LNG and ELECTRIC SHORE POWER infrastructures in the ports of the future: technological solutions for sustainability

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WISE PORT & BUSINESS ENERGY MANAGEMENT: PORT FACILITIES, ELECTRICAL POWER DISTRIBUTION

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Introduction

This presentation highlights the relevance of analyzing the necessary development of the electrical infrastructures of ports and proposes a plan for enhancing and remodeling them.
INTRODUCTION ON PORT FACILITIES

Ports are primarily industrial and commercial areas.

The ports are the interface of maritime transport and are integrated in the surrounding land.
The ports are required to arrange their electrical power distribution systems in a microgrid, adequate even to power the ship from shore.
VENICE

Harbors must have *an energy master plan*. 
The energy service management for electrical distribution systems has to be carried out like a new occasion of economic business by the port authorities.
The harbor areas cannot remain *an assortment of uncoordinated systems*, but need a *comprehensive design and an efficient management* to organize all the users/tenants as a *common power system adequate to the new business of the energy service*. 
The implementation of renewable energies (offshore wind, photovoltaic panels, cogeneration & trigeneration, energy storage, etc.) could be possible with a natural evolution of the electrical systems in a common area of power demand as a microsystem.
This presentation would focus the special requirements, characterizing port facilities so different among industrial facilities, and diverse from many other commercial facilities.
Different activities, related to the type of services offered, usually characterize the ports

Typically, the electrical facilities of a seaport include:

- **Outdoor facilities and civil infrastructure** such as docks, embarking and disembarking passengers and cargo areas;
- **Technical building** - transport terms such as maritime stations, terminals and travel offices, stores, technology and service inside buildings, etc.
- **Buildings and public service facilities** such as control centers and social and health assistance, customs and immigration, etc.
Typically, the electrical facilities of a seaport include:

- **Civil structures for shipbuilding** activities and industrial installations, etc.
- **Cruise Ship Terminals** to accommodate cruising personnel on ships.
- **Container terminals** to accommodate the movement of container loaded goods to and from ships.
Typically, the electrical facilities of a seaport include:

- Oil carriers to accommodate the passage of bunker fluids.
- Marina docks to mooring and supply yachts and small boats.
- **Automated terminals** more and more terminals are becoming almost 100% automated where no humans are used to move container loads within port terminals.
- **Lighting systems** for parking areas, roads, railway sidings, industrial shipbuilding yard etc.
INTRODUCTION ON PORT FACILITIES

All these covered and uncovered areas are equipped and serviced by more or less complex technological systems.

Two special areas are high energy absorbers, the container terminals (cranes and refrigeration container) and the docks for the shore to ship power supply.
The electrical needs and energy consumptions in the port activities are increased over time with many tens of megawatts.
cranes and refrigeration containers
<table>
<thead>
<tr>
<th>Period 2012</th>
<th>Port of Los Angeles</th>
<th>Port of Long Beach</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Annual Energy Consumption</strong></td>
<td>200,000 to 250,000 MWh</td>
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<tr>
<td><strong>Peak Hourly Average Demand</strong></td>
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<td>27 MW</td>
<td>21 MW</td>
</tr>
<tr>
<td><strong>Total Annual Cost of Demand and Energy</strong></td>
<td>$28 to 32 MM</td>
<td>$18 to 22 MM</td>
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OPERATIONAL APPROACH LOOKING TO A GLOBAL PORT

In port areas usually close to residential districts, the risks coming from pollution are caused by sulphur oxides SOx, nitrogen oxide NOx and by particulate matter emissions PM from ship exhausts.
The port management has to take into consideration the shore to ship power systems, which compel the harmonization of the systems to allow supplying power to ships of different technologies.
The development of shore to ship technology is another important feature of port electric grid evolution, with the possibility of reversible utilization as a local generation.

