Reversible substations in Spanish conventional-DC lines

Energy Area
Strategy Directorate
Renfe

Rome, Oct 4th, 2017
Context
Main Traction Energy Figures

- 2%
- 88%
- 78%
- 31%

Gross Tn-KM
Consumption
CO₂ Emissions

12%
22%
31%

73 M Liters Diesel
2,337 GWh Electricity

1% of the total national electricity consumption
## Electrified Lines

### Types of lines

<table>
<thead>
<tr>
<th>Type</th>
<th>Km</th>
<th>Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non electrified</td>
<td></td>
<td>Diesel expressed in GWh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6,051.6 (40%) 731.8 GWh (24%)</td>
</tr>
<tr>
<td>Electrified</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DC</td>
<td>3Kv</td>
<td>6,423.6 (42%) 1,353.4 GWh (44%)</td>
</tr>
<tr>
<td></td>
<td>1,5Kv</td>
<td>346 (2%) 21.6 GWh (1%)</td>
</tr>
<tr>
<td>AC</td>
<td>25Kv</td>
<td>2,474.1 (16%) 962.2 GWh (31%)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>15,295.3 3,069 GWh</td>
</tr>
</tbody>
</table>

- 10% Diesel consumptions in electrified lines
- Conventional Lines: DC
- High Speed Lines : AC

**DC represents 45 % of total energy and 59 % of electricity consumption**
Context
Electrified Lines

Km LINES

60% Electrified
40% Non Electrified

DC
AC
75%
25%

Conventional Lines
High Speed Lines (> 250 Km/h)

Consumption

962 GWh 59 substations
1,375 GWh 384 substations

AC
DC
41%
59%

DC
AC
962 GWh 59 substations
1,375 GWh 384 substations

High Speed Lines (> 250 Km/h)

AC
DC
41%
59%

Conventional Lines

60% Electrified
40% Non Electrified

59 substations
384 substations
Altern current (AC)
Energy Recovery

- 73.5 GWh sold back a year to electricity supplier
- 7% Total AC lines Consumption
- 5 € Million saved (a year)

> 21,000 electric housing consumptions
**Direct current: First Experience** Substation ‘La Comba’ (Málaga)

**Context**

- Merlin Project
- Commuter Service
- Frequency: 1 train/20 min.
- 18 stations
- 3 substations
- 31.35 Km

- Fleet: EMU, 4 coaches
- Trains 464 series CAF
- 3 Kv – DC Headline
Direct current: First Experience  Substation ‘La Comba’ (Málaga)

Outcomes

<table>
<thead>
<tr>
<th>Total consumption</th>
<th>Total energy sold back to the grid</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.6 GWh/year (all line)</td>
<td>1 GWh/year (La Comba)</td>
</tr>
<tr>
<td>2.6 GWh/year (La Comba)</td>
<td>(11.6% line – 38.5% Substation)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total cost savings</th>
<th>Pay back period</th>
</tr>
</thead>
<tbody>
<tr>
<td>65 K € /year</td>
<td>12 years</td>
</tr>
</tbody>
</table>
**Next steps**
Simulation and decision making Process

**SYCE**

**TAKEN INTO ACCOUNT:**

**ROLLING STOCK**
- Timetables
- Type of Rolling Stock
- Recovery capacity of the train
- Ancillary services consumption
- ....

**POWER SYSTEM**
- Electric demand profile
- Overhead line wearing
- Ancillary services consumption
- Inverter performance
- Transformer performance
- Rectifier performance
- ......

**OTHERS**
- Energy cost
- Market Regulation
- ....

**Profitable if**
> 1 Gwh/year of estimated energy recovered
## Next steps

6 new substations (bidding process)

<table>
<thead>
<tr>
<th>Substation</th>
<th>Energy recovered (GWh-year)</th>
<th>Cost saved (€ year)</th>
<th>Pay-back period* (year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcorcón (Madrid)</td>
<td>2.7</td>
<td>162,000</td>
<td>3.4</td>
</tr>
<tr>
<td>Getafe (Madrid)</td>
<td>1.5</td>
<td>90,000</td>
<td>6.2</td>
</tr>
<tr>
<td>Olabeaga (Bilbao)</td>
<td>1.5</td>
<td>90,000</td>
<td>6.2</td>
</tr>
<tr>
<td>Guarnizo (Santander)</td>
<td>1.1</td>
<td>66,000</td>
<td>8.4</td>
</tr>
<tr>
<td>Areyns (Barcelona)</td>
<td>1.9</td>
<td>114,000</td>
<td>4.9</td>
</tr>
<tr>
<td>Martorell (Barcelona)</td>
<td>1.3</td>
<td>78,000</td>
<td>7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>10</strong></td>
<td><strong>600,000</strong></td>
<td><strong>5.6</strong></td>
</tr>
</tbody>
</table>

Total investment: 4.8 € M *(3.4 € M with public grants)  
Investment supported by Renfe  
Total CO₂ saved emissions: 1,74 Tons
Next steps
Self consumption

Cost energy purchased: 100 € MWh (>40% taxes)
Cost sold back energy: 60 € MWh

Hydrogen generation and storage

Combined clean energies
Batteries Storage
Stations
Thank you

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