COLD IRONING

Clean Energy for Sustainable Ports

Bilbao, September 20th 2017
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   2.2. Technical solution
   2.3. Facilities on operation and ongoing projects

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4. Summary
1. Introduction
COLD IRONING, what and why?

- *Cold Ironing* is a port facility to plug ships at berth into the shore-side grid enabling to switch off on board auxiliary generators.

- *Cold Ironing* cuts to ZERO local emissions, noise and vibration.

- Transferring power from on board generator to shore supply is made safely with automatic synchronization and without disconnecting ship loads.

- 100% of the ship power demand at berth must be supplied, including hoteling, HVAC, loading/unloading operations, reefers etc.

- Other names that are used for the same technology: *Shore Connection*, *Shore-to-ship Power*, *Shore-side electricity*, *On-shore Power Supply*, *Alternative Maritime Power*. 
1. Introduction

How much does a ship at berth pollute?

Cruise consuming 7 MVA at berth pollutes as much as 9,000 (of NOx) or 3,000 (of PM) cars (Diesel Euro VI, 100 km/h)

The power supplied by on-board generators equals the residential power demand of 6,000 people.

Cruise terminal BCN 2016
- 6 berths
- 758 calls
- >2.6 million of passengers
- >20,000 visitor/day in summer time
Environmental benefits of *Cold Ironing*:

- **Locally**, at the port: zero emission, noise, vibration

- **Globally**

![Graph showing emission reductions](image)

- Emission factors of auxiliary engines using 2.7% sulphur fuel
- Emission factors of auxiliary engines using 0.1% sulphur fuel
- Emission factors of shore connection based on coal power plant generation
- Emission factors of shore connection based on EU25 power generation

Source: ENTEC Study 2005

- Today’s best alternative at port
2. Cold Ironing
2.1. International regulation
2.1 International regulation

Europe:

- Directive 2005/33/UE establishes, from 1st January 2010, a maximum Sulphur content of % 0,1 in marine fuels used by ships at berths in EU ports.
- MARPOL Annex VI establishes additional limits regarding emissions of NO\textsubscript{x} and SO\textsubscript{2}.
- Directive 2014/94/UE relative to the deployment of an alternative fuels infrastructure, establishes a coverage of *Electricity at shore-side* by end 2025 in ports of TEN-T core network.

<table>
<thead>
<tr>
<th>Year</th>
<th>IMO MARPOL Annex 6</th>
<th>Directive 2005/33/UE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NO\textsubscript{x} max. (g/kWh)</td>
<td>SO\textsubscript{2} max. (% m/m)</td>
</tr>
<tr>
<td>2010</td>
<td>11,8</td>
<td>4,5%</td>
</tr>
<tr>
<td>Julio 2010</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>9,6</td>
<td>4,5%</td>
</tr>
<tr>
<td>2012</td>
<td>9,6</td>
<td>3,5%</td>
</tr>
<tr>
<td>2015</td>
<td>9,6</td>
<td>3,5%</td>
</tr>
<tr>
<td>2016</td>
<td>2,3</td>
<td>0,5%</td>
</tr>
<tr>
<td>2020</td>
<td>2,3</td>
<td>0,5%</td>
</tr>
</tbody>
</table>
2. Cold Ironing

2.2. Technical solution
Standarization:

ISO/IEC/IEEE 80005, focuses on “any ship, any port” concept with regard to connecting vessels to shore power.

- IEC/ISO/IEEE 80005-1 (2012), High Voltage Shore Connection. 6,6/11 KV and >1 MVA
- IEC/ISO/IEEE 80005-2, Communication Protocol
- IEC/ISO/IEEE 80005-3, Low Voltage Shore Connection: typical < 1MVA
2.2 Technical solution

Equipment and solutions:

IEC-61936-1
Electrical installations with nominal voltage >1 kV AC

IEC/ISO/IEEE 80005-1

IEC-60092-nnn
Electrical installations in ships

Shore-side installation

On-board installation
2.2 Technical solution

Case study: Pasaia Port

In: 630 A
Vn: 30 kV
Icc: 25 kA

30 kV
1.000 kVA
0,680 kV

Static Converter
50/60Hz

0,680 kV
1.000 kVA
6,6 kV

In: 630 A
Vn: 6,6 kV
Icc: 25 kA

Connection BOX

Shore
Shore-Side Control Room
Ship-side Control Room

Shore Ethernet Lan
Firewall
HMI
PLC
Ship Ethernet Lan
Plc
Hmi
Firewall
2. Cold Ironing

