	full discharge required every 3 months
Cycle life (80% DoD)	500 up to 2000	200-300	Up to 1000, but regular maintenance required
Environmental Impact	Moderate	High	High
Cost	High	Low	Moderate
Maturity for subsea applications	Moderate	Low	Low
Energy Density (Wh/kg)	90-250	30-50	45-120

Methodology for all Use Cases

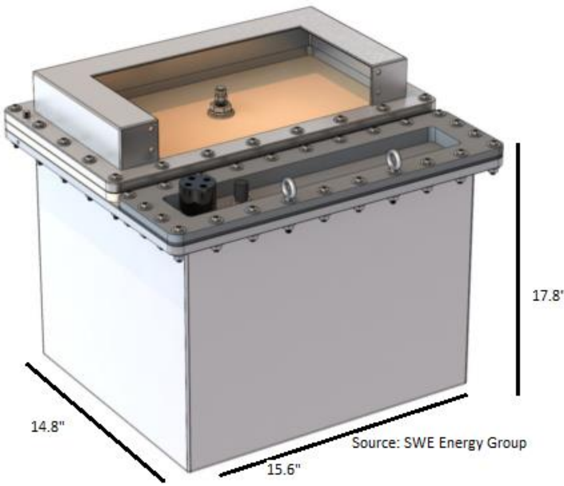
- Cost and Dimensions of Battery Module
  - Baseline Parameters for Subsea Battery
  - Compare cost of Battery Power v/s Cable Costs
  - Extrapolate data for larger distances

Attribute	Value	Unit
Cost per kWh	$ 3,600	$/kWh
Capacity of each subsea ready module	3.25	kWh
Maximum weight deployable	40000	Kg
Capacity of 40 tonne battery system	4330	kWh
Cost of 40 tonne battery system	$ 15,560,000	

