



----- POWER STORAGE IN D OCEAN -----

D6.2. HAZID study



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1. INTRODUCTION

The POSEIDON project is a project aimed at demonstrating the applicability of three innovative fast-response energy storage systems (ESS) in waterborne transport. These systems include supercapacitors, flywheels, and magnetic energy storage system. The project focuses on integrating these ESS onboard ships to enhance energy efficiency, cost competitiveness, and safety in maritime environments.

The POSEIDON project is funded by the European Union's Horizon 2020 program, with a total budget of 5 million euros. This funding supports the collaboration of 12 national and international entities working together to achieve the project's goals.

A HAZID (Hazard Identification) is essential for the POSEIDON project to ensure the safety and regulatory compliance of the innovative ESS. The HAZID process helps identify potential hazards early in the project lifecycle, allowing for timely corrective actions and comprehensive risk management. This is crucial for addressing safety concerns, regulatory requirements, and long-term risks associated with the deployment of these advanced energy storage systems in maritime settings.

To facilitate the preparation of the HAZID we will divide the HAZID study of the project in three workshops. Each workshop will focus on a specific technology, during this workshop the participants will discuss about the necessary processes to integrate the system on a containerised solution and how the system must operate on this kind of environment.

Due to the final TRL to reach in this project, the flywheel (KESS) and the supercapacitors (EES) are going to be mounted and tested on the vessel from Balearia's "Cap de Barbaria" so the HAZID will consider the containerized solution to evaluate the dangers that may occur. Meanwhile, for the super magnet (SMES), the POSEIDON project doesn't contemplate to test its functioning onboard so we will contemplate a containerized solution like the one developed for the KESS and the EES but adapting it to the new requirements.

To carry out the HAZID workshop some information about the technology, with some explanation about the decisions made during engineering and the designing part of the development, will be shared between all the participants so everyone can know about the functioning of those systems. Apart from the information from the storage technologies, some information about the ship and some specifications of the container will be also sent to all the participants in the workshop.

2. TERMS OF REFERENCE

In this part of the deliverable, we will concentrate on the HAZID, particularly the necessary documents, scope, approach, key participants, and expected outcomes upon completion of the HAZID. Additionally, it will summarize the HAZID procedure and the results of the workshop, since it has been conducted with the relevant stakeholders:

2.1. OBJECTIVES

- **Risk Assessment:** Conducting a thorough HAZID (Hazard Identification) to identify and mitigate potential risks associated with the integration and operation of ESS.
- **Stakeholder Engagement:** Involving various stakeholders, including maritime operators, regulatory bodies, and technology providers, to gather insights and feedback.
- **Knowledge Sharing:** Facilitating discussions on best practices, challenges, and solutions related to the deployment of advanced ESS in the maritime sector.

2.2. PARTICIPANTS

- CTN --> Deliverable leader & project coordinator. CTN will organize the meetings and ensure its good functioning.
- TPH --> Work Package leader & expertise in naval engineering projects. TPH will contribute to the workshop by sharing its expertise at naval engineering projects.
- ABS --> HAZID facilitator. ABS will collaborate by sharing its expertise with safety regulation and assisting during the procedure of the HAZID.
- OCEM --> EESS designer and manufacturer of the adaptations. CIEMAT will provide a deep knowledge about the functioning of the EESS.
- CIEMAT --> KESS designer. CIEMAT will provide a deep knowledge about the functioning of the KESS.
- Cyclomed --> SMES designer. Cyclomed will provide a deep knowledge about the functioning of the SMES.
- ANTEC --> KESS & SMES manufacturer. ANTEC will participate in the workshop providing a more effective view of the functioning of the KESS & SMES and the necessary equipment connected for its good functioning.
- Balearia --> Shipowner of the "Cap de Barbaria". Balearia will inform about the container installation specifications and the operation of the ship where it will be installed.
- DAMEN --> Shipbuilder. DAMEN will collaborate in the HAZID by offering its experience on the necessary adaptations to the system to adapt to the maritized environment in which it will be installed.
- EFESTO --> grid side electric supplier and HLC collaborator. EFESTO will give information about the necessary grid connection for a safe energy distribution through the container and about the high-level controller.