2.3. Facilities on operation and ongoing projects
### Power demand requirements of commercial vessels: (MW,kV,Hz)

<table>
<thead>
<tr>
<th>Category</th>
<th>LV</th>
<th>HV</th>
<th>50 Hz</th>
<th>60 Hz</th>
<th>MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Container (&lt;140 m) Reefers</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
<td>0.2-1 MW</td>
</tr>
<tr>
<td>Container (&gt;140 m) Reefers</td>
<td>88%</td>
<td>12%</td>
<td>6%</td>
<td>94%</td>
<td>0.8-8 MW</td>
</tr>
<tr>
<td>Ro-Ro Ferries</td>
<td>0%</td>
<td>30%</td>
<td>30%</td>
<td>70%</td>
<td>1.5-2 MW</td>
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<tr>
<td>Ro-Pax Bulk/cargo</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
<td>1.4-2.7 MW</td>
</tr>
<tr>
<td>Tankers</td>
<td>100%</td>
<td>0%</td>
<td>20%</td>
<td>80%</td>
<td>4.1-7.3</td>
</tr>
<tr>
<td>Cruceros (&lt;200m)</td>
<td>12%</td>
<td>88%</td>
<td>38%</td>
<td>64%</td>
<td>7.5-11</td>
</tr>
<tr>
<td>Cruceros (&gt;200m)</td>
<td>12%</td>
<td>88%</td>
<td>38%</td>
<td>64%</td>
<td>7.5-11</td>
</tr>
</tbody>
</table>
Cold Ironing worldwide implementation:

2.3 Facilities on operation and ongoing projects

Source: World Ports Climate Initiative (WPCI)
## Ports using Cold Ironing:

<table>
<thead>
<tr>
<th>Year of introduction</th>
<th>Port name</th>
<th>Country</th>
<th>Capacity (MW)</th>
<th>Frequency (Hz)</th>
<th>Voltage (kV)</th>
<th>Ship types making use of SSE</th>
<th>Number of berths with SSE installed</th>
<th>Number of unique ships that are connected to SSE at berth</th>
<th>Total number of annual calls that use SSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000-2010</td>
<td>Gothenburg</td>
<td>Sweden</td>
<td>1.25-2.5</td>
<td>50 &amp; 60</td>
<td>6.6 &amp; 11</td>
<td>RoRo, ROPAX</td>
<td>6</td>
<td>11</td>
<td>1515</td>
</tr>
<tr>
<td>2000</td>
<td>Zeebrugge</td>
<td>Belgium</td>
<td>1.25</td>
<td>50</td>
<td>6.6</td>
<td>RoRo</td>
<td>1</td>
<td>3</td>
<td>200</td>
</tr>
<tr>
<td>2001</td>
<td>Juneau</td>
<td>U.S.A</td>
<td>7-9</td>
<td>60</td>
<td>6.6 &amp; 11</td>
<td>cruise</td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>Los Angeles</td>
<td>U.S.A</td>
<td>7.5-60</td>
<td>60</td>
<td>6.6</td>
<td>container, cruise</td>
<td>24</td>
<td>54</td>
<td>46</td>
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<tr>
<td>2005-2006</td>
<td>Seattle</td>
<td>U.S.A</td>
<td>12.8</td>
<td>60</td>
<td>6.6 &amp; 11</td>
<td>cruise</td>
<td>2</td>
<td>9</td>
<td>83</td>
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<tr>
<td>2006</td>
<td>Kemi</td>
<td>Finland</td>
<td>50</td>
<td>6.6</td>
<td></td>
<td>ROPAX</td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>Kotka</td>
<td>Finland</td>
<td>50</td>
<td>6.6</td>
<td></td>
<td>ROPAX</td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>Oulu</td>
<td>Finland</td>
<td>50</td>
<td>6.6</td>
<td></td>
<td>ROPAX</td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>Antwerp</td>
<td>Belgium</td>
<td>0.8</td>
<td>50 &amp; 60</td>
<td>6.6</td>
<td>container</td>
<td>2</td>
<td>9</td>
<td>83</td>
</tr>
<tr>
<td>2008</td>
<td>Lübeck</td>
<td>Germany</td>
<td>2.2</td>
<td>50</td>
<td>6</td>
<td>ROPAX</td>
<td>1</td>
<td>3</td>
<td>38</td>
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<tr>
<td>2009</td>
<td>Vancouver</td>
<td>Canada</td>
<td>16</td>
<td>60</td>
<td>6.6 &amp; 11</td>
<td>cruise</td>
<td>2</td>
<td>10</td>
<td>104</td>
</tr>
<tr>
<td>2010</td>
<td>San Diego</td>
<td>U.S.A</td>
<td>16</td>
<td>60</td>
<td>6.6 &amp; 11</td>
<td>cruise</td>
<td>3</td>
<td>4</td>
<td>18</td>
</tr>
<tr>
<td>2010</td>
<td>San Francisco</td>
<td>U.S.A</td>
<td>16</td>
<td>60</td>
<td>6.6 &amp; 11</td>
<td>cruise</td>
<td>1</td>
<td>3</td>
<td>38</td>
</tr>
<tr>
<td>2010</td>
<td>Verkö, Karlskrona</td>
<td>Sweden</td>
<td>2.5</td>
<td>50</td>
<td></td>
<td>cruise</td>
<td>1</td>
<td>1</td>
<td>118</td>
</tr>
<tr>
<td>2011</td>
<td>Long Beach</td>
<td>U.S.A</td>
<td>16</td>
<td>60</td>
<td>6.6 &amp; 11</td>
<td>cruise</td>
<td>1</td>
<td>1</td>
<td>118</td>
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<tr>
<td>2011</td>
<td>Oslo</td>
<td>Norway</td>
<td>4.5</td>
<td>50</td>
<td>11</td>
<td>cruise</td>
<td>1</td>
<td>1</td>
<td>360</td>
</tr>
<tr>
<td>2011</td>
<td>Prince Rupert</td>
<td>Canada</td>
<td>7.5</td>
<td>60</td>
<td>6.6</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>Rotterdam</td>
<td>Netherlands</td>
<td>2.8</td>
<td>60</td>
<td>11</td>
<td>ROPAX</td>
<td>2</td>
<td>4</td>
<td></td>
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<tr>
<td>2012</td>
<td>Ystad</td>
<td>Sweden</td>
<td>6.25-10</td>
<td>50 &amp; 60</td>
<td>11</td>
<td>cruise</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>Trelleborg</td>
<td>Sweden</td>
<td>0-3.2</td>
<td>50</td>
<td>10.5</td>
<td>cruise</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>Hamburg</td>
<td>Germany</td>
<td>12</td>
<td>50 &amp; 60</td>
<td>6.6 &amp; 11</td>
<td>cruise</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: World Ports Climate Initiative (WPCI)
Ports planning to use *Cold Ironing*:

- Amsterdam
- Barcelona
- Bergen
- Civitavecchia
- Georgia
- Genoa
- Helsinki
- Hong Kong
- Houston
- Kaohsing
- Los Angeles
- Le Havre
- Livorno
- Marseille
- Nagoya
- Oakland
- Oslo
- Richmond
- Riga
- Rome
- South Carolina
- Stockholm
- Tacoma
- Tallinn
- Tokyo
- Venice
- Yokohama
- Philippines

Source: World Ports Climate Initiative (WPCI)
3. Implementation

3.1. Some relevant figures
Cost analysis: investments, operational costs and cost effectiveness

- **ULSFO** price
- **Electricity** price
- Vessel **power/energy** demand
- **Call duration** at berth
- Number of **calls and frequency**
- **Investments** in port infrastructure and in ship’s equipment
- **Savings** in ship generators **maintenance**
- **Savings in CO₂** allowances
- **Savings** in **port taxes** and other bonus (electricity tariff,..)
3.1 Some relevant figures

- **Investment in port infrastructure**: 0,5÷5 M€, with installed power from 1 MVA to 10 MVA.

- **Investment in ship´s equipment**: 0,4÷1 M€.

- **Port taxes reduction (vessel´s tax T-1)**: Ro-Pax, 25.000 GT, demanding 1MVA at berth during 2.500 hours/year, could save up to 100.000€/year, equivalent to 33% of the electricity bill.

- **Avoided emissions**: (Ro-Pax demanding 1MVA at berth during 2.500 hours/year) 690 ton. of CO₂, 26 ton. of NOₓ, 10 ton. of SO₂ and 500 kg of PM. Equivalent to 9.000 (NOx)/3.000 (PM) cars (20.000 km/year, Average speed 60 km/h, Diesel Euro VI).
4. Summary
Cold Ironing is the unique alternative to cut to ZERO local emissions, noise and vibration.

Cold Ironing is a tested technology and successfully implemented at dozens of ports worldwide.

The Cold Ironing interoperability is guaranteed following the standardization promoted by ISO/IEC 80005.

Most of the new vessels are Cold Ironing ready.

Cold ironing is mandatory in the west coast of USA and many other countries are adopting regulations to facilitate the deployment of the required infrastructure, as directive 2014/94/UE.
COLD IRONING

Future Energy?
Thanks!