The shore to ship power systems comply with the standard IEC 80005-1 / ISO / IEEE, but many other standardizations are still necessary.
OPERATIONAL APPROACH LOOKING TO A GLOBAL PORT

The shore to ship power system has to allow powering the ships by means of *either 50 Hz or 60 Hz frequency*, therefore, these systems can be replicated at the international level not only in Europe, but worldwide.

The cold ironing requires a dedicated transformer with voltage side of the ship equal to 6.6 kV or 11kV.

**The typical load of cruise ships can take up to 11 MVA, while the load of container ships up to 3 MVA.**
OPERATIONAL APPROACH LOOKING TO A GLOBAL PORT

Block diagram of a typical described HVSC system arrangement.
The connection between the two systems is obtained thanks to sockets, SPO (Shore Power Outlet) placed on the dock by two cables coming from the ship and moved by a lifting member and connected by operators by means of CMS (Cable Management System).
The hole in the wharf is being worked on to complete the vault for installing the SPO box.
ENERGY MASTER PLAN OF PORTS

The complex of power systems in a port is a relevant case of system that needs

• a comprehensive and permanent design
  “Plan-Do-Check-Act” cycle ISO 22313
  Societal security — Business continuity management systems — Guidance

• energy management in a global approach (main innovation)

To meet these goals, Business Continuity Management (BCM) is an essential component to be considered

operational efficiency
ENERGY MASTER PLAN OF PORTS

The BCM is effective to the degree that it recognizes the importance to organize and coordinate with an adequate and qualified technical staff:

- analyzing its objectives and organization needs,

- implementing and operating controls, measures and procedures reducing the energy consumptions, the utilization inefficiency and the loss of continuity service, prompt restoration of faults

- monitoring and reviewing the effectiveness of the same management.
A main matters objective for the BCM is to develop planning guidelines:

- for *new advanced solutions* of the electric infrastructure in port areas;
- for *an integrated utilization* of the services;
- for *compatibility with shore to ship (cold ironing)* power supply systems.
Electrical distribution architecture has a vital impact on power system performances.

Ports require a general planning of predictable developments with a flexible distribution (road map).

architecture efficiency
Advanced configurations are needed by a port area such as:
- the *loop configuration* that requires special design of the protection plan in order to ensure discrimination in all of the fault circumstances.
Advanced configurations are needed by a port area such as:

- a **multiple ended configuration** involving independent sources as the utility and the local renewable ones. Power demand upper to 10 MW it is even recommendable a voltage supply in **HV**

**Supervision and remote control systems** ensure an optimized economic and energy management, increasing the quality and the safety of the services.
A sample of a global distribution in a port
In other words the global distribution in a port can be subdivided in:
- **a main loop of the primary MV** distribution in all the areas,
- **secondary loops-islands** of local MV distribution systems of transformers power stations,
- **tertiary distribution systems** at special MV levels (3, 6, 11 kV own of the port) and LV levels (400 V, 1 kV).
THE PORT AS MICROGRID

Considering the amount of power and the energy consumptions, the management of all the electrical systems such as a *unique advanced grid* is essential to constitute a *wise* system for port areas.

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THE PORT AS MICROGRID

Harbor areas have to be considered as a unique energetic territory and new management business of energy have to be carried out by the port authorities.

All the port systems, fed by a common integrated grid, can be arranged to achieve high degrees of quality and continuity, and save energy as well as reduce costs.
THE PORT AS MICROGRID

The purpose is to promote the creation of micro-grids that would put together environmental necessities with quality of the services, promoting higher levels of:

- **Energy efficiency of the grid**, considering the losses of the system;
- **Load diagram control**, through utilization management, load shedding, recharge of vehicles and eventually storage management, evoluted drive system for the port cranes in order to optimize the energy absorptions, etc.;
- **Quality of energy** (safety and emergency supply);
- **Safety** (new configurations, distribution with non-traditional voltage levels, TN system with local transformers, local ground system, special components).
THE NEEDS OF NEW MANAGEMENT BUSINESS TECHNIQUES

