Shore Power
Compatibility Between Inland Waterway and LV Sea Vessels

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Executive Summary

The maritime sector is vast, encompassing a multitude of vessel types, each tailored to their operational environments and specific needs. Central to the discourse on maritime sustainability is the implementation of shore power. However, the integration of shore power is not without its challenges, particularly when examining the compatibility between inland waterway vessels and sea-going vessels. The following conclusions are drawn in a study by EICB for Port of Rotterdam:

1. **Differing Standards and Regulations:** Inland and sea-going vessels are governed by different standards. The variations, like the IEC 60309-2 for inland navigation and IEC 60309-5 for sea-going vessels, result in incompatible connections. Furthermore, the draft IEC/IEEE 80005-3 standard's applicability to inland vessels remains unclear, underscoring the need for clearer demarcation in finalized regulations.

2. **Power and Design Variations:** The power needs diverge between seagoing and inland vessels due to size, activities, and machinery. Inland vessels might also possess unique design features distinct from their sea-going counterparts, influencing shore infrastructure requirements.

3. **Electrical Specifications:** While inland navigation vessels tend to align with the voltage and frequency of European Ports, sea-going vessels typically operate at 440V at 60Hz. The standards also differ in their specifications, with EN 16840:2017 allowing up to 400V, while IEC/IEEE 80005-3 permits higher voltages.

4. **Operational and Safety Concerns:** Safety remains paramount. Differing vessel types necessitate distinct safety protocols, especially when using shore power systems designed for another vessel type.

5. **Grid Configurations:** Both standards, while aiming for safe shore power connections, have distinct requirements. The inland navigation standard offers flexibility in grid configurations, whereas the IEC/IEEE 80005-3 standard emphasizes the IT-grid system for its fault resilience.

6. **Operation and Handling:** Inland navigation vessels have user-friendly shore power systems, accessible to regular persons. Contrarily, the IEC/IEEE 80005-3 standard mandates specialized training, underscoring its more intricate operation.

7. **Future Electricity Needs**: As the inland waterway transport sector pivots towards sustainable propulsion methods, such as battery and hydrogen propulsion, the true potential of shore power will manifest in case vessels have significant onboard battery capacities and in case vessels have frequent docking periods. Currently this is not the practice.

8. **Regulatory Restrictions and Future Considerations**: Current regulations, including ES-TRIN and ADN, pose limitations on using shore power during specific operations like loading and unloading. However, the industry's push towards shore power necessitates investigations to see if these restrictions can be lifted safely. Additionally, the integration of swappable container battery systems with shore power introduces both challenges and opportunities, particularly concerning the cost implications for vessels.

In conclusion, the integration of shore power for maritime sustainability is a complex undertaking with significant technical, operational, and regulatory barriers. A synergy of shore power between Low Voltage maritime and inland navigation vessels is not feasible at this stage of technique, regulations and demand.

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1. Introduction

The Port of Rotterdam Authority has identified a pressing need to analyze and improve shore power facilities for inland freight vessels and river cruise vessels. Shore power, the provision of electrical power to a ship at berth from a source based on the land, plays a pivotal role in reducing emissions and ensuring sustainable operations in ports. As ships turn to electricity for their power needs while docked, it is imperative to have a standardized and efficient shore power system in place.

This study was commissioned as part of a subsidy project endorsed by the Ministry of Infrastructure and Water Management, with references made to decisions dated 16th December 2021, 31st March 2022, and 15th March 2023. Our aim is threefold:

1. To conduct a comprehensive shore power analysis for inland freight vessels and river cruise ships and subsequently draft recommendations for the establishment and implementation of a national standard for low-voltage (LV) connections for such vessels in the Netherlands.
2. To inventory from the ship's side: capturing current and future technical capabilities and requirements, encompassing a consultation with key stakeholders such as shipping companies, ship owners, shipbuilders, and shipyards. This segment also explores into prevailing energy consumption patterns and shore power connections, and developments in onboard hybrid systems.
3. From the shore side: gathering insights from various ports, especially in Western Europe and from the Association of Seaports, supplemented with relevant inland ports, This study is based on the analysis of existing regulations, safety requirements, standards, and pilot projects to understand the current status of shore power facilities and standards.

This report presents findings from the abovementioned analysis and the report provides insight into the possibilities of combining shore power for both inland waterway vessels and the segment of sea vessels requiring low voltage connections.

2. Methodology

This chapter outlines the methods and procedures we used to gather and analyze data, ensuring our conclusions are robust and actionable.

- Ongoing Projects, Publications, and Activities Related to Shore Power for Inland Waterway Vessels and Ports. We undertook a systematic review of current projects, publications, and activities focusing on shore power. This gave us a clear perspective on the ongoing efforts and innovations in the field.
- Regulations for Shore Power for Inland Vessels - National and European. We explored into both national and European regulations governing shore power for inland vessels. This helped us discern the regulatory landscape and identify areas of alignment and potential conflict.
- Shore Power Standards for Inland Waterway Vessels. Through literature studies, we explored the prevailing standards for inland waterway vessels. We aimed to understand the existing norms and their impact on the implementation of shore power solutions.
- Shore Power Standards for Low Voltage for Sea Vessels. We extended our research to study the standards associated with low voltage shore power for sea vessels. This deep dive allowed us to gauge the nuances and specificities of these standards.
- Comparing the Standards for Inland Vessels and Low Voltage Sea Vessels. A comparative analysis was conducted to highlight similarities, differences, and potential areas of synergy between the standards for inland vessels and those for low voltage sea vessels.
- Compatibility Challenges Between Inland Waterway and Sea-going Vessels. Given the distinct nature of inland waterway and sea-going vessels, we explored the compatibility challenges they face when adopting shore power. This provided insights into potential hurdles.