2.3. METHODOLOGY

- Preparation:
 - Data Collection: Gather all relevant data, including process descriptions.
 - Pre-Workshop Briefing: Conduct a briefing session to familiarize participants with the objectives and scope of the workshop.
 - Identify potential global or system hazards of design/vessel
- Risk Assessment Workshop

- Facilitation: The facilitator leads the session, encouraging open discussion and idea generation.
- Hazard Identification: Participants identify potential hazards associated with the system, process, or project under review.
- Documentation:
 - Hazard Register: Record all identified hazards in the Excel sheet created for this technology.

2.4. HAZID WORKSHEET

The format of the HAZID worksheet will be the following:

HAZARD (CATEGORY)	CAUSE	CONSEQUENCES	EXAMPLE	Safeguard	
				Recommendations	Action points
Global node	Vessel design	Inclination	The inclination of the ship affect the functioning of all the equipment.	Recommended to check the inclination of its functioning Adapt the position of the system inside the container	Test if the system is able to work properly
				Install a inclination regulator to adapt the system	Test if the system is able to work properly
Global node	Acceleration/mooving of the vessel vibrations	Affect the container installation	The vibration of the vessel movement affect the container connection/equipment	The vibration issue has to be analyzed by the company Some anti vibration pads might be needed	
Global node	Acceleration/mooving of the vessel vibrations	Affect the SMES cryogenic system	The movement may affect the internal components of the cryogenic system	Study the effect of the vibrations on the technology Installation of antivibration pads if needed	Check if the cryogenic system have certification for vibration

Where:

- The Hazard column will indicate the category of the hazard studied.
- The cause column will show the scenario in which a hazard can happen during the lifecycle of the ESS.
- The consequence will define the hazards we can find due to the scenario described in the cause column.
- In the example column we will describe the process that can produce a malfunctioning/ damage of the ESS studied.
- The safeguard will indicate actions/ studies to carry out to ensure the good functioning of all the components. There will be two different types of actions: recommendations (to be considered for future projects in which we use this type of technology) and action points (actions to be studied for this specific approach in the POSEIDON project).

2.5. DOCUMENTATION SHARED WITH ASSISTANTS TO THE HAZID WORKSHOP

To prepare the HAZID workshop for each technology the following information will be shared between the participants:

- Design basis, functional specification and/or technical specification of the new technology
- Applicable design references, codes, standards and guidelines, and technical justification for any proposed deviations
- Documentation about the installation placement of the container and the EES in the container.

- Documentation about the electrical connection of the ship and the container side electrical grid.
- Lessons learned, references and examples of comparable designs.

3. HAZID STUDY SMES

HAZARD (CATEGORY)	CAUSE	CONSEQUENCES	EXAMPLE	Safeguard	
				Recommendations	Action points
Global node	Vessel design	Inclination	The inclination of the ship affects the functioning of all the equipment.	· Recommended to check the inclination of its functioning · Adapt the position of the system inside the container	Test if the system is able to work properly
				· Install a inclination regulator to adapt the system	Test if the system is able to work properly
Global node	Acceleration/moving of the vessel vibrations	Affect the container installation	The vibration of the vessel movement affects the container connection/equipment	· The vibration issue has to be analysed by the company · Some anti vibration pads might be needed	
Global node	Acceleration/moving of the vessel vibrations	Affect the SMES cryogenic system	The movement may affect the internal components of the cryogenic system	· Study the effect of the vibrations on the technology · Installation of antivibration pads if needed	Check if the cryogenic system have certification for vibration
Global node	Cargo powder	Dust entering the containerized solution and affecting the superconductors	Some powder from transporting tracks enters the container and affect the auxiliary system	· For fixed installation: There will be a ventilation provider, study to be conducted on the necessary air changes per hour (Similar for humidity levels) · Consider the inside of the container as an explosive atmosphere	Study the ventilation system to be installed. · Study the consequences of powder entering the container
Global node	Fumes or ventilation rate calculation		Failure in fumes or ventilation dissipation system could produce risk of overpressure or suffocation	· Some fumes detectors will be installed and an extinction equipment will be installed with some overpressure equipment · The ventilation system should work with Helium so is important to know the air changes per hour, the maximum volume of Helium · The use of Helium can procure suffocation so the pipes for its transport have to be certified and calculated in case somebody enters the container. · Some PPE should be given to the workers who enter the container · A further study of expanding pressure from Helium leakage should be done.	· Inform the volume of Helium necessary for the SMES functioning. · Inform about the pipe protection for Helium transport.

