COLD IRONING
Emissions Reduction Alternative for Cruise Ships while in Port

Cruise Workshop
New Orleans, February 17, 2004
WHY NOW?

• Significant port growth
• Serious health impacts from air pollution
• Ports under pressure to reduce emissions
• Many options to reduce emissions
• Cold Ironing is proven technology that works today
Cold Ironing (a.k.a. “shore power”) virtually eliminates emissions from ship aux engines.

<table>
<thead>
<tr>
<th></th>
<th>Ship Aux Engines</th>
<th>Gas Fired Power Plant</th>
<th>Percent Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>lb/MWh</td>
<td>lb/MWh</td>
<td></td>
</tr>
<tr>
<td>NOx</td>
<td>32.4</td>
<td>0.123</td>
<td>99.6 %</td>
</tr>
<tr>
<td>SOx</td>
<td>27.1</td>
<td>0.007</td>
<td>99.9 %</td>
</tr>
<tr>
<td>Particulate</td>
<td>1.8</td>
<td>0.025</td>
<td>98.6 %</td>
</tr>
<tr>
<td>CO₂</td>
<td>1,591.7</td>
<td>810.000</td>
<td>49.1 %</td>
</tr>
<tr>
<td>HC and VOC</td>
<td>0.9</td>
<td>0.067</td>
<td>92.6 %</td>
</tr>
</tbody>
</table>

- HFO oil ship auxiliary engine emissions based on July 2002 Entec Report prepared for European Community
- Power plant emissions based on Siemans-Westinghouse 2x1 F gas fired combined cycle with Dry Low NOx and SCR
WHY CRUISE SHIPS?

• High electric demand while in port (MW)

• High frequency of port calls for same ship (hours)

• High annual electric requirements (MWh)

MWh = Air Emissions
BALANCING SHORE POWER BENEFITS

SHIP LINE PROFITABILITY → COMMUNITY QUALITY OF LIFE

COMMUNITY QUALITY OF LIFE → REGIONAL ECONOMIC VITALITY

REGIONAL ECONOMIC VITALITY → SHIP LINE PROFITABILITY
FORMULA FOR SUCCESS

• Customize solutions – not one size fits all

• Key components for shore power success:
  – Development focus and project management
  – Willing and capable landlord (port authority)
  – Support of Public Agencies (regulators)
  – Economical power supply (utility)
COMPONENTS OF SHORE POWER PROJECTS

Dock Watts LLC
Program Manager
DOCK WATTS’ DEVELOPMENT MODEL

• Select optimal candidates (ports & ships)

• Optimize design
  – Ship on-board equipment; minimize cost, maximize portability
  – Connection between ship and port (cable management system)
  – Port/terminal electric facilities (distribution, utility interface)

• Capture economic value from emission reductions

• Finance project

• Negotiate economical power supply
SHORE POWER DESIGN CONSIDERATIONS

• Port call frequency and duration
• Electric load profile while in port
• Safety
• Tidal range and draft
• Mooring operations
• Ship loading and unloading operations
SHORE POWER DESIGN CONSIDERATIONS

• Ship-to-shore interface
• Connect and disconnect operations
• Utility interface
• Communications
• Emissions verification
RELATIVE SHORE POWER COSTS

PORT COSTS
A FACTOR OF 10 TIMES MORE THAN
SHIP COSTS

$5.0 million historical
< $3.0 million target

$500,000 historical
< $250,000 target
**CRUISE SHIP EMISSIONS**

**Assumptions:**
- **kW Cruise Ship Electric Demand**: 7,000
- **Hours per call for shore power connect time**: 1.5
- **NOx lb/MWh**: 32.4
- **SOx lb/MWh**: 27.1
- **PM lb/MWh**: 1.8

**Annual Net Installed Berthing Average Berthing Gross Generation Time Hour Time Hour**

<table>
<thead>
<tr>
<th>Vessel Name</th>
<th>Tonnage (kW)</th>
<th>Installed Generation (kW)</th>
<th>Calls/yr</th>
<th>Annual Berthing Time (Hours/yr)</th>
<th>Average Hours per call</th>
<th>Net Berthing Time (Hours/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carnival Ecstasy</td>
<td>70,367</td>
<td>10,560</td>
<td>105</td>
<td>1,321</td>
<td>13</td>
<td>1,164</td>
</tr>
<tr>
<td>Carnival Pride</td>
<td>85,920</td>
<td>60,504</td>
<td>37</td>
<td>397</td>
<td>11</td>
<td>342</td>
</tr>
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</table>