All the above-mentioned steps were explored through:

- Literature Studies: We reviewed existing literature, including academic papers, industry reports, and regulatory documents, to get a holistic understanding of each topic.
- Interviews: Structured interviews were conducted with industry experts, ship owners, and other stakeholders to gain in-depth insights and firsthand accounts.
- Workshops with DNV: Collaborative workshops were organized with DNV, leveraging their expertise to dive deeper into the topics and foster discussions that led to concrete findings.

3. Ongoing projects, publications, and activities related to shore power for inland waterway vessels and ports:

Shore power, also known as cold ironing and Onshore Power Supply, is an important solution for reducing emissions and promoting sustainability in the maritime industry. It involves providing electrical power to ships while they are docked at ports or terminals, enabling them to turn off their onboard generators and utilize cleaner energy sources. Inland waterway vessels, which operate on rivers, canals, and other waterways, are also adopting shore power systems to mitigate environmental impacts.

> *Onshore Power Supply (OPS), have been installed in various locations in Arnhem and Nijmegen through funding provided by the national air quality program (NSL). These OPS installations enable the* ***connection*** *of both river cruise ships and* ***inland waterway freight ships****.*
>
> *In Nijmegen, there are multiple OPS cabinets located at the Waalkade quay. These cabinets offer a range of connections, including* ***230V/16A****,* ***400V/32A****,* ***400V/63A****, and* ***400V/125A****. Additionally, each cabinet is equipped with a* ***Powerlock connection (400V/400A)****. The cabinets have the capacity to connect* ***multiple cargo ships simultaneously*** *or* ***a single river cruise ship****. Similarly, in Arnhem, OPS has been implemented at the Nieuwe Kade and more recently (2019) at the Nieuwe Haven.*
>
> *In 2019 a total of approximately 1 million kWh was delivered to ships in Arnhem, and more than 500,000 kWh in Nijmegen*

Ongoing projects, publications, and activities focused on shore power for inland waterway vessels and ports play a crucial role in advancing this technology and driving its implementation.

The following ongoing projects, publications, and activities were identified and reviewed during the study:

1. Project: "Versnelling Uitrol Walstroom" (Accelerating the Rollout of Shore Power)
   - Partners: Havenbedrijven Amsterdam en Rotterdam, KVNR, StenaLine, Ministry of Infrastructure and Water Management
   - Objective: Improve the commercial rollout of shore power for both sea and inland waterway vessels in Dutch ports, with a focus on standardized low-voltage shore power connections.
   - Activities: Development of recommendations, analysis of technical requirements, exploration of synergies with international standards, and collaboration with maritime advisory firms.
2. Publication: "Quickscan walstroom 2.0 voor binnenvaart" (Quickscan Shore Power 2.0 for Inland Navigation)
   - Conducted by: RHDHV (Royal HaskoningDHV)
   - Focus: Examines the potential for implementing shore power for inland waterway vessels, including the need for higher energy demands, synergy with international standards, and benefits for container terminals.
3. Research: European Union's Directive 2014/94/EU and the AFIR.
   - Objective: Establishes a framework for the deployment of alternative fuels infrastructure, including shore power, for inland waterway vessels.
   - Activities: Setting requirements, promoting harmonization, and supporting the development of infrastructure and technical standards.
4. Activity: International Electrotechnical Commission (IEC) Standardization Efforts
   - Objective: Prepare proposals for standardized low-voltage shore power connections for inland waterway vessels within the IEC framework.

- Activities: Collaboration with maritime advisory firms, gathering insights from stakeholders, and presenting recommendations in the IEC context.

5. Project: Central Commission for the Navigation of the Rhine (CCNR)
    - Objective: Establish standards for shore power connections and electrical installations for inland navigation vessels on the Rhine and other European waterways.
    - Activities: Developing technical requirements, safety guidelines, and interoperability standards for shore power systems.

4. Regulations for Shore Power for Inland Vessels:

This chapter presents an overview on the main regulations which are relevant for on shore power for inland vessels. The following regulations are described in more detail in this chapter:

- COMMISSION RECOMMENDATION 2006/339/EC
- Guideline shore-side electricity inland shipping" Nationale Havenraad (2009)
- Directive 2014/94/EU: on the deployment of alternative fuels infrastructure
- European Standard laying down Technical Requirements for Inland Navigation vessels (ES-TRIN) 2023/1
- International Carriage of Dangerous Goods by Inland Waterways (ADN 2023)
- Alternative Fuels Infrastructure Regulations (AFIR)

COMMISSION RECOMMENDATION 2006/339/EC

This document is a recommendation from the European Commission to the Member States on how to promote the use of shore-side electricity for ships at berth in ports. The document explains the benefits of shore-side electricity for reducing air pollution, noise and greenhouse gas emissions from ships, and provides advice on the technical requirements, costs and cost-effectiveness of installing and using shore-side electricity. The document also urges the Member States to work within the International Maritime Organization to develop harmonized standards for shore-side electrical connections, and to report to the Commission on their actions to reduce ship emissions in ports.

The document mentions that shore-side electricity is also well suited to inland vessels, but does not provide any specific details or guidance for this type of ships.

"Guideline shore-side electricity inland shipping" Nationale Havenraad (2009)

This guideline stipulates specifics for :

- Shore-side electricity: A way to provide electricity to ships at berth in ports, reducing their need to run engines and generators, and thus lowering air pollution, noise and greenhouse gas emissions.
- Technical requirements: The standards and specifications for shore-side electricity infrastructure, such as voltage, frequency, capacity, connectors, meters and safety measures.
- Costs and cost-effectiveness: The factors that influence the costs of installing and using shore-side electricity, such as demand, location, network capacity, tariffs and subsidies. The benefits of shore-side electricity for public health, environment and climate change.
- Recommendations: The actions that the Member States should take to promote the use of shore-side electricity, such as providing incentives, facilitating permits, ensuring compatibility, cooperating with stakeholders and reporting to the Commission.

The document states that shore-side electricity is intended to provide electricity to ships at berth in ports, reducing their need to run engines and generators, and thus lowering air pollution, noise and greenhouse gas emissions. **Shore-side electricity can be used for various purposes on board the ships, such as lighting, heating, cooling, ventilation, communication, navigation, security and entertainment**. However, the document also notes that **shore-side electricity may not be sufficient for some specific uses, such as refrigeration of cargo or operation of deck machinery**. In these cases, the ships may still need to use their own power sources or alternative solutions.

The guideline suggests that a standard connection cabinet typically contains multiple connections, with a standard 5-pole CEE socket of 63A, 400V. Other cables with different ratings (32A, 16A, 400V, or 230V) should be accommodated using corresponding sockets in the cabinet. However, safe connection for 230V cables to 5-pole CEE sockets may not always be possible. The sockets should feature nickel-plated contact bushings.

For river cruise connections, a transformer station is typically required, the size of which depends on the number of river cruise berths to be supplied. The design powers are: 200kVA (1 berth), 360kVA (2 berths), 520kVA (3 berths), and so on. The river cruise connections themselves can be placed either in the transformer station or in a separate cabinet on the quay. Ideally, the connections should be as close to the ship's connection point as possible due to the limited length of the cable. River cruise connections use the powerlock system (400A, 400V) or one or more CEE 400V, 125A, 5-pole sockets.

Directive 2014/94/EU: on the deployment of alternative fuels infrastructure

This document is a directive from the European Parliament and the Council of the European Union, which aims to promote the use of alternative fuels, including shore power, in the transport sector and the deployment of the relevant infrastructure. The document sets out minimum requirements for the building-up of alternative fuels infrastructure, such as recharging points for electric vehicles and refueling points for natural gas and hydrogen, as well as common technical specifications and user information requirements. The document also requires Member States to adopt national policy frameworks outlining their targets, objectives and measures for the development of the alternative fuels market.

The document mentions that shore-side electricity supply can serve maritime and inland waterway transport as clean power supply, in particular in ports where air quality or noise levels are poor.

The document requires Member States to assess the need for shore-side electricity supply in their national policy frameworks, and to install it as a priority in ports of the TEN-T Core Network by 31 December 2025. The document also provides technical specifications for shore-side electricity supply installations for maritime transport. For inland navigation this is limited to only a short sentence in Annex-II (Technical specifications)- point 1.8. “Shore-side electricity supply for inland waterway vessels”. No reference is made to a standard.

In the communication COM(2019) 598 final point 1.8 of Annex-II is amended (EU 2019/1745) as follows “The standard EN **15869-2** ‘Inland navigation vessels - Electrical shore connection, three phase current 400 V, up to **63 A**, 50 Hz - Part 2: Onshore unit, safety requirements’” or standard **EN 16840** "Inland navigation vessels - Electrical shore connection, three phase current 400 V, at least 250 A, 50 Hz" depending on energy requirements.

European Standard laying down Technical Requirements for Inland Navigation vessels (ES-TRIN) 2023/1

ES-TRIN stands for European Standard laying down Technical Requirements for Inland Navigation vessels. It is a standard that contains the technical requirements necessary to ensure the safety of inland navigation vessels on European inland waterways. The standard includes provisions for the construction, equipment, and outfitting of inland vessels, specific provisions for certain categories of vessels such as passenger ships and container ships, provisions concerning the model of the inland ship certificate, and instructions for the application of the technical standard. The CESNI Committee has regularly updated and published ES-TRIN since 2015.

Article 10.08 of the ES-STRIN (2023/1) is about the electrical connection to the shore or other external networks. It specifies the requirements for the feed-in unit, the earthing connection, the protective devices, the indicator devices, the panel and the sockets for connecting the onboard electrical installations to an external power source. It also refers to some European Standards that apply for different current levels and types of cables.

Article 10.08:

1. The feed-in unit, that is the entire onboard equipment for transferring electrical power to the craft, must be designed as follows:
    a. Transfer from shoreside power supply systems:
        i. For **currents up to 125 A**, the requirements of European Standards **EN 15869-1 : 2019** and **EN 15869-3 : 2019** are to be complied with.
        ii. For **currents greater than 250 A**, the requirements of European Standards **EN16840 : 2017** are to be complied with.

International Carriage of Dangerous Goods by Inland Waterways (ADN 2023)

The ADN 2023, which stands for the European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways contains general provisions and regulations for the transport of dangerous goods by inland waterways.