HAZARD (CATEGORY)	CAUSE	CONSEQUENCES	EXAMPLE	Safeguard	
				Recommendations	Action points
Global node	Drop object	A small drop or a collision with a vehicle during embarkation or disembarkation could damage the equipment	During parking manoeuvring a car hits the container track	- Additional protection should be included to the cooling components. - The hazard of leakage of cryogenic liquid should be calculated. - The safety zone for the track should be indicated.	
Global node	Small colision	Collision between components of the system	Sensitive cryogenic equipment can be suffering damages	The equipment could be damaged because of the internal movement of components. To be studied for both the cryogenic system and the coil structure of the SMES	- Study if acceleration/vibration movements can produce collisions between coils - Study if the accelerations/vibrations can produce collisions to the cryogenic system
Global node	Flooding	Some water enters the container and affect the electronics	Some water reaches the deck where the container is located	Ship damage and flooding / Water on deck.	
Global node	Lightning	Being hit by a lightning	During stormy weather, a lightning strikes the container	It is possible to have a lighting protection, study how this protection would be working with the ship grid	How sensitive are the supermagnetic system to be affected by a lighting.
Global node	Explosive atmosphere	In case there are dangerous equipment onboard, the equipment installed offside the converter must ensure safety operation.		Evaluate the dangerous zones where to avoid installing equipment outside the container or prepare that equipment to be ATEX protected.	
Technology node	Materials	The materials are not tolerant for a salinity ambient		Study the salinity tolerance of the system	Study if the cooling system can prevent salinity inside the container for the POSEIDON operation.
Technology node	Power quality	Problems on the grid side connection of the ship	The energy supplied by the system has adjustment problems to the grid side	Have in mind for integration the power quality assurance	

HAZARD (CATEGORY)	CAUSE	CONSEQUENCES	EXAMPLE	Safeguard	
				Recommendations	Action points
Technology node	Start up/ Shut down operation	Periods of inactivity can affect the energy storage system and its performance.		·Ensure the system have enough quantity of energy before powering on. ·The vessel operator should know when to start/stop the system	
Technology node	Cryogenic burns	Loss of containment, possibility of human injury or structural damage (due to brittling)		·Plan maintenances to prevent losses. ·Safety measures for resisting low temperatures in the zone near the cryogenic system. ·PPE for people working inside the containerized solution ·Danger due to burns should be studied.	
Technology node	Cooling	The container can reach a inadequate temperature inside	Emergency discharge of the system could produce a lot of heat inside the container	·Study to be conducted on the heat transfer of the container. Time and temperatures reached are values of interest (in the container is natural convection) ·Redundancy system in case the cryogenic failure. ·We have to study if the difference of temperature is dangerous for the vessel	
Technology node	Redundancy	In case the technology stops working there isn't another power supply source to ensure ship functioning		·Study what would be the consequences if the system stops working	
Technology node	Effect of the container (noise)	The noise level inside the container could affect people around the container solution		·Study the noise produced by the super magnetic system.	·Study the noise produced by the super magnetic system.
Technology node	Control/Monitoring/alarm system	A hazard occurs and we can't react until we notice	We are unable identify high temperature inside the container.	·Basic sensors will be installed inside the container to control critical parameters.	·Provide all documentation for control monitoring, alarm and safety (necessary alarms for this system should be defined) · Define parameters to detect when we have a problem on the system

