Smart & Sustainable Ports

An IEEE European Public Policy Committee Position Statement

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Introduction
To decarbonize all human activities, including maritime transportation as envisaged via the Paris Agreement (2015), the Climate Change Conference (COP26) at Glasgow (2021), the European Green Deal and the “Fit-For-55” package of the European Union (EU), and the IMO resolutions, electric energy is considered one of the most readily available alternative energy carriers for the maritime sector. Electrification is considered as an appealing means towards more environmentally friendly waterborne vessels with particular regard to electric propulsion, optimized management of energy sources, and onboard loads. Renewable fuels of non-biological origin, potentially derived from hydrogen, are a viable alternative.

The IEEE European Public Policy Committee (EPPC), representing a large community of European engineering professionals, proposes that European policy makers develop a policy framework for transforming ports from single purpose transportation hubs into sustainable energy-based hubs, mostly via electrification. The policy framework would have the following elements, without limitation:

- Ship-to-shore electric interconnection (“cold ironing”), with
  - Novel power distribution networks comprising power transformers and power converters at ports to handle variable load power demands as well as mismatched frequencies and voltages between the grid service and load requirements;
- Electrification of local support vessels (shuttle ferries, tugs, water taxis, etc.);
- Integration of renewable and sustainable energy sources/fuels and appropriate storage;
- Appropriate adaptation (i.e., upgrade, extension and expansion) of the already existing electric national grids serving transmission and distribution.

Background
In Europe, policy makers are incentivizing the decarbonization of maritime transport through the following proposals:

- Emissions from the maritime transport sector will be covered by the European Emission Trading System. The associated auctioning revenues will be used to support decarbonization efforts in the maritime sector via the Innovation Fund.
- The “Alternative Fuels Infrastructure Regulation” will mandate ports to provide “shore-to-ship electrical interconnections”, and the FuelEU Maritime Regulation will mandate ships to use these shore power facilities. The Regulations, also, allow for alternative solutions for ships at berth, namely the use of batteries, fuel cells, and renewable energy sources.
- The draft delegated act on “Renewable Fuels of Non-Biological Origins” spells out what type of fuels, in particular those derived from hydrogen, can be considered renewable.
- DG ENER and DG MOVE of the European Commission, as well as associations of ports like ESPO and ECSA, have expressed their interest in this concept as a means to render these policy targets a reality. In particular, within DG MOVE, there is a working group named “Sustainable Ports Subgroup (SPS)”, which is concentrating on cultivating the concept of “sustainable smart ports”. It is anticipated that the SPS can be the ideal stakeholder group to discuss the findings of the policy document which is being proposed.

**IEEE Recommendations**

On the technical level, the first major step towards a greener maritime sector is the “ship-to-shore” electric interconnection of ships at berth or alternatively “cold ironing”. According to this concept, when ships are in port, they completely shut down their engines (including their auxiliary engines, i.e., the electric generators), while they are supplied by the inland National Grid. A subsequent second step consists of charging the onboard battery which powers the electric vessels, which is an exceedingly viable alternative to diesel engines for short-sea shipping applications.

The power demand of ships at berth varies from 0.2 MVA up to 20 MVA, depending on their type, size, mission, etc., which requires thorough long-term grid expansion planning. An additional challenge consists in the operating frequency of most ships, which is 60 Hz in contrast to that of the European Grid which is 50 Hz. Meeting the occasionally large power demands at a different frequency can be achieved through a combination of measures such as power electronic converters, along with energy storage systems, renewable or other environmentally friendly energy sources. This can be accompanied by a centralized energy management system which supervises and manages all energy transactions within ports via power digitized tools (e.g., SCADA systems, IIoT technology, smart meters etc.).

In addition, an issue exists of local electric waterborne mobility connected with port electrification. In fact, if we think of ports to be electrified to allow recharging docked electric (hybrid) ships after long sea crossing, we should also consider that harbour supporting vessels such as tugs must be zero-emission and must run on electricity. In water cities (e.g., Venice, Amsterdam, etc.) this concept should extend to the whole city's waterborne mobility, including water buses, water taxis, freight vessels, and private boats. A similar field of application is the inland ports, as the latter provide an alternative means of transportation of goods and people within an urban area.

Within this context of extensive electrification, ports have to be the key link in the hybrid electric transportation and energy chain, facing challenges in terms of providing substantial amounts of energy upon demand as well as a series of innovative energy-related services of superior quality without adverse environmental and societal impact. However, there are a number of issues that need to be faced both from the technical (e.g., stability, resiliency, reliability, power quality, flexibility) and regulatory (e.g., ports and ships in the electric market) points of view. Exploitation of “smart-grid” technologies with some necessary adaptation to the specific circumstances of ports and their end-clients, the ships, seems the ultimate key path towards the development of a “sustainable smart port” concept. In order to better organize the re-engineering project of ports a roadmap has been synthesized. Each step of this roadmap introduces challenges that must be met while there is a brief outline of the way that this can be done.
In summary, the main pillars of this roadmap are:

- Having as foundation stones the resolutions of the International Maritime Organization (IMO) and the European Union, each Member-State of EU develops its policy on the maritime transport affairs including the energy transformation of (sea and inland) ports.

- Future energy demands of ports are calculated based on appropriate long-term load forecasting procedures. Forecasting must take into account the current transportation status of the ports as well as their development plans as they are mapped in the masterplans. Considering the importance and the transportation load of the ports, the core ports are of first priority, followed by the ports of the comprehensive network, and finally all other ports. Load forecasting (in terms of both power and energy) consists of/should consider:
  - Ship-to-shore electrical interconnections. An electronic registry of the electric energy demands of all ships at berth as outlined in IEEE 45.1 is highly recommended as a means to facilitate the load forecasting under discussion.
  - Charging of ships powered by electric batteries.
  - Charging of other energy storage units used, e.g., in electric vehicles of any kind.
  - Taking into consideration any injection from Renewable Energy Sources installed in port areas (e.g., PV’s installed ashore or near-shore, small scale wind-generators, units generating energy from sea-waves etc.) in possible combination with onshore energy storage devices.
  - Meeting Dock lighting energy demands.
  - Meeting the energy demands of cooling in-transit reefers.
  - Meeting the demands of cargo handling cranes (referring to containership quays).
  - Taking into account any other consumers.
  - Taking into account the local production and/or storage of alternative fuels like Hydrogen.

- Network Development plans of the DSO’s and TSO’s are updated taking into account the expansion plans of the ports. The Regulating Authorities of Energy amend the National Energy Strategic Plans accordingly.

- Port infrastructure is designed to be upgraded. Particular attention must be paid to electrical interconnection of ships. Compliance of related equipment with IEC/ISO/IEEE 80005 series of standards ascertains its interoperability in all ports.

- Studies of interconnection the upgraded port distribution grid with the upgraded Distribution and/or Transmission Network are performed. Considering the equipment to be installed in ports (frequency converters, voltage and isolation transformers, etc.) the ship networks that must be synchronized for short time intervals, the smart grid configurations, a series of electrical studies is recommended to be done, e.g.:
  - Load flow and voltage drop analyses.
Insulation coordination study accompanied with other ElectroMagnetic Transient (EMT) studies.
- Harmonic load flow and harmonic resonance studies.
- Short circuit study.
- Dynamic and transient stability study.
- Other special studies due to the smart micro-grid and multi-energy nature of the port networks.

- Electric infrastructure is procured, installed and commissioned.
- A sophisticated Energy Management System enabling the Supervision and Control of Operation of the smart Port electric Grid must be developed. This advanced SCADA system will facilitate Monitoring of all energy transactions via digitalization of power techniques, while it can be exploited as a means to attain “Demand Response” on the port side; in this way, the port and/or its prosumers can be seen as flexible energy aggregators with their adjustable demands being under negotiations.
- Operation of the port and its clients in the energy market is launched. To this end, the ports need to be somehow taken into consideration in the corresponding EU Directives, while an international related policy incentivizing the whole project must be eventually developed.
- Electrical training of the port personnel is performed.

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