Tesla PowerWall

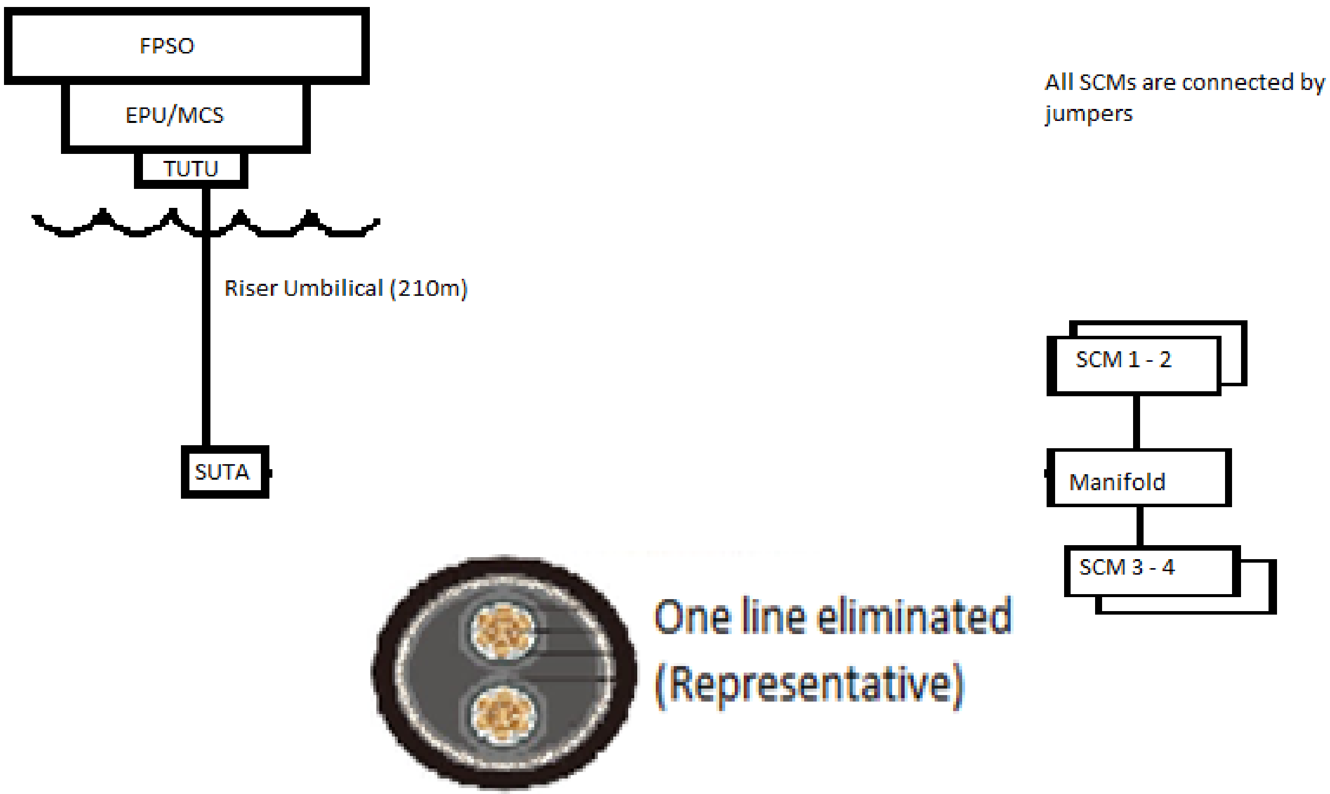


SWE SeaSafe Module

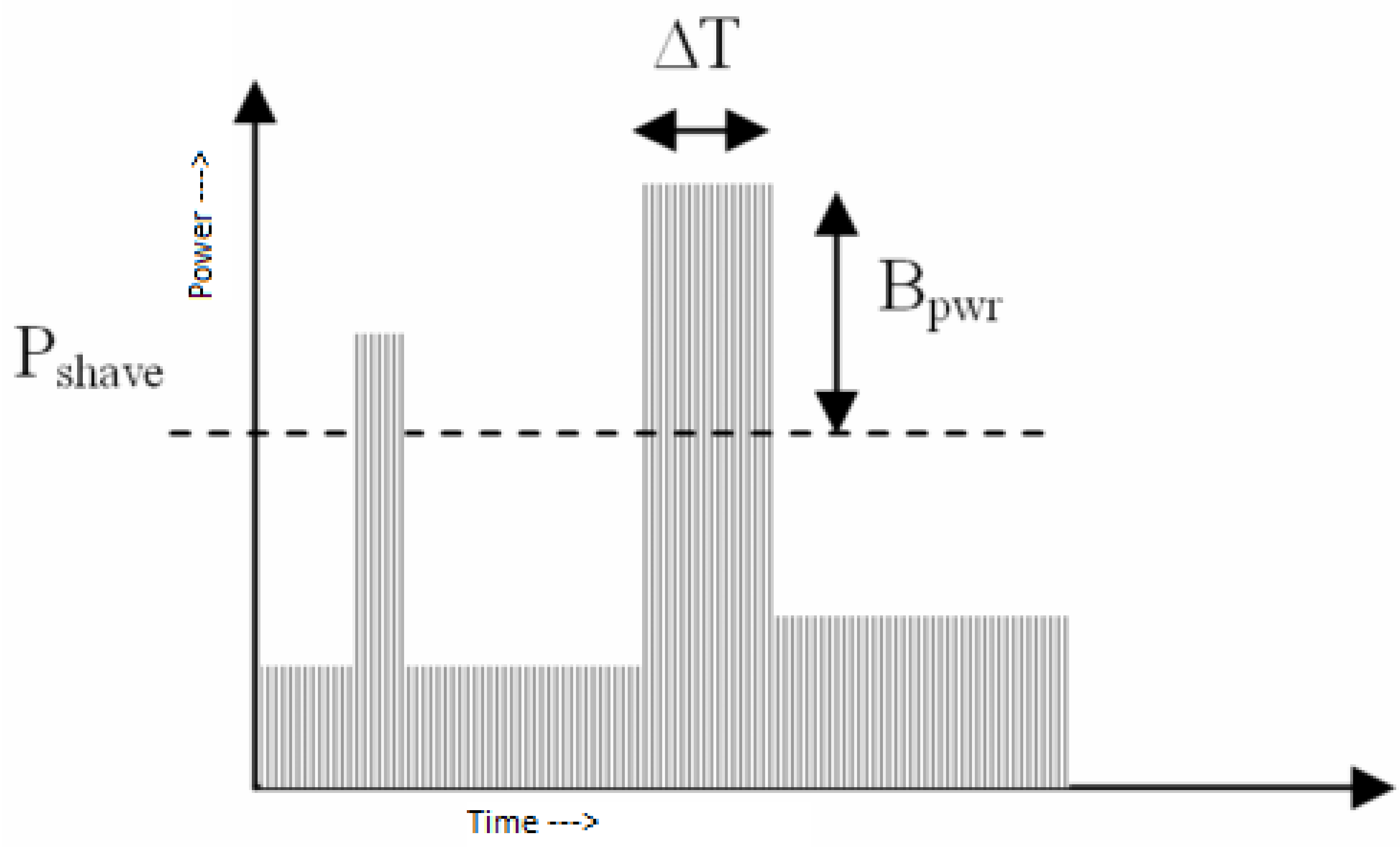


Part Two: Use Cases

- Use Case 2: Eliminate a single redundant line



Use Case 3:Peak Load Shaving



Use Case 1 (No cables)