HAZARD (CATEGORY)	CAUSE	CONSEQUENCES	EXAMPLE	Safeguard	
				Recommendations	Action points
System	independence of the system	The system is unable to face a power loss peak		·There should be installed an UPS	
System	Interference with the existing electrical connections	The connection between the container and the vessel electrical grid are unable to be connected		The modification needed will be checked with a Classification society (Current and Voltage THD will be within the regulation limits (5%))	· Balearia and the system integration team for the container have to agree on a common connection point.
System	Feasibility with other renewable sources of energy	Maybe a change in the electrical connection would be needed to integrate renewable energy sources		·Lagging phenomena on photovoltaic sources.	· ABS will have a discussion with the OEM about this technology combined with renewable energy sources
System	Fire fighting	In case of fire there have to be a firefighting system to prevent damages		·There will be installed some sensors for fumes/ fire at the container that will operate a firefighting system. ·There should be an alarm to provide information about the fire alarm to the ship. (Light and noise alarm)	·We have to study which firefighting system for the cryogenic installation; it could be different than the supercaps ones
System	Fire in the garage	A fire in the garage occurs heating up the exterior of the container		·The heat from the fire can affect the operation of the system. The container has to be able to maintain the temperature safe Elaborate a procedure in the event of a fire in the garage, disconnect the container. Once disconnected, the container will automatically stop and then proceed to de-energize	·Does the Container Boundary has insulation A-60
System	Bilge system	Toxic material inside. When firefighting with water, contaminated water can lead to the bilge producing ship damage or danger			·Describe all the liquid (description of the cooling system is needed) that can escape from the system and be extracted by the bilge system
System	Emergency and escape routes	The installation of the container affects the emergency routes of the ship		·Not obstructing any evacuation route	

HAZARD (CATEGORY)	CAUSE	CONSEQUENCES	EXAMPLE	Safeguard	
				Recommendations	Action points
System	Maintenance	Without maintenance the system could fail due to the fatigue of materials		·Maintenance plan should be prepared for this container/system, this will be reflected on a manual.	
System	Venting	High pressure in the container due to helium expansion		·Helium expansion due to cryogenic failure should be studied	
System	Stray Magnetic Fields	The magnetic field of the SMES might affect other electronic equipment		·Analyse maximum allowed values of magnetic field inside the container	
System	Quench events in superconducting coil Rapid helium boil-off causing pressure buildup/explosion	Rapid helium boil-off causing pressure buildup/explosion	Sudden loss of superconductivity due to thermal disturbance	Install redundant pressure relief valves + automated quench recovery systems	Conduct quench simulation tests; Verify venting capacity meets 700:1 expansion ratio
System	Ice accumulation on cryogenic surfaces	Slip hazards and equipment damage		Implement heated drip trays + moisture sensors Establish infrared thermal inspection protocol	Establish infrared thermal inspection protocol

4. HAZID STUDY KESS

HAZARD (CATEGORY)	CAUSE	CONSEQUENCES	EXAMPLE	Safeguard	
				Recommendations	Action points
Global node	Vessel design	Inclination	The inclination of the ship affects the functioning of all the equipment.	· Check the inclination of its functioning system at 21.5 °. · Check if the inclination for trim is 10°	· Make a graph to correlate the maximum inclination and maximum lifetime for the bearings
Global node	Acceleration/moving of the vessel vibrations	Affect the container installation		· The vibration issue has to be analysed by the company	· The flywheel will be installed with some rubber pads; they have to be tested in the real model. · The planned pads to be installed had been tested in other previous model of flywheel. · The pads should be also tested on the vessel to know the effect on the maritime environment. · The rubber pads are for vibration, if they are installed check that they are capable to lifting and pushing down.
Global node	Acceleration/moving of the vessel vibrations	Affect the electronic components of the KESS	The movement may affect the electronics of the KESS	· Study the effect of the vibrations on the technology.	· No risk identified for the POSEIDON approach
Global node	Cargo powder	Dust entering the containerized solution and affecting the electronics	Some powder from transporting tracks enter the container and affect the magnetic/cryogenic system	For fixed installation: There will be a ventilation provider, study to be conducted on the necessary air changes per hour	

HAZARD (CATEGORY)	CAUSE	CONSEQUENCES	EXAMPLE	Safeguard	
				Recommendations	Action points
				(Similar for humidity levels)	
Global node	Fumes or ventilation rate calculation		Failure in fumes or ventilation dissipation system could produce risk of overpressure or suffocation	· Installation of fumes detector · Installation of an extinction equipment with some overpressure equipment.	
Global node	Drop object	A small drop or a collision with a vehicle during embarkation or disembarkation could damage the equipment	During parking manoeuvring a car hits the container track	The safety zone for the containerized solution should be indicated	Study if the collision could produce damage in the system
Global node	small collision	Collision between components of the system	Sensitive electronic equipment can be suffering damages		Study the damage that a small collision can produce on the system
Global node	Flooding	Some water enters the container and affect the electronics	Some water reaches the deck where the container is located	It will affect first the electronical parts rather than the mechanical, so the contention measures should focus on the electronic part	The electrical part of the KESS is not flood resistant, but the casing should be studied Recommended to add a containment to protect the coils from the possible flooding. Ask ANTEC
Global node	Lightning	Being hit by a lightning	During stormy weather, a lightning strikes the container	It is possible to have a lighting protection, study how this protection would be working with the ship grid	