**Average Electric Load, Annual Energy, Nox Emissions, SOx Emissions, PM Emissions, Total Emissions**

<table>
<thead>
<tr>
<th>Vessel Name</th>
<th>Electric Load (kW)</th>
<th>Annual Energy (MWh/yr)</th>
<th>Nox Emissions (Ton/Year)</th>
<th>SOx Emissions (Ton/Year)</th>
<th>PM Emissions (Ton/Year)</th>
<th>Total Emissions (Ton/Year)</th>
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<tr>
<td>Carnival Ecstasy</td>
<td>7,000</td>
<td>8,145</td>
<td>132.0</td>
<td>110.4</td>
<td>7.2</td>
<td>249.6</td>
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<tr>
<td>Carnival Pride</td>
<td>7,000</td>
<td>2,391</td>
<td>38.7</td>
<td>32.4</td>
<td>2.1</td>
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**Total**

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<td><strong>TOTAL</strong></td>
<td>10,535</td>
<td>170.7</td>
<td>142.8</td>
<td>9.3</td>
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<td>322.8</td>
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*Electric Load and Hotelling hours based on the Report by Environ; Analysis of Vessel Population for Cost Effective Cold Ironing for the Port of Long Beach (November 19, 2004)*

*Emissions Factor Assumptions based on En Tec Report to the European Community (July 2002)*
## ESTIMATED COST EFFECTIVENESS

**ASSUMPTIONS:**
- Shore Side Cost: $5,000,000 per berth
- Ship Side Cost: $500,000 per ship
- Emissions Reduction Period: 5 years

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<tr>
<th>Vessel Name</th>
<th>Calls/yr</th>
<th>Net Berthing Time (Hours/yr)</th>
<th>Annual Total Energy (MWh/yr)</th>
<th>Nox Emissions Ton/Year</th>
<th>SOx Emissions Ton/Year</th>
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- Berth Cost: $5,000,000
- Ship Cost: $1,000,000
- Total Cost: $6,000,000

* Estimated cost effectiveness based solely on assumed capital cost of facilities and does not reflect operating cost.
* Operating cost would include net power cost, connection operations, and facilities maintenance.
* Net power cost should reflect difference between the cost of utility supplied power and ship costs to generate on-board power.

Annual emissions based on ship electric load data presented in the November 19, 2004 Environ Report to the Port of Long Beach and emissions factors presented in the July 2002 Entec report to the European Community.
$6.0 million capital cost assumed for ship and shore facilities. Analysis considers estimated emissions reductions over five years.

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<th>SOx</th>
<th>Total Emissions</th>
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<tr>
<td>Carnival Ecstasy</td>
<td>660</td>
<td>552</td>
<td>1,248</td>
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<tr>
<td>Carnival Pride</td>
<td>194</td>
<td>162</td>
<td>366</td>
</tr>
<tr>
<td>Total, Two Ships</td>
<td>854</td>
<td>714</td>
<td>1,614</td>
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Cost Effectiveness

- $7,000/ton
- $8,400/ton
- $3,700/ton

Annual emissions based on ship electric load data presented in the November 19, 2004 Environ Report to the Port of Long Beach and emissions factors presented in the July 2002 Entec report to the European Community. Operating costs are not reflected in the above analysis.
PRINCESS CRUISE LINES
SHORE POWER – JUNEAU, ALASKA
PRINCESS CRUISE LINES
SHORE POWER - JUNEAU, ALASKA

• Emission opacity issue

• Involved 28 vendors from five different countries

• Four Princess Cruise ships retrofitted

• Up to 13 MW of power delivered at 11 kV

• $4.5 million cost, ship and shore electric facilities
  (additional $1.1 million for shore-side steam boilers and piping)

• Project completed in nine months
JUNEAU PROJECT
TECHNICAL COMPONENTS

• Shore side electric substation
• Cable management system
• Ship modifications
• Synchronized power transfer equipment
• Shore side steam boiler and piping
  (not recommended for future cruise ship shore power project)
PROACTIVE
INDUSTRY ADVOCACY

• Influence air quality regulations

• Capture emission reductions value

• Establish shore power standards
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