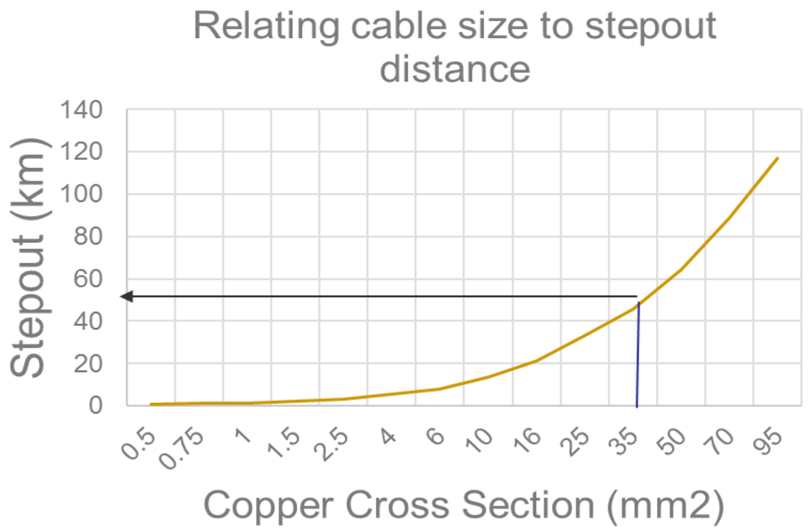
- Feasibility Check
  - Practical feasibility

Attribute	Value	Unit
Changeover/recharge required every	2.5	years
Capacity of 40 tonne battery system	4330	kWh
Weight of battery system	40	Te
Practical feasibility	Feasible	

- Economic feasibility

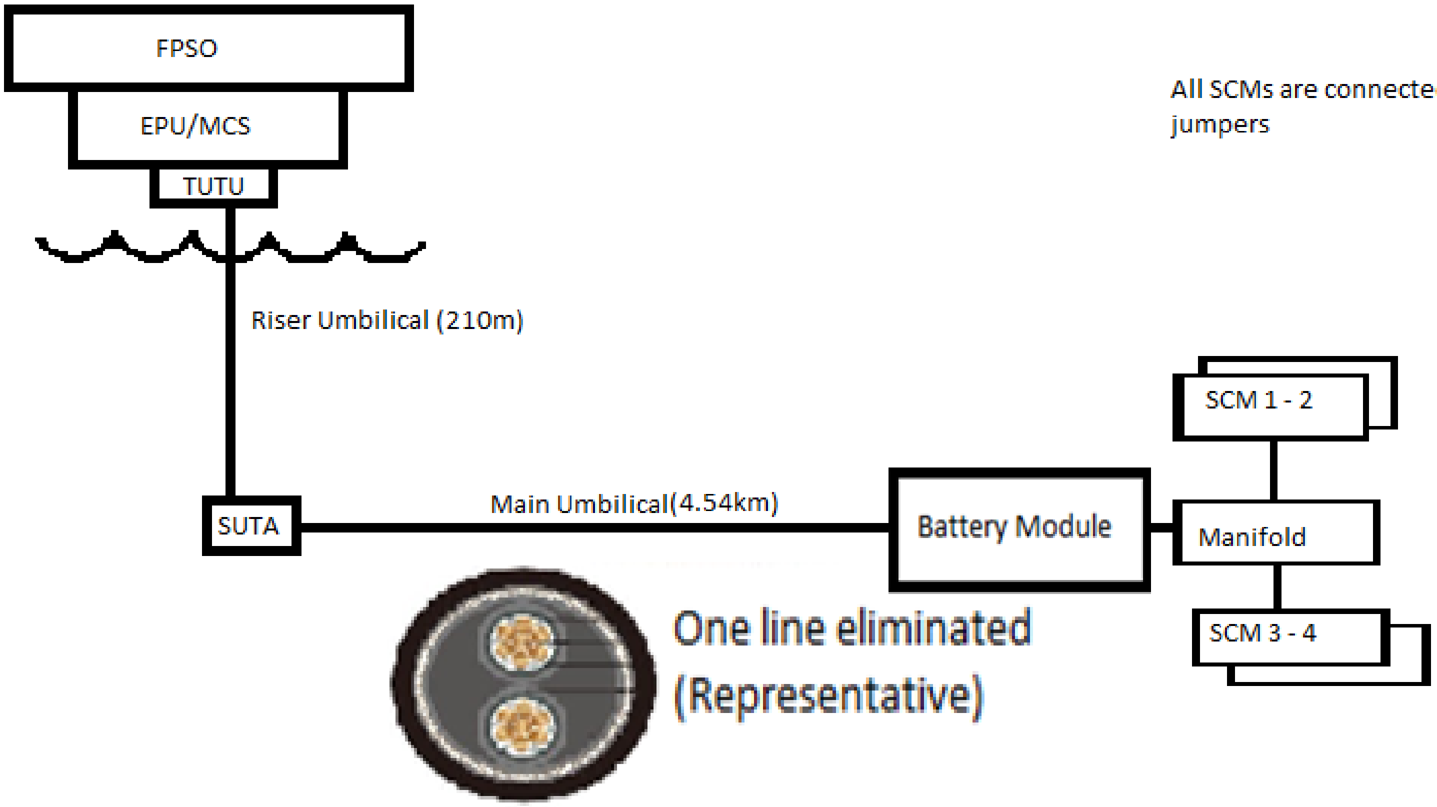
Attribute	Value
Cost of each 40 Te Battery System	$ 15,560,000
Cable Cost	$6,925,000
Economic feasibility	Infeasible

Extrapolating for larger distance



Attribute	Value
Total Cable Cost at 45.5 km	$73,312,000
Cheapest Battery Solution	$223,000,000
Economic feasibility	Infeasible

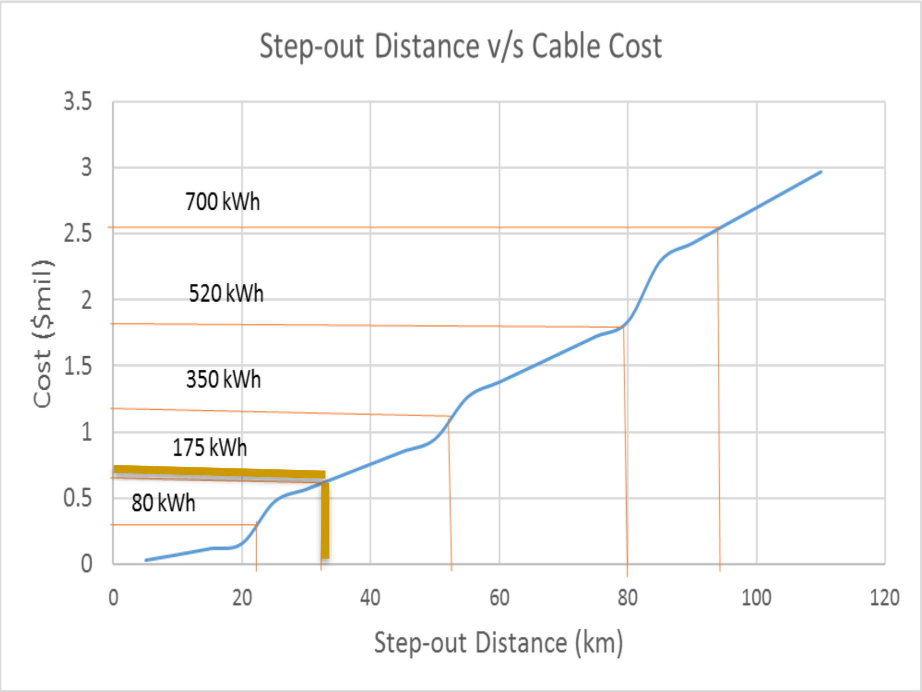
Use Case 2: Eliminating a single line



All SCMs are connected by jumpers

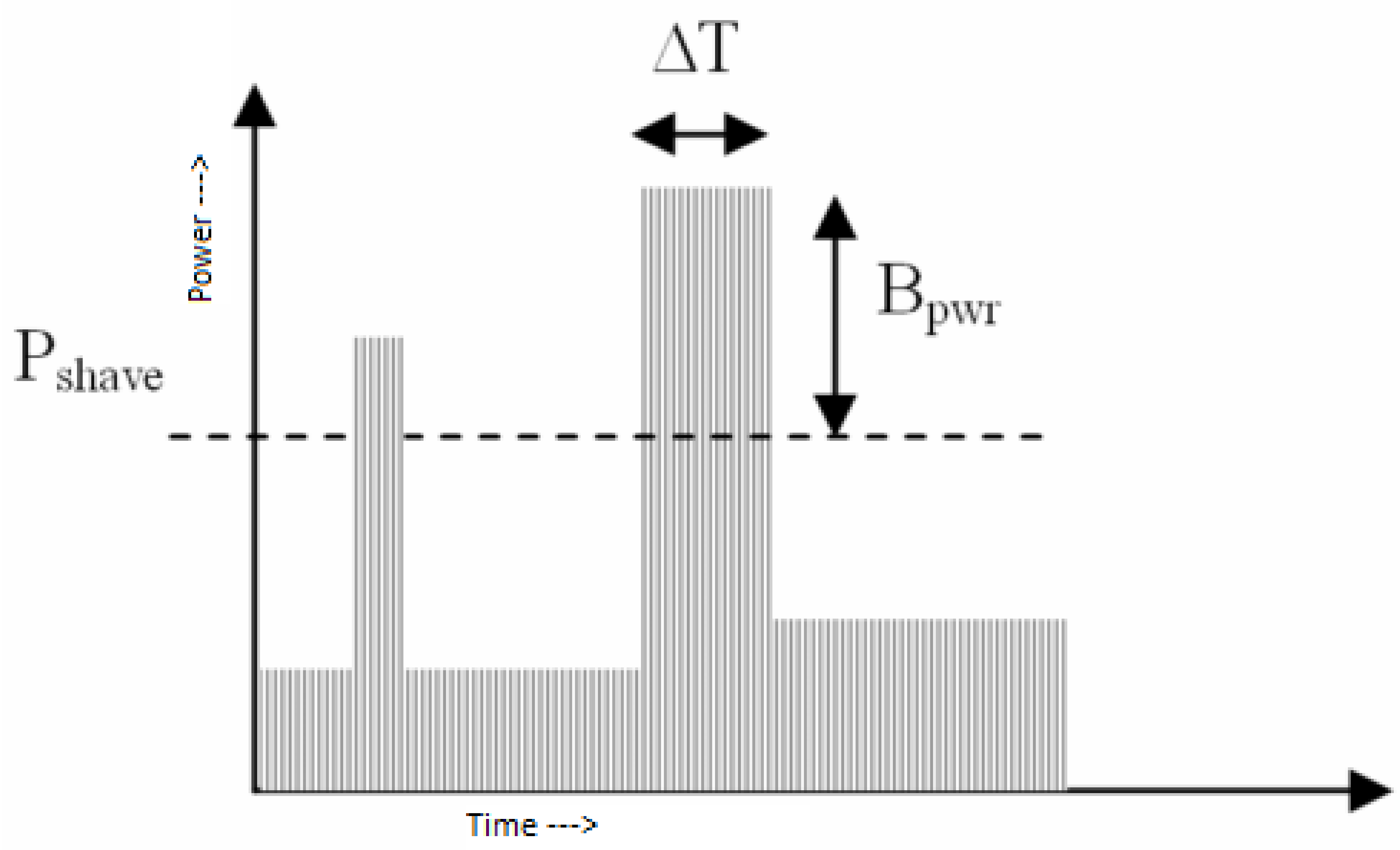
Use Case 2: Eliminating a single line

- Extrapolating for Larger Distances



Backup Duration (Months)	Battery Capacity (kWh)	Battery weight (tonne)	Volume of Module (m3)	Cost module (Mil)
1	175	1.6	3.5	~$0.8

Use Case 3:Peak Load Shaving



Use Case 3:Peak Load Shaving

- Feasibility

Attribute	Value	Unit
Battery Capacity Including 8%/year Degradation	192	kWh
Battery weight	1.77	Tonne
Volume of Module	3.84	m3

OceanWorks International

UPS - 3000SC

Specifications

- 6m x 2.4m x 1.4m half height ISO container
- 13600kg in air weight
- 100% titanium pressure vessel with dual o-ring seals
- Vibration qualified to IEC60068-2-64, Category 2
- 20+ year design life on 5 year maintenance service
- Class ISO8 Clean-room assembly (pressure vessels)
- 50,000 Hrs MTBF (MIL-HDBK-217) at 25°C
- 24Hours minimum charge time, actual charge time depends on available power
- Three 50kWh independent battery stings, fully redundant, providing 150kWh start of life capacity

Source: OceanWorks International

Summary and Conclusion

- Recommended Battery Chemistry for Subsea Use

Li-ion: $LiNiMnCoO_2$ (NMC)

- Battery replacing cables?

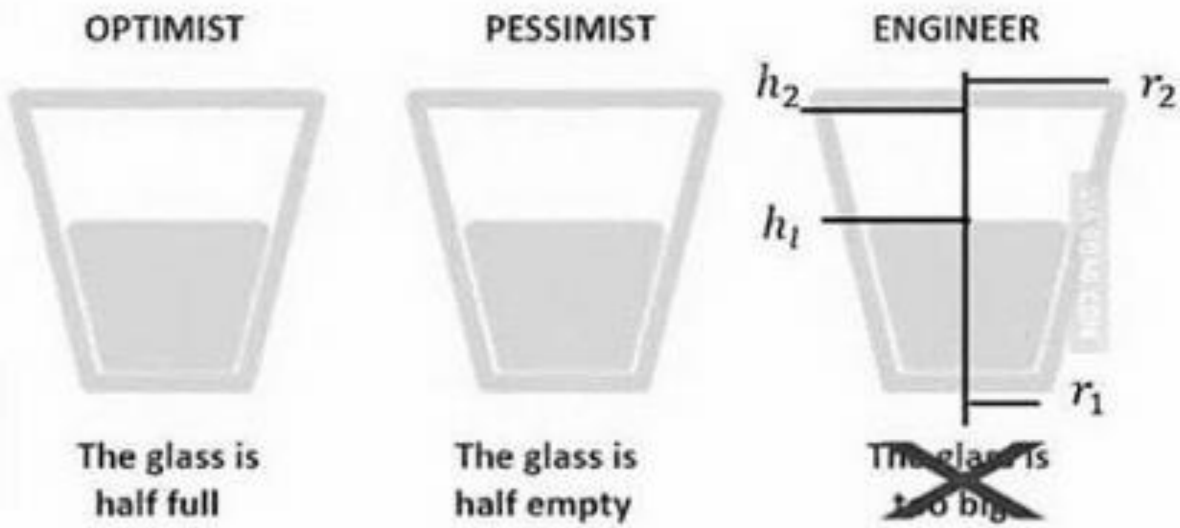
Not anytime in future

- Battery Technology for Satellite Well Development

In-depth analysis recommended

- Peak Load Shaving Using Batteries

Feasible using current technology



$$\%V_l = \frac{100[\int_0^{h_2}(\frac{h_2}{r_2 - r_1})^2 \pi \ dh - \int_0^{h_l}(\frac{h_2}{r_2 - r_1})^2 \pi \ dh]}{\int_0^{h_2}(\frac{h_2}{r_2 - r_1})^2 \pi \ dh}$$

The End

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