HAZARD (CATEGORY)	CAUSE	CONSEQUENCES	EXAMPLE	Safeguard	
				Recommendations	Action points
Global node	Explosive atmosphere	In case there are dangerous equipment onboard, the equipment installed offside the converter must ensure safety operation.		· Evaluate the dangerous zones where to avoid installing equipment outside the container or prepare those equipment to be ATEX protected.	
Technology node	Materials	The materials should be tolerant for a salinity ambient		Study the salinity tolerance of the system	Study if the cooling system can prevent salinity inside the container for the operation.
Technology node	Power quality	Problems on the grid side connection of the ship	The energy supplied by the system has adjustment problems to the grid side	Have in mind for integration the power quality assurance.	
Technology node	Heat in the wires of the electronical part (coils)	Heat from the bearings can affect other components		These coils are air forced cooled, but the heat transferred should be considered	
Technology node	Collision of the flywheel	As the flywheel spins at high rpm, any failure can produce high damage		Make sure that, in case of flywheel collision, there is a safety zone so anybody could get hurt.	Study the containment of the flywheel inside the device.
Technology node	Start up/ Shut down operation	The starting/ stopping process has to be controlled to know when there is risk due to the operating of the system		· Ensure the system have enough quantity of energy before powering on. · The system have to be able to stop without the electronics (only with the safety valve)	
Technology node	Cooling	The operation of flywheel will produce some of heat inside the container		· Study to be conducted on the heat transfer of the container. · Time and temperatures	

HAZARD (CATEGORY)	CAUSE	CONSEQUENCES	EXAMPLE	Safeguard	
				Recommendations	Action points
				reached are values of interest	
Technology node	Redundacy	Redundancy may not be necessary for the demonstration, but if the technology is installed on a vessel and becomes unavailable, it's important to assess whether continued operation without it is acceptable		Determine the consequences if the system stop working	
Technology node	Effect of the container (noise)	The noise level inside the container can affect the surrounding environment		Necessary PPE inside the container if the electrical machine is working.	It has to be measured the noise level when the machine is operating.
Technology node	Control/Monitoring/alarm system	In case of danger, it should be detected and notified so the security actions should be carried out		· Recommended to add an emergency bottom outside of the container (wait 10 minutes so it is stopped). · Sensor at the entrance so nobody enters the container during its functioning (for this application) · There should be an alarm to provide information about the fire alarm to the ship. (Visual and acoustic alarm)	· Test the time to discharge the system until it goes to 0 rpm
Technology node	Revolution drops under 400 rpm	The energy consumed by the system is higher than the energy that is supplied		Evaluate the speed value is not worth having the system rotating	
System	independence of the system	Prevent the lack of generated energy		There should be installed an UPS	

HAZARD (CATEGORY)	CAUSE	CONSEQUENCES	EXAMPLE	Safeguard	
				Recommendations	Action points
System	Interference with the existing electrical connections	The members of the consortium will act in accordance with the connection points, safety measures, and potential interferences with the existing vessel.		The modification needed will be checked with a Classification society (Current and Voltage THD will be within the regulation limits (5%))	
System	Feasibility with other renewable sources of energy	The question is raised about how the connection would differ on a vessel designed to also integrate renewable energy sources. The inquiry focuses on the feasibility of installing supercapacitor technology on such a vessel, considering the intermittent nature of renewable energy sources.	Lagging phenomena on photovoltaic sources		
System	Fire fighting	The container is equipped with fire-fighting systems and alarm systems, which are to be connected to the vessel's systems.		There will be installed some sensors for fumes/ fire at the container that will operate a fire fighting system.	· Verify the feasibility of using CO2 as fire fighting solution for both flywheel and supercaps
System	Fire in the garage	A fire event on the vessel's open deck could have implications for multiple areas of the vessel, including the container.			
System	Bilge system	In case there are some waste that is necessary to collect so we prevent dangers		To be studied the interaction with water of the materials used for the KESS system in case they could produce residue to be treated	Study the installation of a manually operated normally closed drainage valve

HAZARD (CATEGORY)	CAUSE	CONSEQUENCES	EXAMPLE	Safeguard	
				Recommendations	Action points
System	Emergency and escape routes	The evacuation routes shouldn't be affected by any danger produced because of the operation of this system		Not obstructing any evacuation route	
System	Maintenance	To prevent problems due to fatigue there should be planned some maintenance activities to monitor the status of the critical components		Maintenance plan should be prepared for this container/ system, this will be reflected on a manual.	
System	Bearings	As critical components is important to control the bearings to prevent dangers		Monitor the temperature and once it reaches the limit temperature establish a speed reduction so the bearings can be cooled.	Reduce the flywheel speed if the temperature of the upper or lower bearings exceeds 100°C
System	Excessive dissipation of heat inside the container from the flywheel (casing)	The heat produced on the bearings, coils and electric machine stator could accumulate and create a risk due to the high temperatures		· It will be necessary to calculate the heat dissipated over the range of operating conditions. · It will be necessary a ventilation analysis of the container	

5. HAZID STUDY EESS

HAZARD (CATEGORY)	CAUSE	CONSEQUENCES	EXAMPLE	Safeguard	
				Recommendations	Action points
Global node	Vessel design	Inclination	The inclination of the ship affects the functioning of all the equipment.	· Check the inclination of its functioning system at 21.5 °. · Check if the inclination for trim is 10°	· Make a graph to correlate the maximum inclination and maximum lifetime for the bearings
Global node	Acceleration/moving of the vessel vibrations	Affect the container installation		· The vibration issue has to be analysed by the company	· The flywheel will be installed with some rubber pads; they have to be tested in the real model. · The planned pads to be installed had been tested in other previous model of flywheel. · The pads should be also tested on the vessel to know the effect on the maritime environment. · The rubber pads are for vibration, if they are installed check that they are capable to lifting and pushing down.
Global node	Acceleration/moving of the vessel vibrations	Affect the electronic components of the KESS	The movement may affect the electronics of the KESS	· Study the effect of the vibrations on the technology.	· No risk identified for the POSEIDON approach
Global node	Cargo powder	Dust entering the containerized solution and affecting the electronics	Some powder from transporting tracks enters the container and affect the magnetic/cryogenic system	For fixed installation: There will be a ventilation provider, study to be conducted on the necessary air changes per hour (Similar for humidity levels)	

HAZARD (CATEGORY)	CAUSE	CONSEQUENCES	EXAMPLE	Safeguard	
				Recommendations	Action points
Global node	Fumes or ventilation rate calculation		Failure in fumes or ventilation dissipation system could produce risk of overpressure or suffocation	- Installation of fumes detector - Installation of an extinction equipment with some overpressure equipment.	
Global node	Drop object	A small drop or a collision with a vehicle during embarkation or disembarkation could damage the equipment	During parking manoeuvring a car hits the container track	The safety zone for the containerized solution should be indicated	Study if the collision could produce damage in the system
Global node	small collision	Collision between components of the system	Sensitive electronic equipment can be suffering damages		Study the damage that a small collision can produce on the system
Global node	Flooding	Some water enters the container and affect the electronics	Some water reaches the deck where the container is located	It will affect first the electronical parts rather than the mechanical, so the contention measures should focus on the electronic part	The electrical part of the KESS is not flood resistant, but the casing should be studied Recommended to add a containment to protect the coils from the possible flooding. Ask ANTEC
Global node	Lightning	Being hit by a lightning	During stormy weather, a lightning strikes the container	It is possible to have a lighting protection, study how this protection would be working with the ship grid	
Global node	Explosive atmosphere	In case there are dangerous equipment onboard, the equipment installed offside the converter must ensure safety operation.		Evaluate the dangerous zones where to avoid installing equipment outside the container or prepare those	

HAZARD (CATEGORY)	CAUSE	CONSEQUENCES	EXAMPLE	Safeguard	
				Recommendations	Action points
				equipment to be ATEX protected.	
Technology node	Materials	The materials should be tolerant for a salinity ambient		Study the salinity tolerance of the system	Study if the cooling system can prevent salinity inside the container for the 2 month operation.
Technology node	Power quality	Problems on the grid side connection of the ship	The energy supplied by the system has adjustment problems to the grid side	Have in mind for integration the power quality assurance.	
Technology node	Heat in the wires of the electronical part (coils)	Heat from the bearings can affect other components		These coils are air forced cooled but the heat transferred should be considered	
Technology node	Collision of the flywheel	As the flywheel spins at high rpm, any failure can produce high damage		Make sure that, in case of flywheel collision, there is a safety zone so anybody could get hurt.	Study the containment of the flywheel inside the device.
Technology node	Start-up/ Shut down operation	The starting/ stopping process has to be controlled to know when there is risk due to the operating of the system		· Ensure the system have enough quantity of energy before powering on. · The system have to be able to stop without the electronics (only with the safety valve)	
Technology node	Cooling	Emergency discharge of flywheel will produce a lot of heat inside the container		· Study to be conducted on the heat transfer of the container. · Time and temperatures reached are values of interest	

HAZARD (CATEGORY)	CAUSE	CONSEQUENCES	EXAMPLE	Safeguard	
				Recommendations	Action points
Technology node	Redundancy	Redundancy may not be necessary for the demonstration, but if the technology is installed on a vessel and becomes unavailable, it's important to assess whether continued operation without it is acceptable		Determine the consequences if the system stop working	
Technology node	Effect of the container (noise)	The noise level inside the container can affect the surrounding environment		Necessary PPE inside the container if the electrical machine is working.	It has to be measured the noise level when the machine is operating.
Technology node	Control/Monitoring/alarm system	In case of danger, it should be detected and notified so the security actions should be carried out		· Recommended to add an emergency bottom outside of the container (wait 10 minutes so it is stopped). · Sensor at the entrance so nobody enters the container during its functioning (for this application) · There should be an alarm to provide information about the fire alarm to the ship. (Visual and acoustic alarm)	· Test the time to discharge the system until it goes to 0 rpm
Technology node	Revolution drops under 400 rpm	The energy consumed by the system is higher than the energy that is supplied		Evaluate the speed value is not worth having the system rotating	
System	Independence of the system	Prevent the lack of generated energy		There should be installed an UPS	
System	Interference with the existing electrical connections	The members of the consortium will act in accordance with the connection points, safety measures, and potential interferences with the existing vessel.		The modification needed will be checked with a Classification society (Current and Voltage THD will be within the	

HAZARD (CATEGORY)	CAUSE	CONSEQUENCES	EXAMPLE	Safeguard	
				Recommendations	Action points
				regulation limits (5%)	
System	Feasibility with other renewable sources of energy	The question is raised about how the connection would differ on a vessel designed to also integrate renewable energy sources. The inquiry focuses on the feasibility of installing supercapacitor technology on such a vessel, considering the intermittent nature of renewable energy sources.	Lagging phenomena on photovoltaic sources		
System	Fire fighting	The container is equipped with fire-fighting systems and alarm systems, which are to be connected to the vessel's systems.		There will be installed some sensors for fumes/ fire at the container that will operate a firefighting system.	· Verify the feasibility of using CO2 as firefighting solution for both flywheel and supercapacitors
System	Fire in the garage	A fire event on the vessel's open deck could have implications for multiple areas of the vessel, including the container.			
System	Bilge system	In case there are some waste that is necessary to collect so we prevent dangers		To be studied the materials used for the KESS system in case they could be toxic	Study the installation of a manually operated normally closed drainage valve
System	Emergency and escape routes	The evacuation routes shouldn't be affected by any danger produced because of the operation of this system		Not obstructing any evacuation route	
System	Maintenance	To prevent problems due to fatigue there should be planned some maintenance activities to monitor the status of the critical components		Maintenance plan should be prepared for this container/ system, this will be	

HAZARD (CATEGORY)	CAUSE	CONSEQUENCES	EXAMPLE	Safeguard	
				Recommendations	Action points
				reflected on a manual.	
System	Bearings	As critical components is important to control the bearings to prevent dangers		Monitor the temperature and once it reaches the limit temperature establish a speed reduction so the bearings can be cooled.	
System	Excessive dissipation of heat inside the container from the flywheel (casing)	The heat produced on the bearings could accumulate and create a risk due to the high temperatures		· It will be necessary to calculate the heat dissipated over the range of operating conditions. · It will be necessary a ventilation analysis of the container	