The use of movable electrical cables in the protected zone is prohibited. However, this does not apply to intrinsically safe power circuits or for the connection amount others the onboard power network of a ship with shore power; provided that:

a) the electrical cables and power unit comply with an approved standard (e.g., **EN 15869-03:2019**);

b) The power unit and connections are **located outside the protected zone**.

Connecting and disconnecting plugs/sockets is only possible when they are not under voltage. Additionally, the use of electrical cables to connect a ship's electrical system to **shore power is not allowed during loading or unloading of substances that require explosion protection** or when the **ship is in or directly adjacent to an onshore designated zone**.

Alternative Fuels Infrastructure Regulations (AFIR)

Alternative Fuel Infrastructure Regulation(AFIR) is a proposal by the European Union to support the deployment of alternative fuel infrastructure for all modes of transport in Europe. The AFIR proposal is part of the 'Fit for 55' package, which aims to enable the EU to reduce its net greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels and to achieve climate neutrality in 2050.

The main objectives of the AFIR are threefold: to ensure that there is a **sufficient infrastructure network** for recharging or refueling road vehicles or ships with alternative fuels, to **provide alternative solutions so that vessels at berth and stationary aircraft do not need to keep their engines running**, and to **achieve full interoperability throughout the EU** and make sure that the infrastructure is easy to use.

According to article 10 of the AFIR, Member States are required to ensure that **all TEN-T core inland waterway ports have at least one installation providing shore-side electricity supply to inland waterway vessels by January 1, 2025**. Additionally, all TEN-T comprehensive inland waterway ports must have at least one installation providing shore-side electricity supply to inland waterway vessels by January 1, 2030.

Specific details on the standards to be used are mentioned in **ANNEX II 4.4.2**

Annex II Technical specifications:

4. Technical specifications for electricity supply for maritime transport and inland navigation

4.2. Shore-side electricity supply for inland waterway vessels shall comply at least with the standard **EN 15869-2:2019** or standard **EN 16840:2017** depending on energy requirements.

4.6. Technical specifications for vessel-to-port grid communication interface in automated onshore power supply (OPS) and battery recharging systems for inland navigation vessels

Summary

The outlined regulations and guidelines establish a comprehensive framework for the transition towards shore power in inland vessels. The collective aim is to reduce greenhouse gas emissions, and minimize air and noise pollution in ports, while promoting energy efficiency. Each document provides guidance on the technical, safety, and cost-related aspects of implementing shore power, with an emphasis on harmonizing standards and ensuring adequate infrastructure.

The table below serves as a summary of the significant regulations and guidelines related to the implementation of shore-side electricity for inland vessels. Each entry highlights a specific document, its main objective, referred standards, and electrical specifications.

Regulation / Guideline	Purpose	Standards	Voltage (V)	Current (A)
COMMISSION RECOMMENDATION 2006/339/EC	Encourage the use of shore-side electricity for ships at berth in ports	Not specified	Not specified	Not specified
Guideline shore-side electricity inland shipping, Nationale Havenraad (2009)	Define specifications for shore-side electricity, including technical requirements, costs and cost-effectiveness	Not specified	400V, 230V	63A, 32A, 16A
Directive 2014/94/EU	Promote the use of alternative fuels, including shore power, in the transport sector and the deployment of relevant infrastructure	EN 15869-2, EN 16840	400V	Not specified
ES-TRIN 2023/1	Ensure the safety of inland navigation vessels on European inland waterways	EN 15869-1, EN 15869-3, EN16840	400V	Up to 125A, > 250A
ADN 2023	Regulate the transport of dangerous goods by inland waterways	EN 15869-03	Not specified	Not specified
Alternative Fuels Infrastructure Regulations (AFIR)	Support the deployment of alternative fuel infrastructure for all modes of transport in Europe	EN 15869-2, EN 16840	Not specified	Not specified

5. Shore Power Standards for Inland Waterway Vessels

This chapter presents an overview on the standards which are relevant for on shore power for inland vessels and compares the standards. The focus of the research being conducted is to determine if there is potential synergy in shore power provision at ports between sea vessels and inland vessels using Onshore Power Supply (OPS). The potential for this synergy is largely dependent on the compatibility of standards applicable to both types of vessels.

In this chapter, we will present the findings of the investigation on the compatibility of the standards EN 15869-1:2019 and EN 16840 for inland navigation, and their relationship with the IEC 80000-3 standard for seagoing vessels under low voltage.

The **degree of compatibility between these standards** will influence the interoperability of inland and seagoing infrastructure, affecting not only the technical aspects of shore power implementation but also its cost-effectiveness, feasibility, and overall industry acceptance.

Through an in-depth analysis of these standards, we aim to provide insights into the potential for harmonization of shore power standards for both inland and seagoing vessels, which is crucial for realizing a seamless transition towards this sustainable energy source.

EN 15869-1:2019 Inland navigation vessels. Electrical shore connection, three phase current 400 V, 50 Hz, up to 125 A General requirements

The EN 15869-1:2019 is a European Standard that applies to inland navigation vessels, particularly focusing on their electrical shore connections. Here's a summary of the main elements of the document:

- **Scope:** This standard specifies requirements for electrical installations for the shore supply of **berthing inland navigation vessels** with electrical energy, **three-phase current 400 V, 50 Hz with a rated current of up to 125 A**. It applies to the supply of inland navigation vessels in ports and moorings for commercial inland navigation and provides information on billing procedures.
- **Purpose:** The standard is designed to enable vessels to **use a shore-based power supply when berthed**, reducing noise and exhaust pollution caused by the continuous operation of on-board generators. This requires a **uniform Europe-wide shore connection** that can be activated and deactivated by the vessel's crew without assistance from shore-based personnel. The standard contains electrical safety requirements to prevent hazards when using and breaking the shore connection.
- **Components:** The electrical shore connection consists of the power supply station, shore connection cable, and feeding unit.
- **Electrical Characteristics:** The electrical shore connection is designed for a minimum three-phase current of **400 V, 50 Hz**, 32 A. There are additional options for three-phase connections for 63 A and **125 A** and a single-phase connection for **230 V, 16 A**.
- **Activation:** The shore connection unit can only be energized via an activation medium and it should be possible to start and stop the electrical power supply at any time without assistance from shore-side personnel.
- **Related Standards and Documents:** It mentions related standards like **EN 15869-2** and **EN 15869-3** (for on-shore unit and on-board unit additional requirements), **EN 60309-1**, and **EN 60309-2** (for plugs, socket-outlets, and couplers for industrial purposes).
- **Terms and Definitions:** The document provides definitions for key terms like "electrical shore connection," "power supply station," "shore connection unit," "activation medium," "feeding unit," "on-board network," and "shore connection cable."

In conclusion, the standard provides comprehensive guidelines for the implementation, use, and billing of electrical shore connections for inland navigation vessels single-phase connection for 230 V, 16 A, a minimum three-phase current of 400 V, 50 Hz, 32 A, 63 A and 125 A.

EN 15869-2:2019 Inland navigation vessels. Electrical shore connection, three phase current 400 V, 50 Hz, up to 125 A On-shore unit, additional requirements

The standard **EN 15869-2:2019** applies in connection with **EN 15869-1** to the supply of electrical energy to docked inland navigation vessels and **sets additional requirements for the on-shore unit** of the **electrical shore connection** with the maximum operating current to 125 A. The operating instructions have been aligned with the requirements of **EN 16840**.

- **Scope:** The scope of **EN 15869-2:2019 is to set additional specifications for the on-shore unit** of the electrical shore connection system used to supply electricity to berthed inland navigation vessels.
- **Purpose:** The aim of the standard is **in line with EN 15869-1:2029** to reduce environmental pollution, specifically noise and exhaust emissions from onboard diesel generators, which tend to continue operating even when **vessels are berthed**. The standard accomplishes this by **detailing requirements for an on-shore electrical power supply** that allows vessels to switch off their generators while docked, reducing both noise and air pollution. The specifications ensure the uniformity of connections across Europe, making it easy for the vessel's crew to activate and deactivate the shore connection without the need for assistance from on-shore personnel. Additionally, the **standard includes electrical safety requirements** to prevent hazards when connecting and disconnecting shore power supplies.
- **Components:** A shore connection unit consists of a circuit breaker/s, residual current operated circuit breaker/s (RCCB) type A or F and socket-outlet/s according to EN 15869-1, three-phase meter and activation medium. **Technical measures shall be taken to ensure that only one of the existing socket-outlets can be activated at each shore connection unit**. Circuit breaker, residual current operated circuit breaker (RCCB) and socket-outlets shall be protected against misuse.
- **Electrical Characteristics:** The electrical shore connection is in line with EN 15869-1:2029 designed for a minimum three-phase current of **400 V, 50 Hz**, 32 A. There are additional options for three-phase connections for 63 A and **125 A** and a single-phase connection for **230 V, 16 A**.
- **Related Standards and Documents:** The EN 15869-2:2019 standard supersedes EN 15869-2:2010 and is part of the EN 15869 series in connection with EN 15869-1:2019. The Operating instructions" are aligned with requirements of EN 16840. The standard refers to a series of documents that inform its content and requirements. These include EN 60529 regarding enclosure protection degrees, and HD 60364-7-730, which details requirements for onshore units of electrical shore connections for inland navigation vessels.
- **Requirements:**
    a. General: The power supply station should have a three-phase line protection fuse, overvoltage protection, and one or more shore connection units. Technical measures should ensure that only one socket-outlet can be activated per shore connection unit. Protection against misuse is essential.
    b. Lighting: The power supply station should have enough lighting to illuminate the control elements, operating instructions, plug-in connectors, and three-phase meter.
    c. Mechanical and environmental requirements: The power supply station should be flame retardant, firmly mounted, and should not be possible to open with common tools. The power supply station should operate at an ambient temperature of -20 °C to +60 °C and have at least an IP 54 degree of protection.
    d. Electrical safety: The power supply station should meet the requirements of HD 60364-7-730.
    e. Operating instructions: Clear and legible instructions for users should be provided, detailing necessary operating steps and key information.
    f. Other provisions: Ergonomics should be considered for any controls. The manufacturer should provide installation instructions, maintenance guidelines, and ensure the safety of the power supply station.

In conclusion, EN 15869-2:2019, together with EN 15869-1, provides comprehensive guidelines for the supply of electricity to docked inland navigation vessels from on-shore units, with a focus on those with an operating current up to 125A. The detailed specifications set out in EN 15869-2:2019 aim to standardize connections across Europe It also contains provisions for electrical safety to minimize hazards during the connection and disconnection process.

EN 15869-3:2019

EN 15869-3:2019 is a European standard addressing electrical shore connections for inland navigation vessels. It focuses on technical specifications for three-phase currents of 400V, 50Hz, up to 125A. Here are the main elements addressed:

- **Scope:** The document provides supplementary requirements for the shore connection cable and the feeding unit of the electrical shore connection in relation to EN 15869-1.
- **Normative References:** The document refers to other relevant standards and documents, including EN 15869-1, EN 50525-2-21, EN 50363-2-1, EN 60309-1, HD 60364-5-51, EN 60529, EN 60811-403, EN 60811-404, EN 61558-2-4, and others.
- **Terms and Definitions:** This section clarifies the terms and definitions used throughout the document.
- **Requirements:**
    a. Types of the shore connection cable (Type A and Type B).
    b. Detailed specifications for the shore connection cable, including general requirements, guidelines for laying, and extensions.
        i. A flexible cable according to EN 50525-2-21 shall be used for a shore connection cable according to this European Standard.
        ii. For the laying of the shore connection cable the risk particularly of back injury to workers involved in the manual handling of loads shall be minimized, for further information see EU Council Directive 90/269/EEC.
        iii. It is therefore recommended to select the cable length such that the mass of one single shore connection cable does not exceed 20 kg.
        iv. For heavier cables, mobile cable reels should be used
    c. Comprehensive specifications for the feeding unit, including general, mechanical, and electrical requirements. It also provides guidelines for the connection of the isolating transformer and operating instructions.
        i. The feeding unit contains a rotating field direction indicator with an optional phase sequence changeover switch, an all pole switch, an isolating transformer, a three-phase circuit breaker, an indicator light, and an electrical interlock against on-board supply system generators.
        ii. The feeding unit shall be connected to the main switchboard by an isolating transformer in accordance with EN 61558-2-4.

    d. Circuit Breaker: Circuit-breaker according to EN 15869-2 with trip current type C according to EN 60898-1.
    e. Operating Instructions: Clearly legible operating instructions shall be provided for the crew personnel which explain the necessary operating steps.
- **Designation:** This section outlines how to designate the shore connection cable and feeding unit according to the standard.
- **Annex A:** Informative annex providing details about the maximum length of the shore connection cable according to different circumstances.

Interlinking of the Standards:

The three standards in the EN 15869 series are interconnected and form a cohesive set of requirements for electrical shore connection systems in inland navigation vessels. They build upon each other to provide a comprehensive framework for the design, installation, operation, and safety of the systems. Here's how they interlink:

EN 15869-1 sets the general requirements and forms the foundation for the series. It establishes the overall framework and principles for electrical shore connection systems.

EN 15869-2 expands on EN 15869-1 by specifying additional requirements for the on-shore unit. It provides more detailed guidelines for aspects specific to the power supply station, ensuring the safe and efficient operation of the on-shore unit.

EN 15869-3 complements EN 15869-1 and EN 15869-2 by focusing on the shore connection cable and feeding unit. It provides specific requirements for these components, including cable types, cable properties, feeding unit design, operating instructions, and marking. EN 15869-3 completes the set of standards by addressing the essential aspects related to the shore connection cable and feeding unit.

Together, these three standards create a comprehensive set of requirements for electrical shore connection systems in inland navigation vessels. They cover the overall system, the on-shore unit, and the shore connection cable with its feeding unit, ensuring the safe, efficient, and standardized provision of electrical power while berthed, thereby reducing noise and exhaust pollution.

EN 16840:2017

EN 16840:2017 is a European Standard that specifies requirements for electrical installations used to supply electrical power to inland navigation vessels while they are in port. The standard focuses on the electrical shore connection, which provides a land-based source of electrical power to the vessel. It aims to address issues such as noise pollution, exhaust emissions, and the need for a uniform on-shore connection across different harbors.

Here are some key points from the standard:

Scope: The standard applies to electrical installations that supply **three-phase AC power at 400 V, 50 Hz, and a rated current of at least 250 A** to vessels in port.

Components: The electrical shore connection consists of several components, including a charging station, transfer station (optional), on-board connecting cables, and an on-board rectifier unit.

Basic Safety Requirements: The standard specifies general safety requirements, including the use of enclosed plug-in connectors with disengaging interlocking mechanisms, specific sequencing for establishing and disconnecting connections, and on-shore connection monitoring to ensure proper connection and disconnection.

Mechanical and Electrical Specifications: The standard provides specifications for the design, layout, and temperature range of the charging station, transfer station (if applicable), on-shore connecting cables, and on-board rectifier unit.

Operating Instructions and Labeling: The standard requires clear operating instructions to be provided, explaining the necessary steps for safe operation. Permanent labeling on the components, such as the charging station, on-shore connecting cables, and on-board rectifier unit, is also required.

The standard includes annexes that provide additional information, such as the general and safety requirements for the shore-based section (Annex A), specifications for on-board connecting cables and the on-board rectifier unit (Annex B), and dimensions for on-shore connection cables (Annex C). It also includes a bibliography with references to related standards and documents.

Key points for the task:

4.2 Electrical characteristics: The electrical shore connection shall be rated **for 400 V, 50 Hz and at least 250 A current**. If higher **currents are required, all components of the electrical shore connection shall be rated for these values**.

4.3.2 Plug-in connectors: Sockets, plugs, on-board plugs and on-board couplings shall be enclosed plug-in connectors with disengaging interlocking mechanisms as per **EN 61984**. Plug-in connections for different rated currents cannot be connected to one another. A connection can only be established in the sequence PE, N, L1, L2, L3 and a disconnection only be possible in the sequence L3, L2, L1, N, PE.

4.3.3 On-shore Connection Monitoring: the current can only be switched on when all five on-shore connection cables are plugged in and locked both on board and on shore.

A.3: Electrical safety: The requirements of HD 60364-7-730

A.4: Further connections: Connections shall be available in the charging station or in the transfer station according to EN 15869-2 for 125 A, 63 A, 32 A and 16 A.

B.1.2 Selection: On-shore connecting cables shall use a single-core, flexible, heavy-duty H07RN-F hose line according to EN 50525-2-21, or a cable which is at least equivalent to this as the cable type. IEC/IEEE 80005-3

The IEC/IEEE 80005-3 standard establishes requirements for High Voltage Shore Connection (HVSC) and Low Voltage Shore Connection (LVSC) systems for providing power supply to ships in port. The relevant chapters of standard are summarized below:

Chapter 1 provides general provisions about the standard and its applicability. It describes the a the scope of the IEC/IEEE 80005-3 standard for low voltage shore connection (LVSC) systems. These systems supply ships with electrical power from shore, and the standard covers design, installation, testing, various subsystems, and specific voltage limits. The standard excludes electrical power supply during docking periods and does not apply to marinas and boatyards. Certain applications may require additional or alternative rules from various authorities.

Chapter 4 is a comprehensive set of general requirements, compatibility assessments, system design, operation, and safety details for the implementation and operation of low voltage shore connection (LVSC) systems, as stipulated by the IEC/IEEE 80005-3 standard. This includes detailed specifications about equipotential bonding, personnel safety, system compatibility, LVSC equipment location and construction, system studies and calculations, and emergency shutdown procedures. It also references several other standards and offers further guidance on ship and shore power connections.

Chapter 5 focuses on ship requirements and design of the ship-side electrical power system, including installation, protection, and control requirements. It covers aspects like grounding, synchronization, compatibility with shore power supply, and connection procedures.

Here are the key points:

- Voltages and Frequencies: Nominal voltage for LV shore connections should be 400V, 440V or 690V as per IEC 60092-201.
- The operating frequencies of the ship and shore electrical systems should match; if not, a frequency converter should be used on shore.
- The phase sequence at the connection point should be L1-L2-L3, 1-2-3, A-B-C or R-S-T, rotating counter-clockwise. A phase sequence indicator must confirm the correct sequence before energizing or paralleling LVSC.
- Quality of LV Shore Supply: The system must have a documented voltage supply quality specification. Ships can only connect to shore supplies that maintain specified voltage, frequency, and total harmonic distortion characteristics. Voltage and frequency tolerances are described.

Chapter 6 elaborates on the shore-side system design and requirements. It details how the shore-side system should provide, maintain, and disconnect the electrical supply to the ship.

Chapter 7 discusses in detail the procedure for testing and maintenance of both ship-side and shore-side HVSC systems. It covers requirements for the initial tests, periodic tests, as well as the tests for ensuring the compatibility between ship-side and shore-side systems.

Chapter 8 outlines the requirements and recommendations for various safety aspects of LVSC systems, including their operation, personal safety, and fire protection measures. This section covers ship requirements, particularly related to electrical and power systems. It provides specific rules and guidelines to ensure that these systems are safely installed, operated, and maintained.

Chapter 9 details about the LVSC system control and monitoring. It outlines the general requirements for protecting ship equipment and control systems, as well as the procedures for load transfer between shore supply and ship generators, either via blackout or automatic synchronization.

Chapter 10: describes verification and testing requirements for the LVSC system, including initial tests of shore-side and ship-side installations, and testing at the first call at a shore supply point. It provides a list of tests that should be performed to ensure system compliance with the standard.

Chapter 11 discusses procedures for periodic tests and maintenance. It stipulates that a record of maintenance and repairs should be maintained for both shore-side and ship-side systems.

Chapter 12 requires manufacturers to provide detailed documentation about the system operation, specifications, startup procedures, fault-finding procedures, maintenance, and repair procedures.

Comparing EN 16840:2017 and IEEE 80005-3

Differences between EN 16840:2017 and IEEE 80005-3 are as flow:

- Covering Low Voltage (LV) shore power supply to vessels in ports with a voltage of 400V. Using higher voltages is only possible within the IEEE 80005-3 standard. The EN 16840:2017 does not allow higher voltages for safety reasons.
- The current power is for both standards for 250A and above. However, in EN 16840:2017 lower currents 16A, 32A, 63A and 125A are part of the standard. For the IEEE 80005-3, this is not the case. IEEE 80005-3 is limited to 250A and above.
- Plug-in connectors, sockets, plugs, on-board plugs and on-board couplings shall be enclosed plug-in connectors with disengaging interlocking mechanisms as per EN 61984.

6. Compatibility Challenges Between Inland Waterway and Sea-going Vessels

Maritime transportation comprises a variety of vessel types, each designed and operated based on their specific requirements and the environments they operate in. Among these, the distinction between inland waterway vessels and sea-going vessels is of particular importance when considering shore power connections. This chapter delves into the compatibility challenges arising from the inherent differences between these two vessel types.

1. Differing Standards and Regulations

   Inland waterway vessels and sea-going vessels often have different national and international standards. For instance, while inland navigation vessels have adopted the IEC 60309-2 standard for plug and socket connections, sea-going vessels rely on IEC 60309-5. These standards have different specifications, leading to incompatible plug and socket connections.

   Furthermore, the IEC/IEEE 80005-3 standard, which is currently in draft form and subject to changes, does not explicitly exclude inland shipping. Though traditionally understood for sea-going vessels, its application for inland vessels remains uncertain. Given its draft status, it is advisable to address this uncertainty in final reports, referencing the EU Regulation on the deployment of alternative fuels infrastructure, which differentiates between sea-going and inland navigation vessels.

2. Power and Design Variations

   The power demands between inland and sea-going vessels can differ due to their size, operational activities, and onboard machinery. Moreover, vessels designed for inland waterways will have different features compared to those traversing open seas, affecting the requirements for shore-based infrastructure.

3. Electrical Specifications

   The electrical specifications for shore connections vary. While the EN 16840:2017 standard only permits voltages up to 400V, the IEC/IEEE 80005-3 allows for higher voltages, such as 690V. For inland navigation vessels, their trading areas correspond with the voltage level and frequency of European Ports they visit, making shore connections efficient. In contrast, sea-going vessels often operate at 440V at 60Hz.

   The EN 16840:2017 also specifies the availability of lower current strengths than 250A, such as 16A, 32A, 63A, and 125A. The IEC/IEEE 80005-3 standard, however, follows a distinct concept, defining a default plug and socket connection with a particular nominal current rating.

4. Operational and Safety Concerns

   Different vessel types can lead to varied safety concerns, especially when attempting to use a shore power connection intended for one vessel type on another. It is thus crucial to ensure that the implemented systems are safe and compatible with the vessels they are intended for.

5. Grid Configurations:

   While both standards aim to facilitate safe and efficient shore power connections, they have distinct requirements. The inland navigation standard is more flexible when it comes to grid configurations. It allows for IT, TN, and TT configurations, providing versatility based on specific needs, operational scenarios, and existing infrastructure.

   On the other hand, the IEC/IEEE 80005-3 standard is specific in its requirements, mandating the use of an IT-grid for shore supply. The preference for the IT-grid system arises from its resilience to initial faults, ensuring that power supply remains uninterrupted in the event of a single fault. This characteristic is particularly valuable in shore supply scenarios, minimizing disruptions and potential hazards.

6. Operation and handling:

For inland navigation vessels, the rules allow any regular person to use the shore power connection. This shows that these systems are designed to be user-friendly. On the other hand, the IEC/IEEE 80005-3 guidelines have stricter rules. They say that their systems are not meant for just anyone. In the standards IEV 826-18-03 and IEV 195-04-03, a regular person is described as someone who doesn't have special training or hasn't been taught how to use the system.

7. Future demand for shore power for future inland vessels

Based on interviews with shipowners, shipyards, system integrators, and other pivotal industry players, we have been able to gather insights, experiences, and perspectives about the current and future demand of shore power for inland waterway vessels. .

The findings from these interviews underscore the present realities and future potential of shore power for inland vessels as following:

1. Current Power Needs and Shore Power Standards:

   Interviews conducted indicated that the supply of shore power in accordance with EN 15869 and EN 16480:2017 suffices the present power demands of inland vessels.

2. Limitations for High Energy Demand Vessels:

   Vessels with high energy demand are not able to use shore power. Primarily, their mode of operation (24/7) often involves continuous navigation with minimal stationary periods in ports, to maximize the productivity and thus making shore power less viable. Additionally, certain critical energy converters, especially on tanker vessels for example keeping cargo at a certain temperature, do not have a technical alternative to enable using electricity as energy source for these applications.

   It is also noteworthy that the ES-TRIN regulation prohibits the use of shore power for energy consumers located in the cargo hold of inland vessels.

3. Future Electricity Needs:

   As the inland waterway sector looks towards sustainable solutions like battery and hydrogen propulsion, experts believe that shore power's real potential will be unlocked once vessels are equipped with fixed onboard batteries and only in case the vessels have frequent stationary periods to use on shore power. However, it is yet questionable into what extent such applications will become competitive. This will mainly depend on the expected favorable price and capacity evolutions of (fixed) batteries which is yet to be seen.

4. Regulatory Restrictions:

   Current regulations, including ES-TRIN and ADN, restrict the use of shore power during ship loading and unloading operations. To harness shore power's full potential, especially in the coming years, investigations need to be launched to determine whether these limitations can be lifted without compromising safety.

5. Battery Systems and Shore Power:

   The integration of swappable interchangeable battery container systems with shore power presents unique challenges and opportunities. Vessels incur costs for the energy used from the battery containers and for the duration these containers are onboard. Further research is necessary to understand how shore power fits into this business model, ensuring it remains economically viable. Here it shall be noted that part of the revenues of swappable battery containers (when not on board of vessels) comes from peak-shaving for stabilizing the electricity grid.

Based on these findings and in addition to the points from the previous chapter, **it can be concluded that, for the time being, synergy of shore power between Low Voltage maritime and inland shipping is not yet sufficiently mature. The situation may change in case (fixed) batteries on board for providing energy for propulsion will become a common solution. However, this development is yet uncertain and needs to be seen.**