In the last years the European Union has actively promoted the **liberalization of the electricity market** in the Member States and has triggered political campaigns to promote energy efficiency and renewable energy. Similarly in USA “Green Power” is being promoted and encouraged.
THE NEEDS OF NEW MANAGEMENT BUSINESS TECHNIQUES

These energy strategies are able to manage the considerable amount of energy generated and consumed within the port network. The distribution of electricity is still inadequate to meet the new demands of eco-compatibility; however, many regulatory constraints and lack of new directives from management, impede the necessary innovation to meet the new environmental and energy goals.
A new vision: the liberalization of the electricity utilization and the related new rules

the energy efficiency and renewable energy require a new strategy for electric energy utilization, because it is impossible to innovate without regulatory changes.
The suggested microgrid has to remain ever net-load and to guarantee that the power flow of local generation has to be maintained local. The impact on the net supply is reduced and the energy exchanges with impair costs are avoided or limited.
THE NEEDS OF NEW MANAGEMENT
BUSINESS TECHNIQUES

A study of the existing rules and laws for instance, in the area of costs for electrical power consumption, is important to facilitate all organizations involved, to distribute this cost fairly amongst all.
It is a common practice, most anywhere in the world, where the utility company billing includes a demand charge to terminal operators for electrical power consumption.
THE NEEDS OF NEW MANAGEMENT BUSINESS TECHNIQUES

This demand charge is based on a short period peak power requirement, usually in Kilowatts, that the utility’s customer is billed for every month. This demand charge is usually a large percentage of the total billings from the utility company, somewhere in the range of 35% to 50% of the total bill received.
The terminal operator may be in a position that receives one bill from the utility company, which not only includes the cold ironing power consumption, but also electricity cost for other equipment within the terminal, such as cranes, reefers, area lighting and buildings within the terminal.
Some existing rules and laws prohibit a terminal operator from re-billing others, after the utility company presents a billing to them.

*How can the terminal operator re-bill the ship owners in such a scenario, requires overcoming some challenges, under the existing rules and regulations.*
Actually the ports does not have a comprehensive energetic plan.
This presentation has focused on the special requirements of electrical power systems serving port facilities that, despite being industrial and commercial areas of primary importance, are not sufficiently treated.

This presentation proposes to plan guidelines for improvements that are aimed at creating a new vision of electric energy utilization for a port area.
The energy service management for electrical distribution systems has to be carried out like a new occasion of economic business by the port authorities. The necessary innovation needs that the actual regulatory constraints are overcome and adequate to meet the new environmental and energy goals.
References


G. Parise, L. Martirano, L. Parise, Evoluted Architectures for Smart Micro Grids, 2013 IEEE IAS Annual Meeting, Orlando (USA), 6-11 October 2103,


G. Parise, L. Martirano, L. Parise, The architecture of electric power systems: some special cases, IEEE I&CPS 2014, Fort Worth (Texas), 20-23 May 2014


Giuseppe Parise (M'82-SM'03-F’10)) is currently a Full Professor of Electrical Power Systems at Sapienza University of Rome.

He has authored about 300 papers and is the holder of two patents and three Prize Paper Awards by IEEE/IAS PSD.

Prof. Parise has been a Member of Superior Council of Ministry of Public Works since 1983.

He is active in the IEEE Industry Applications Society (past Member at Large of Executive Board), chair of the committee I&CPS Forensics and of the committee I&CPS Ports. He is chair of Italy Section Chapter IA34, a member expert of International Electrotechnical Commission (IEC), of the Italian Electrical Commission (CEI) and of the Electrical Italian Association (AEIT), the vice President of Association Safety Technology Research for Industry (ASTRI), President of AEIT Rome’s Section. Since 1975 he has been a Registered Professional Engineer in Italy.
The presentation has made reference to the following publication:
