

Test for implementing electric machinery in public works in Barcelona

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APPROACH

PRIMARY GOAL:

- To prepare the city of Barcelona so that municipal public works can be carried out involving electric machinery which improves the city's environmental quality.

BENEFITS FOR THE CITY:

- 0 smoke and hydrocarbon fuel combustion emissions in public-works machinery.
- Improved noise quality in public works.
- Reduced fuel truck traffic in the city.
- Improving Brand Barcelona as a benchmark in the environmental sustainability of cities.

HOW TO ACHIEVE IT:

- By establishing a protocol that specifies by type of works project, which type of machinery and energy-management system is feasible to use.
- Action plan on energy infrastructures in Barcelona.



INITIAL SITUATION

PRESENT ELECTRIC MACHINERY MARKET ANALYSIS

- There is presently no local market (Catalonia area) of electric machinery manufacturers for public works.
- Electric machinery is not immediately available in the market (on-demand manufacturing).
- No economy of scale for obtaining competitive prices.
- Small, stand-alone machinery with batteries.
- Large machinery (backhoe, pile driver, shield plates, etc.) depends on continuous network connection.

PILOT TEST TO OBTAIN ENVIRONMENTAL AND ENERGY MANAGEMENT DATA.

- Pilot test with Germans Homs and municipal work.
- Implication of Sustainability for Environmental Measure Department.
- Analysis of energy consumption, energy cycle and performance.
- Cost analysis.



PILOT TEST FOR OBTAINING ENVIRONMENTAL AND ENERGY-MANAGEMENT DATA - ELEMENTS



GridtoGo™ Datasheet

gridlogo™ INGENIUM LX 45 OPzV

ffgrid energy
complete power solutions

Features:

- 400/230V 50Hz 3Ø output, 45kVA
- GSM Remote monitoring
- Deep cycle maintenance free OPzV-S battery
- 60 or 90kWh stored energy
- Full system DC isolator with pre-charge
- 100A pass-through capacity
- 125A Auto full system bypass
- Integrated smart Solar PV storage capability
- Advanced EMS with smart device control
- V50 Power™ for enhanced DC bus stability



3Ø or 1Ø 400/230V → 3Ø 400/230V out



MUNICIPAL CHARGING NETWORK



MUNICIPAL PUBLIC WORKS

Cuadro Sinóptico Maquinaria ZERO EMISSION

| | Pisón (Rammer) | Bandeja Vibradora (Vibrating Shaft) | Cargadora ruedas (Wheel Loader) | Dumper | Excavator |
|------------------------|----------------|-------------------------------------|---------------------------------|-------------|-----------|
| Modelo | AP1840e | AS30e | WL20e (230) | DW15e | E217e |
| Tipo Batería | Ion-Litio | Ion-Litio | Plomo-Acido | Plomo-Acido | Ion-Litio |
| Tecnología baterías | BP1400-NCA | BP1400-NCA | AGM | XGEL | NCA |
| Capacidad Nominal (Ah) | 28 | 28 | 230 | 300 | 500 |
| Tiempo trabajo | 60/45/35 min | 80/80/60 min | 2-3h | 6-8h | 5-7h |
| Tiempo de carga (100%) | 390 (120) | 390 (120) | 6h | 7h | 4/7,5h |
| Enchufe Cargo Standard | | | | | |
| Enchufe Cargo Opcional | | | | | |
| | | | | | |



DEPARTMENT OF SUSTAINABILITY FOR MEASURES



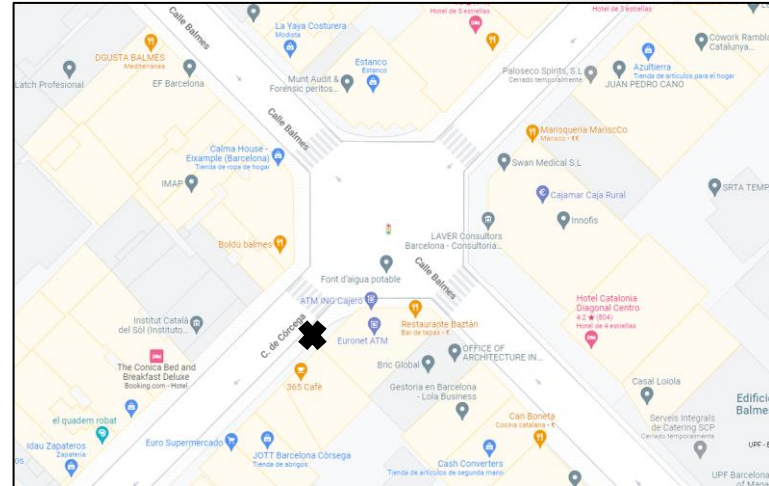
PILOT TEST FOR OBTAINING ENVIRONMENTAL AND ENERGY-MANAGEMENT DATA - ELEMENTS





PILOT TEST FOR OBTAINING ENVIRONMENTAL AND ENERGY-MANAGEMENT DATA - ELEMENTS

Charging point

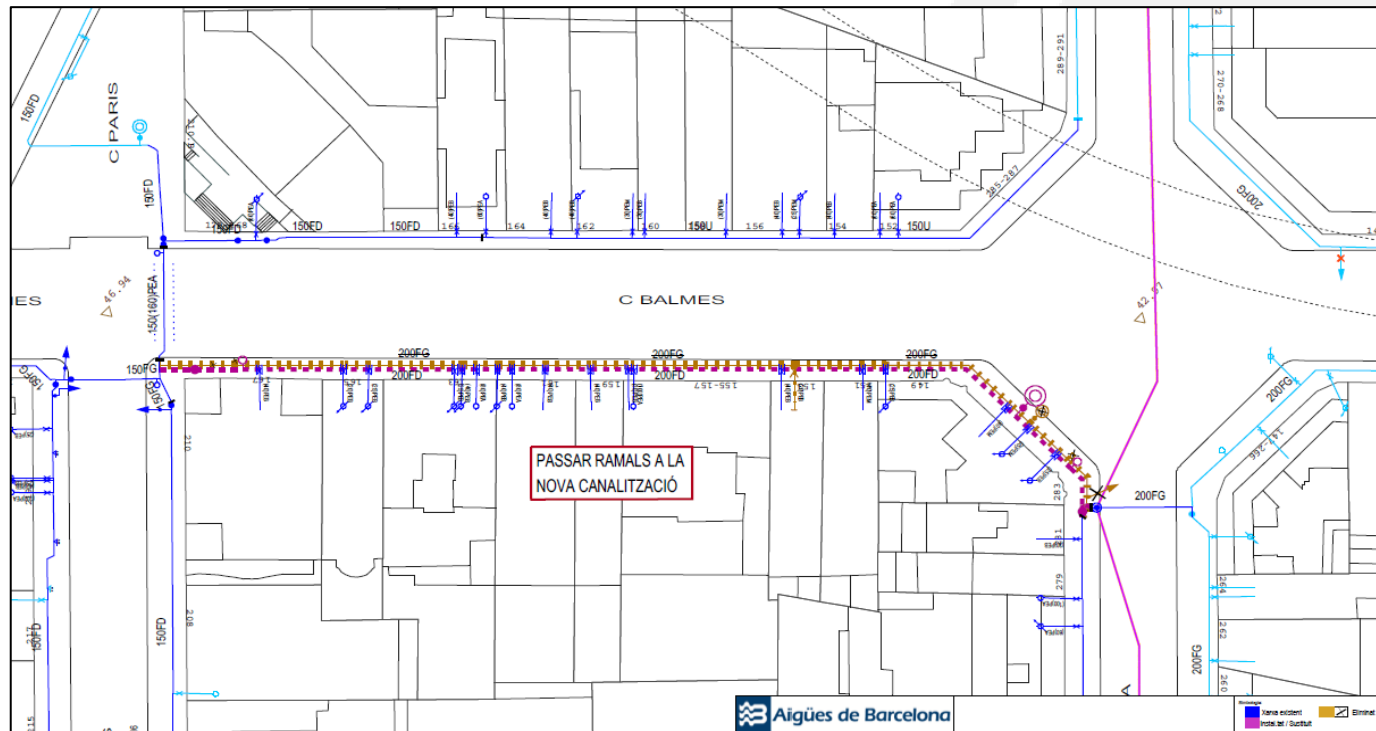




PILOT TEST FOR OBTAINING ENVIRONMENTAL AND ENERGY-MANAGEMENT DATA - WORKS

General data of the work:

- Promoter: Aigües de Barcelona
- Construction management: Aigües de Barcelona
- Construction company: ACSA, Obres i Infraestructures, S.A.O.
- Location: Carrer Balmes 149 – 167
- Total duration: From 20/06/2022 to 22/07/2022
- Duration with electrical machinery: From 20/06/2022 to 10/07/2022





PILOT TEST FOR OBTAINING ENVIRONMENTAL AND ENERGY-MANAGEMENT DATA - RESULTS

PARÀMETRES CONSIDERATS

1. Energy consumption (kWh).
2. Energy cost (€/kWh).
3. CO₂ emissions (kg of CO₂).
4. NO₂ emissions (µg/m³) and PM10 (µg/m³).
5. Noise (dB).

consumption recorded by B:SM

| | Loading time (h) | Consumption (kWh) |
|--|------------------|-------------------|
| Global consumption record (all machines) | 28769,88 | 409,12 |



PILOT TEST FOR OBTAINING ENVIRONMENTAL AND ENERGY-MANAGEMENT DATA - RESULTS

Recorded consumption by electric machines

| | Work time (hr) | Consumption per hour (kWh/hr) | Consumption (kWh) |
|----------------|----------------|-------------------------------|-------------------|
| Mini excavator | 70.50 | 5.10 | 359.55 |
| Dumper | 18.50 | 1.90 | 35.15 |
| Bulldozer | negligible | | |
| Total: | 89.00 | | 394.70 |

Energy consumption of conventional machines

| | Work time (hr) | Consumption per hour (l/hr) | Consum. (l) | Consum. (kWh) |
|----------------|----------------|-----------------------------|-------------|---------------|
| Mini excavator | 70.50 | 3.60 | 253.80 | 2596.37 |
| Dumper | 18.50 | 1.90 | 35.15 | 359.58 |
| Bulldozer | negligible | | | |
| Total: | 89.00 | | 394.35 | 2955.95 |

Energy cost of conventional machines

| | Consumption (kWh) | Cost (€) |
|----------------|-------------------|----------|
| Mini excavator | 359.55 | 128.58 |
| Dumper | 35.15 | 12.57 |
| Bulldozer | negligible | |
| Total: | 394.7 | 141.15 |

Energy cost of conventional machines

| | