



T6.2.3 Hybrid ship control system

Session 04: Operational Scenarios and Safety Planning

09/07/2025

5/10/2025

FLEXSHIP



Table of contents

1. Training 1: Hands-on exercises on operational decision making and safety protocols
2. Training 2: Machines and power electronics maintenance procedures
3. Training 3: Group discussion on maintenance best practices



Table of contents

1. **Training 1: Hands-on exercises on operational decision making and safety protocols**
2. Training 2: Machines and power electronics maintenance procedures
3. Training 3: Group discussion on maintenance best practices

- **Critical Nature of Shipboard Decisions:**

Life at sea often demands split-second decisions. Whether it's responding to a sudden mechanical fault, rerouting in bad weather, or managing an emergency like a fire or power failure, the quality of these decisions can directly impact vessel safety, crew welfare, and mission success. Poor decisions—or delayed ones—can escalate quickly in an isolated maritime environment.

- **Safety, Performance, and Compliance Implications:**

Good decision-making is not just about efficiency—it's about staying compliant with international safety and environmental regulations (e.g., SOLAS, MARPOL, ISM Code). It ensures smooth operations, reduces downtime, prevents costly incidents, and maintains the vessel's reputation. Moreover, aligning decisions with SOPs helps the crew operate as a coordinated unit under stress.

- **Overview of Training Objectives:**

In this session, we will:

- Examine the core principles behind safe and effective decision-making.
- Simulate real-world emergency and operational scenarios.
- Reinforce the role of structured communication, checklists, and post-event reflection.
- Build habits that improve both individual and team performance.

- This slide outlines the core challenges that maritime crews face when making decisions under pressure.
- **Time constraints and high-stress conditions** refer to situations like engine failures, fire alarms, or sudden weather changes where decisions must be made within seconds.
- **Incomplete information** emphasizes that in emergencies, not all system data or environmental inputs may be available, forcing crew members to act on partial knowledge.
- **Dynamic and hazardous environments** include rough seas, low visibility, or mechanical malfunctions, all of which add unpredictability to operational choices. Understanding these factors is essential for preparing crews through simulation-based training and procedural discipline.

Decision-Making Under Pressure: Challenges at Sea

- Time constraints and high-stress conditions
- Incomplete information
- Dynamic and hazardous environments



Key Principles of Safe Decision-Making

FLEXSHIP

- illustrates the foundational elements of effective and safe decision-making in maritime operations:
- **Situational Awareness:** Crew members must continuously monitor their surroundings and equipment to detect anomalies or hazards. It's about understanding what is happening, why it's happening, and what may happen next.
- **Team Communication and Confirmation:** Clear, concise communication among team members ensures that everyone understands roles and intentions. Confirmation protocols, such as repeating back orders, reduce miscommunication during emergencies.
- **Use of Checklists and Predefined Procedures:** Standardized checklists support consistency and help prevent oversight, especially in stressful or time-sensitive conditions. Predefined SOPs guide crews through critical decisions logically and sequentially.
- **Risk Assessment Under Uncertainty:** Crews must often act with limited data. The ability to weigh potential outcomes quickly and choose the option with the least risk is vital to preserving safety and operational continuity.

Key Principles of Safe Decision-Making



Situational
Awareness



Team
Communication
and
Confirmation



Use of
Checklists
and Predefined
Procedures



Risk
Assessment
under
Uncertainty

Case Simulation: Engine Fire Scenario

- This slide presents a realistic fire emergency simulation that takes place in the ship's engine room. It visually represents the structured decision-making process the crew must follow under time constraints:
- **Step 1: Alert Crew** – Immediate communication is vital. Alarms must be acknowledged, and all personnel informed using the designated emergency protocols.
- **Step 2: Isolate the Source** – Shut down affected systems (e.g., fuel pumps, ventilation) to contain the fire and prevent it from spreading.
- **Step 3: Activate Suppression** – Engage fixed fire suppression systems (e.g., CO₂, water mist) or deploy portable extinguishers based on severity and accessibility.
- **Step 4: Report Status** – The bridge and emergency coordinator must be kept updated with real-time reports. This ensures proper coordination and potential escalation to abandon ship if containment fails.
- The graphic emphasizes the **time-sensitive nature** of each step, requiring calm, coordinated action under pressure. This exercise helps crew members build familiarity with high-risk response protocols, improving both speed and effectiveness in real emergencies.

CASE SIMULATION: ENGINE FIRE SCENARIO



Situation: Fire alarm triggered in engine room

Decision flow:
→ Alert crew →
Isolate source →
Activate suppression →
Report status

Time-limited response

- illustrates the critical steps involved in conducting an **abandon ship drill**, a vital safety procedure on board any vessel:
- **Evacuation Coordination:** Quick, orderly evacuation depends on clear leadership and predefined paths. Crew must guide passengers and fellow seafarers calmly toward safety zones.
- **Muster Points and Headcounts:** Everyone on board must gather at assigned muster stations. Accurate headcounts ensure no one is left behind during emergencies.
- **Lifeboat and Life Jacket Checks:** Before launching lifeboats, crew members verify that all life-saving equipment is present, functional, and correctly worn. Familiarity with launching procedures reduces panic and delay.
- **Leadership Roles and Communication:** Clear command structure ensures each task—communication, crowd control, equipment deployment—is handled by trained personnel. The chain of command reduces confusion and improves overall safety outcomes.

Safety Protocol Drill: Abandon Ship Procedure

- Evacuation coordination
- Muster points and headcounts
- Lifeboat and life jacket checks
- Leadership roles and communication

- visually presents the most frequent decision-making mistakes that can occur during shipboard operations and how to proactively avoid them:
- **Overconfidence:** Crewmembers might underestimate risks due to familiarity or past success. Regular training and encouraging second opinions help counter this bias.
- **Delayed Decisions:** Hesitation during critical situations—like a fire or power loss—can lead to cascading failures. Using predefined action plans and drills builds confidence to act quickly.
- **Poor Crew Coordination:** When communication breaks down, tasks are duplicated or missed. Clear delegation, communication protocols, and cross-verification (read-backs) are essential.
- **Ignoring Alerts or Procedures:** Fatigue or distraction can lead to overlooked alarms or skipped checklists. Reinforcing standard operating procedures and promoting a no-blame culture for raising alerts helps ensure safety is prioritized.

Common Decision Errors and How to Avoid Them



Overconfidence



Delayed
Decisions



Poor Crew
Coordination



Ignoring Alerts
or Procedures

Team-Based Exercise: Power Failure During Transit

- This slide represents a simulated team-based exercise designed to prepare the crew for a sudden power failure during a voyage. The scenario challenges team coordination, real-time decision-making, and effective communication in a high-stress environment.
- **Simulated Blackout:** The vessel loses all electrical power while in transit. Navigation, lighting, and propulsion systems are impacted. The crew must quickly assess the scope of the failure.
- **Decision-Making Focus:** Teams must decide how to prioritize power restoration. This includes:
 - **Load Shedding:** Disconnecting non-essential systems to conserve backup energy.
 - **Navigation Rerouting:** Assessing safe stopping points or diverting to a nearby port.
 - **Crew Mobilization:** Assigning personnel to engine room diagnostics, bridge communication, and passenger support if applicable.
- **Team Debrief:** After the simulation, crew teams regroup to review their decisions, response time, and communication flow. This debrief strengthens shared situational awareness and prepares the team for real-life emergencies.



Summary and Course Learned

FLEXSHIP

- This slide reinforces the core takeaways from the training session on operational decision-making and safety protocols:
- **Value of Proactive Drills:** Regular simulations and scenario-based exercises help the crew develop automatic, confident responses to critical situations. Proactive training ensures that teams are prepared before an emergency occurs.
- **Decision Discipline in High-Risk Situations:** Structured decision-making processes, such as following checklists and communication hierarchies, reduce errors during high-stress moments. Discipline in executing protocols is key to minimizing risk.
- **Continuous Training and Feedback Culture:** The most resilient crews are those that learn continuously. Feedback sessions after drills, incident reviews, and lessons learned meetings help the team refine their responses. This culture of reflection and improvement leads to long-term operational excellence.

The visual complements these points with icons and illustrations representing teamwork, situational awareness, and proactive safety culture—reinforcing the message that preparedness and discipline save lives at sea.

Summary and Lessons Learned



Value of proactive drills



Decision discipline in high-risk situations



Continuous training and feedback culture



Table of contents

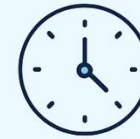
1. Training 1: Hands-on exercises on operational decision making and safety protocols
2. Training 2: Machines and power electronics maintenance procedures
3. Training 3: Group discussion on maintenance best practices

This slide introduces key performance indicators (KPIs) for evaluating maintenance efficiency onboard:

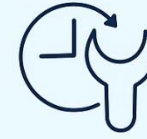
- MTBF (Mean Time Between Failures)
- MTTR (Mean Time to Repair)
- Ratio of Planned vs. Unplanned Maintenance
- Maintenance Cost per Operating Hour
- Predictive Maintenance Accuracy

These metrics help track reliability, costs, and strategic outcomes of maintenance programs.

Measuring Maintenance Effectiveness



MTBF
Mean Time
Between
Failures



MTTR
Mean Time
to Repair



Ratio of Planned
vs. Unplanned
Maintenance



Maintenance
Cost per
Operating Hour



Predictive
Maintenance
Accuracy

Measuring Maintenance Effectiveness

Case Study: Battery Overheating Event

A real-world incident involving battery overheating is analyzed:

- Detection: Identified early through IR imaging
- Response: Load redistribution, module isolation, fan speed adjustments
- Outcome: No escalation, prevention of thermal runaway
- Lessons Learned: Importance of thermal imaging, trend analysis, and crew alertness

Case Study: Battery Overheating Event



Detection

- Identified early through IR imaging



Response

- Load redistribution, module isolation, fan speed adjustments



Outcome

- No escalation, prevention of thermal runaway



Lessons Learned

- Importance of thermal imaging, trend analysis and crew alertness

Key technologies used to detect component degradation and optimize maintenance include:

- Electrochemical Impedance Spectroscopy (EIS)
- Vibration Analysis
- Partial Discharge Monitoring
- Oil Quality and Particle Analysis

These tools enable deeper understanding of failure mechanisms in complex shipboard systems.

Advanced Diagnostic Tools for Marine Systems

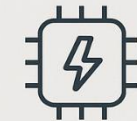
Key technologies used to detect component degradation and optimize maintenance include:



Electrochemical Impedance Spectroscopy (EIS)



Vibration Analysis



Partial Discharge Monitoring



Oil Quality and Particle Analysis

As maintenance platforms become digitally integrated, cybersecurity becomes essential:

- Multi-factor authentication for critical systems
- Data encryption in BMS/PMS communications
- Secure firmware updates and system access control
- Compliance with IMO Cyber Risk Management Guidelines

Cybersecurity in Maintenance Data Systems

For evaluating maintenance integrated, cusedigitally integrated.



Multi-factor authentication for critical systems



Data encryption in BMS/PMS communications



Secure firmware updates and system access control



Compliance with IMO Cyber Risk Management Guidelines

Effective maintenance depends on shared knowledge and team coordination:

- Digital maintenance logbooks and mobile checklists
- Microlearning modules and crew-to-crew mentoring
- QR-code-based troubleshooting guides
- 'Lessons Learned' briefings after major interventions

Collaborative Knowledge Sharing Onboard

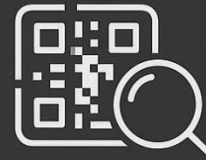
Effective maintenance depends on shared knowledge and team coordination.



Digital maintenance logbooks
and mobile checklists



Microlearning modules and
crew-to-crew mentoring



QR-code-based
troubleshooting guides



"Lessons Learned" briefings
after major interventions

To avoid operational conflicts and downtime:

- Align maintenance schedules with voyage planning
- Link charging/discharging cycles to task alerts
- Coordinate with shore teams via shared digital calendars
- Use smart reminders based on engine hours or usage trends

Integrated Maintenance & Operation Calendar



Align maintenance schedules with voyage planning



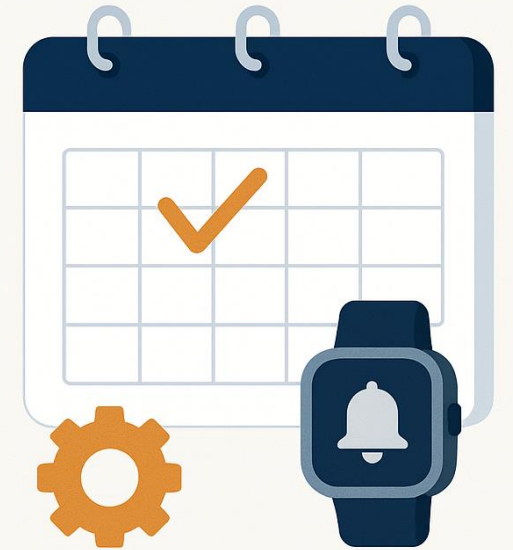
Link charging/discharging cycles to task alerts



Coordinate with shore teams via shared digital calendars



Use smart reminders based on engine hours or usage trends



Strategies to extend battery value and reduce environmental impact:

- Monitoring State of Health (SoH) to inform second-life suitability
- Reusing batteries in stationary energy storage systems
- Following certified recycling procedures (ISO 14001)
- Optimizing usage to reduce early degradation

Battery Lifecycle and Second-Life Planning

- Monitoring State of Health (SoH) to inform second-life suitability
- Reusing batteries in stationary energy storage systems
- Following certified recycling procedures (ISO 14001)
- Optimizing usage to reduce early degradation



Table of contents

1. Training 1: Hands-on exercises on operational decision making and safety protocols
2. Training 2: Machines and power electronics maintenance procedures
3. Training 3: Group discussion on maintenance best practices



2. Maintenance

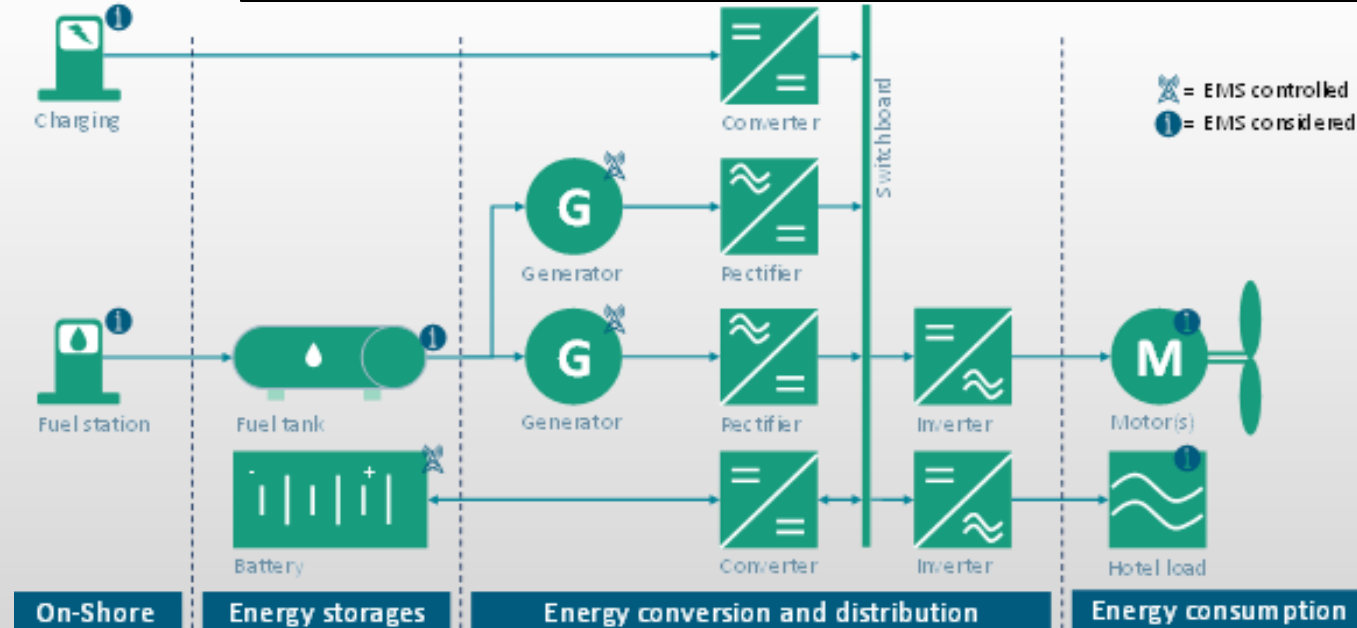
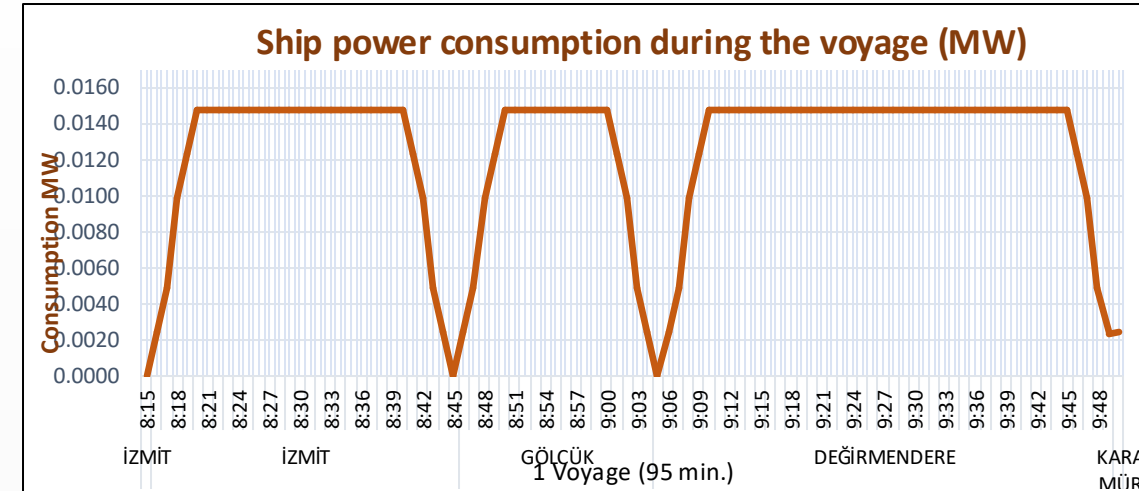
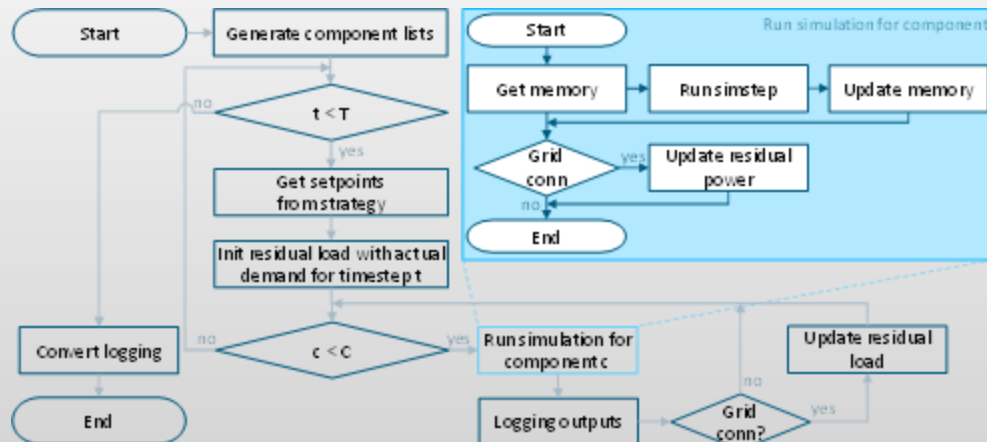
FLEXSHIP

2.3 Best practices for sustainable use

In this session, best practices in the preventive and predictive maintenance of onboard energy systems will be reviewed collaboratively.

Encouraged to reflect on observed challenges, adopted techniques, and lessons learned from operational experience.

The objective is to promote knowledge exchange and to identify practical, scalable approaches applicable to maritime settings.





2. Maintenance

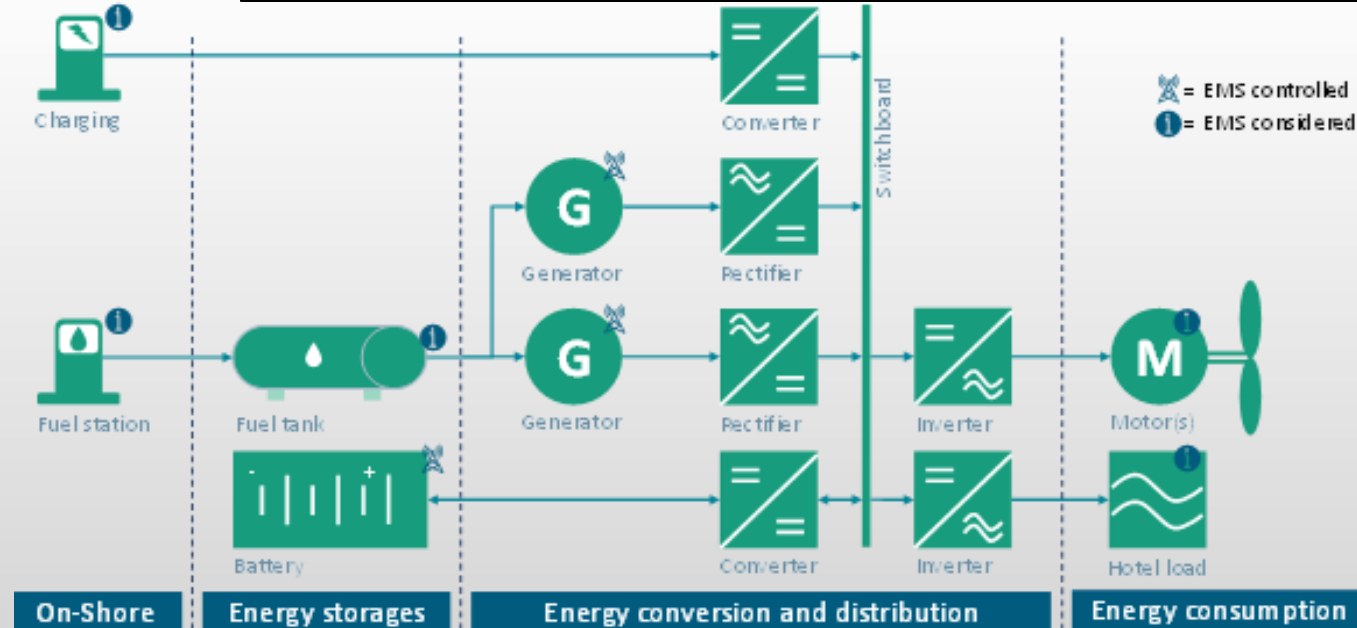
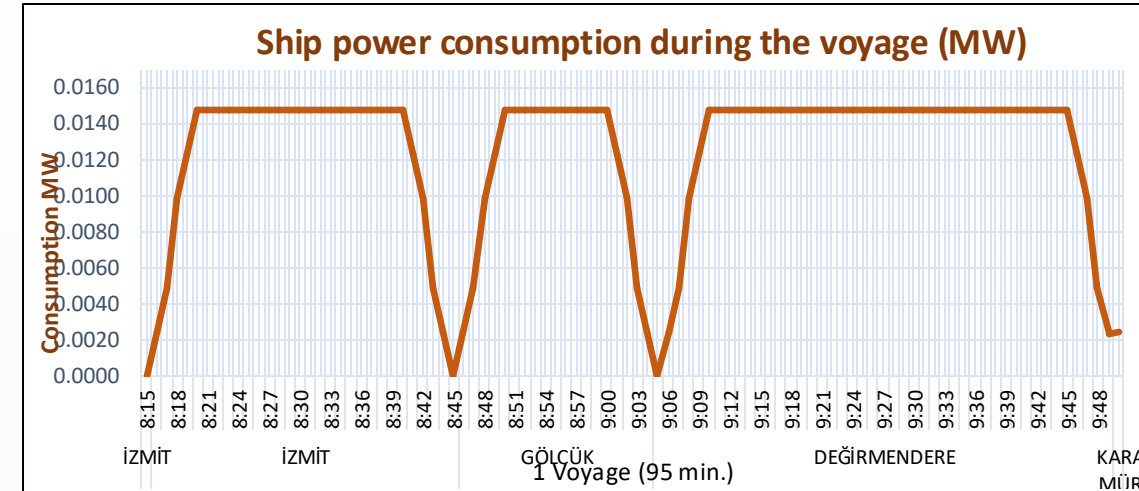
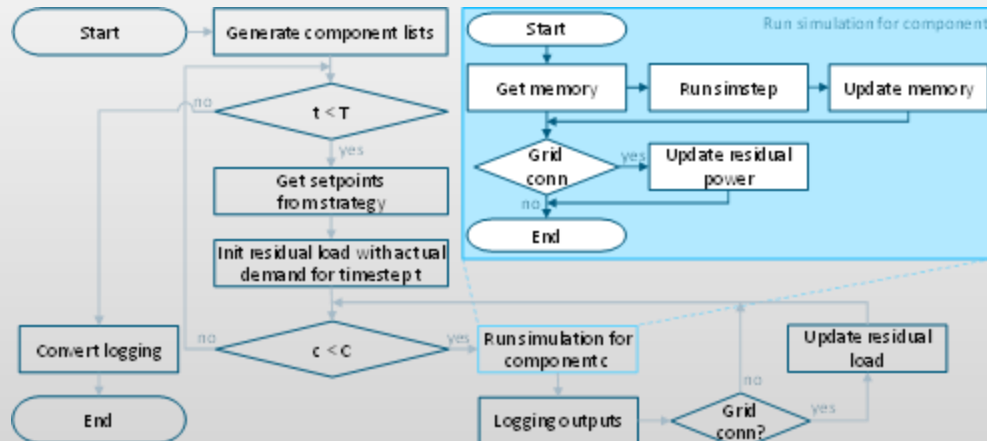
FLEXSHIP

2.3 Best practices for sustainable use

Group discussion will be guided by the following themes:

- Daily and weekly routines: What is being consistently checked or logged?
- Use of diagnostic tools: Are thermal imaging, EIS, or impedance testers being utilized?
- Crew engagement: How is maintenance knowledge being shared onboard?
- Maintenance planning: Are checklists, dashboards, or BMS trends used to schedule tasks?
- Unexpected failures: What corrective actions were taken and what could be done differently?

Participants will be asked to contribute examples and feedback from their own contexts.





2. Maintenance

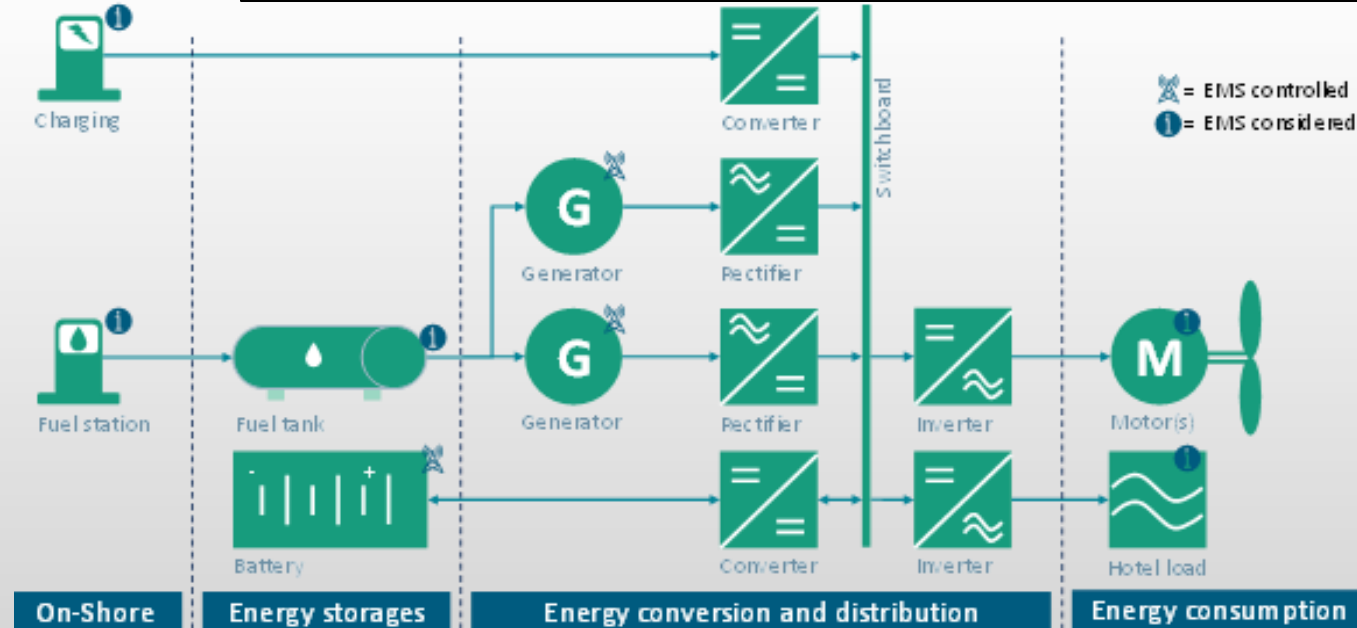
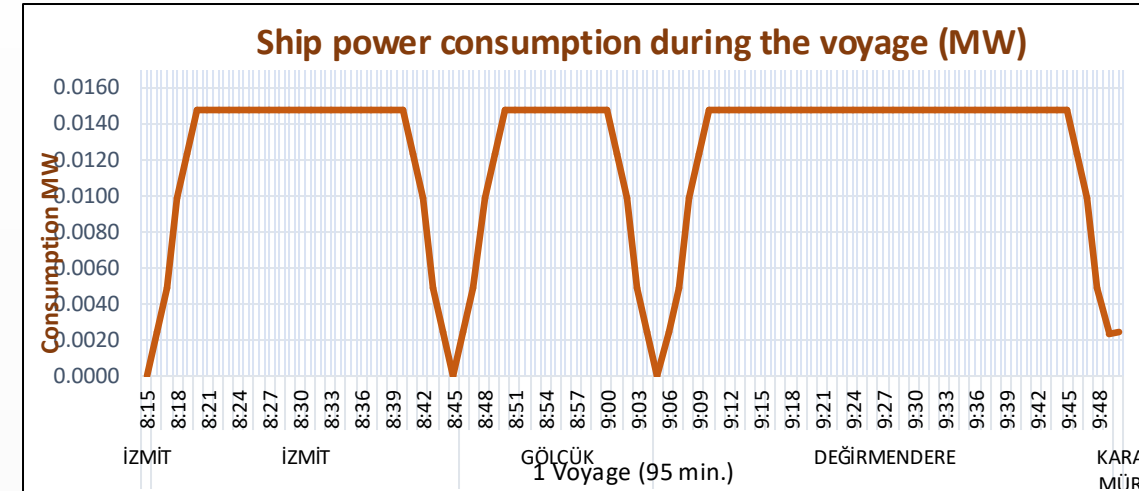
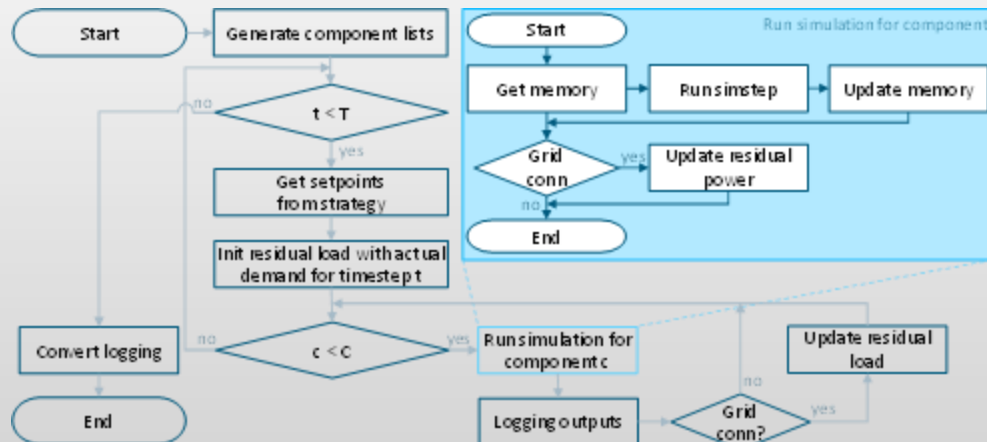
FLEXSHIP

2.3 Best practices for sustainable use

Documented industry best practices have included the following:

- Use of mobile devices to log daily battery temperatures and voltages
- Deployment of IR cameras to identify early-stage thermal anomalies
- Crew training on visual indicators of electrolyte leakage and casing bulge
- Centralization of maintenance records for cross-vessel learning
- Incorporation of predictive algorithms that flag state-of-health degradation

Discussion will explore whether these practices have been applied, adapted, or enhanced in participants' own vessels.





2. Maintenance

FLEXSHIP

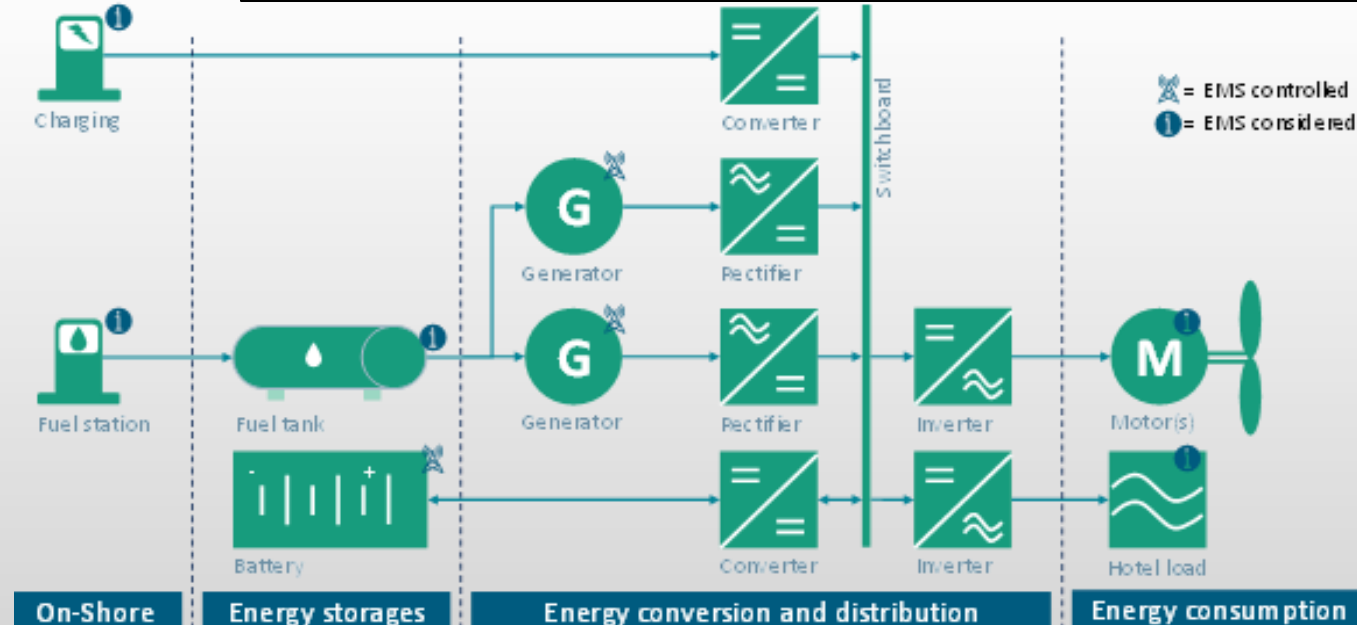
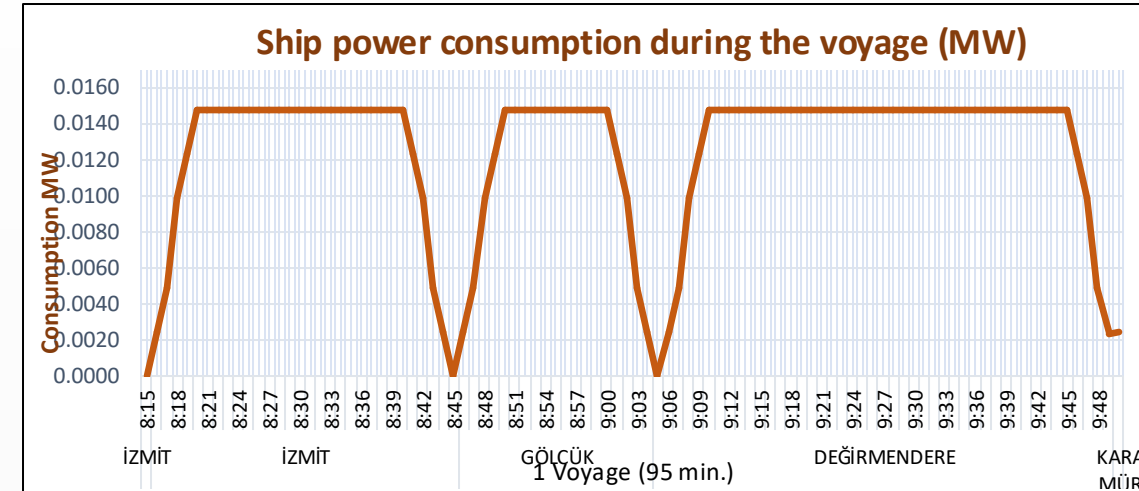
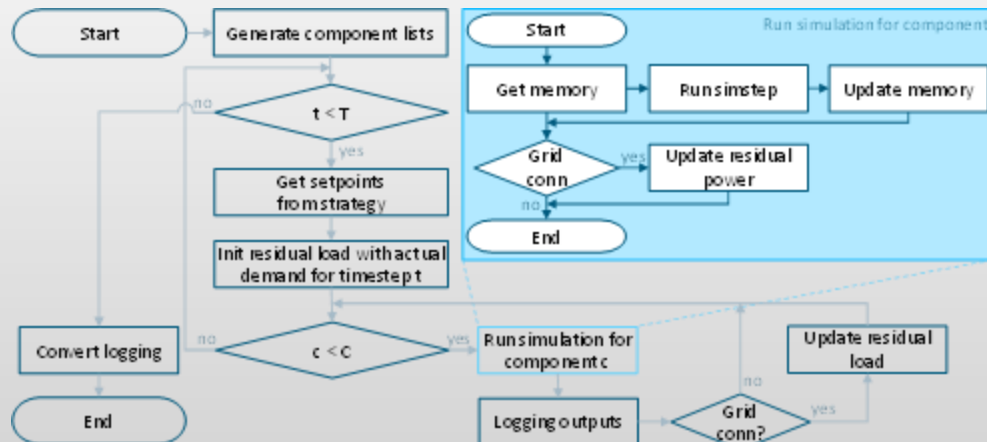
2.3 Best practices for sustainable use

Previous maintenance-related failures have provided critical insights.

Among the most cited issues are:

- Missed early warnings due to lack of trend monitoring
- Overlooked terminal corrosion due to inconsistent inspections
- Limited understanding of SoH drift indicators by crew
- Infrequent review of BMS logs and fault codes
- Poor coordination between ship and onshore maintenance teams

Participants will be invited to describe how similar issues were resolved and what institutional measures were adopted afterward.





2. Maintenance

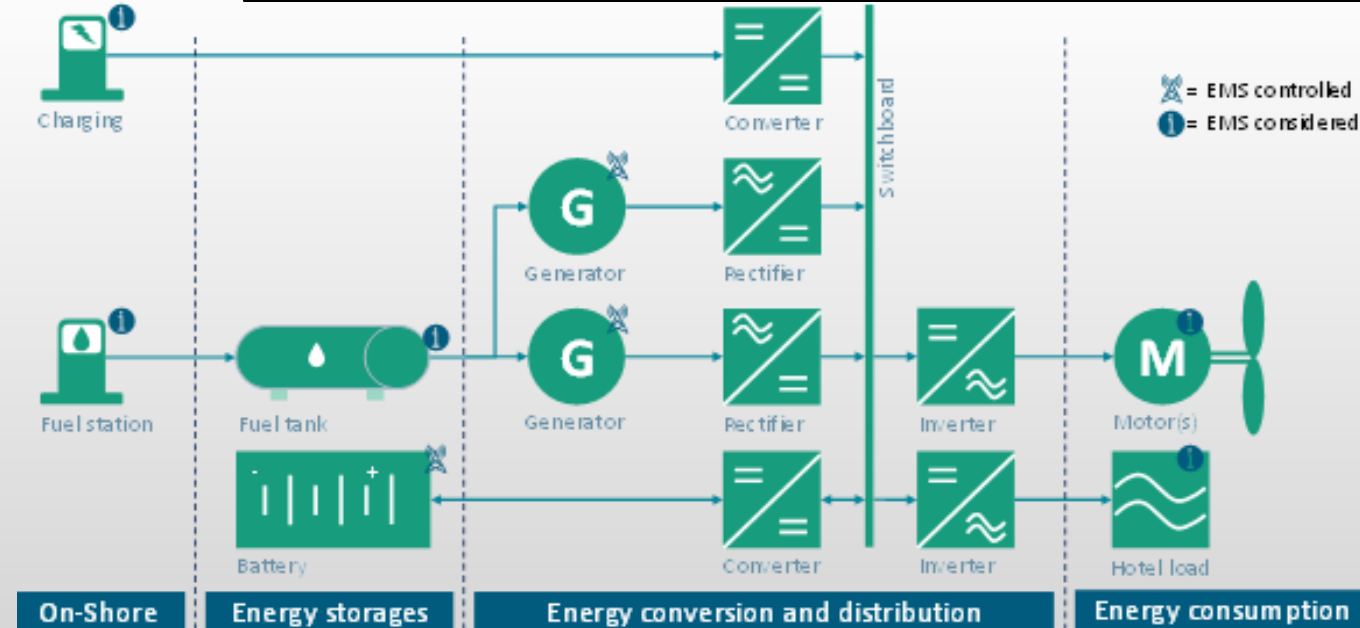
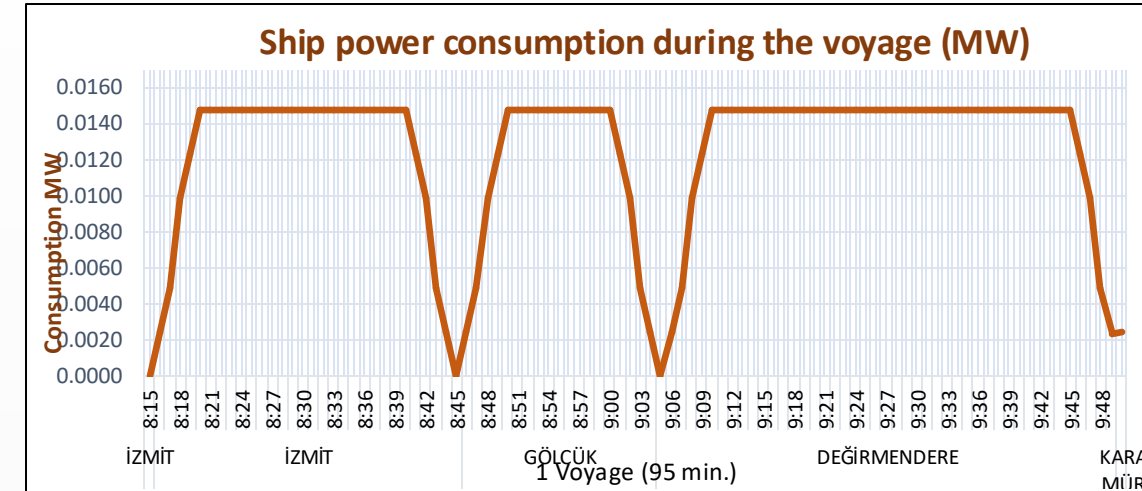
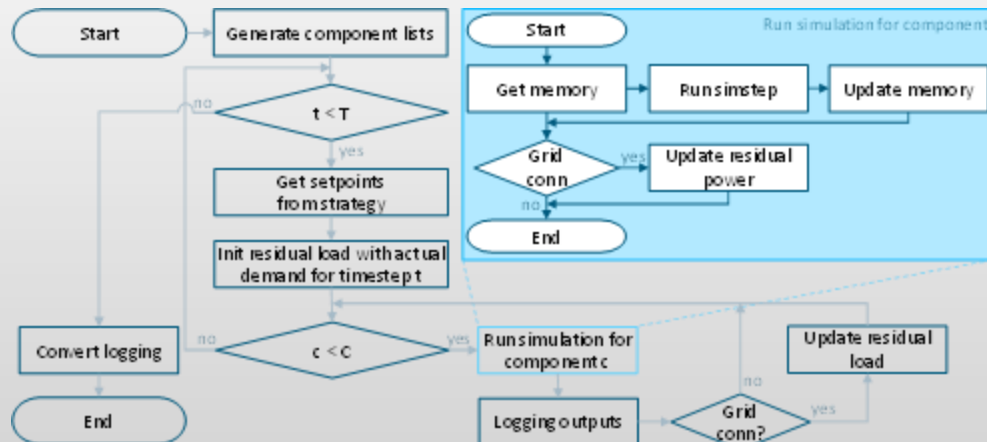
FLEXSHIP

2.3 Best practices for sustainable use

The effectiveness of maintenance is often strengthened through the use of support tools, such as:

- Digital checklists with condition-based triggers
- Dashboards that aggregate real-time BMS data
- Automated reminders linked to operational hours or charging cycles
- Shared incident reporting systems for fleet-wide learning
- Integration of maintenance schedules with vessel operation plans

Attendees will be asked to share which tools they rely on and what improvements they would propose.





2. Maintenance

FLEXSHIP

2.3 Best practices for sustainable use

Energy Management Strategies

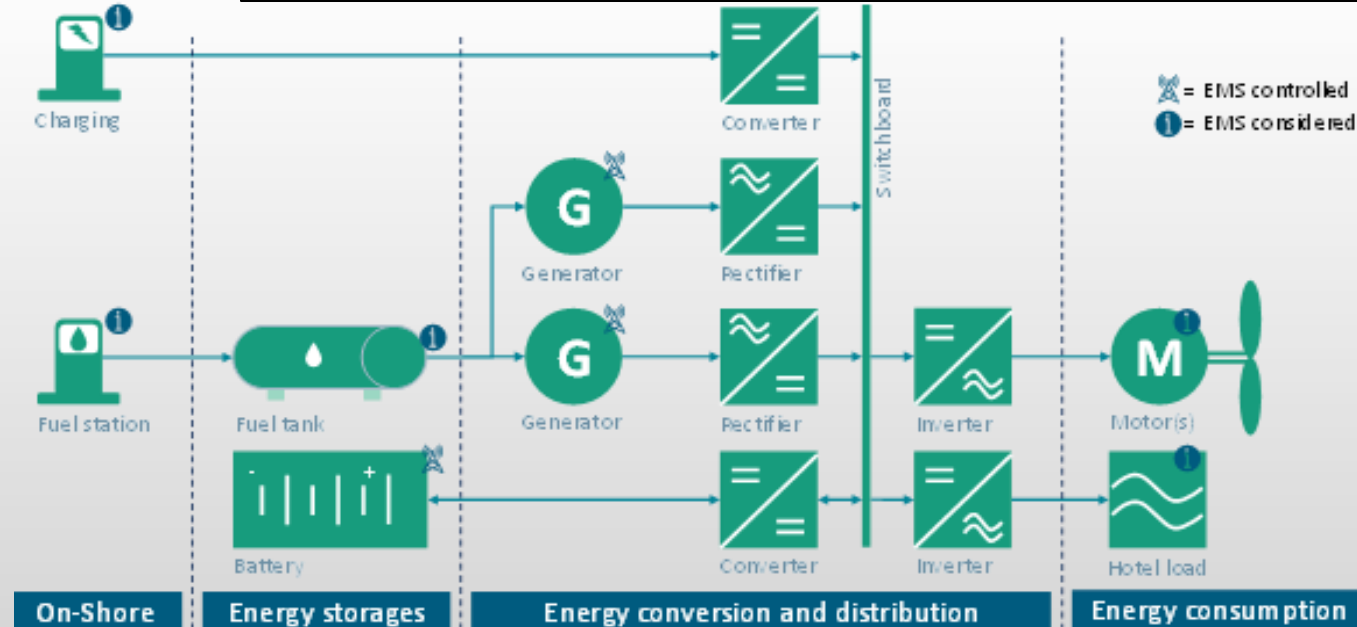
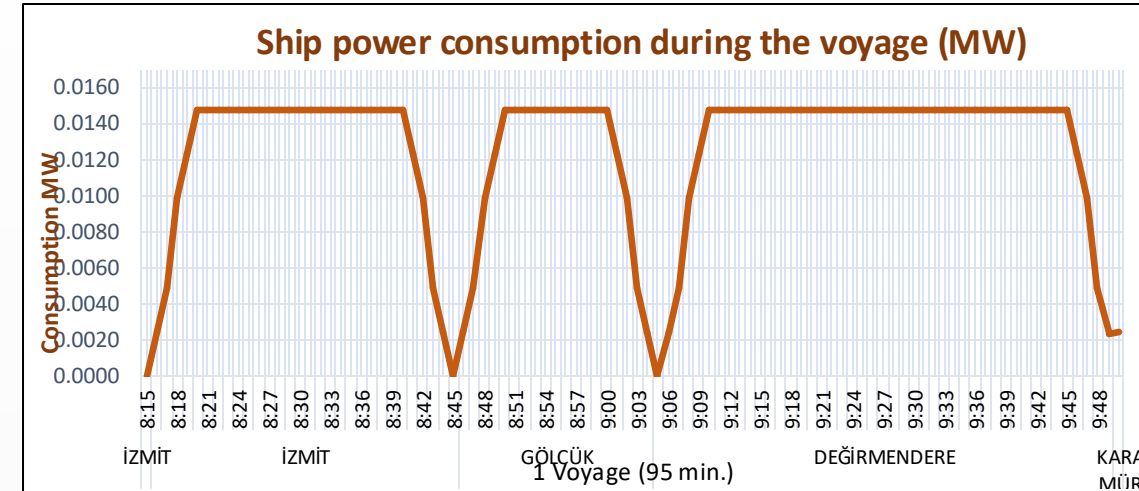
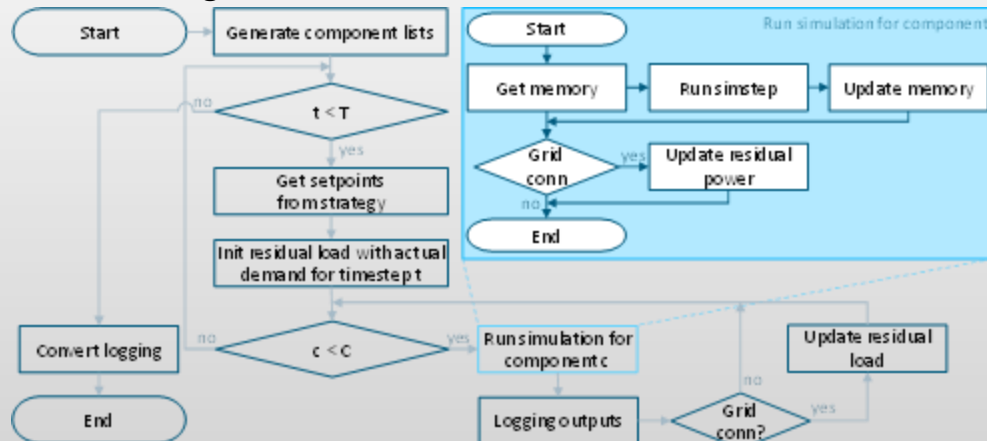
- energy-efficient systems and sensors
- real-time monitoring and control
- dynamic power management technologies

Environmental Considerations

- reduce harmful emissions
- emission monitoring and reporting systems

Life Cycle Management of Battery System

- second-life applications and recycling options
- degradation patterns
- enabling optimized usage
- extending the service life of batteries



Thanks for your attention!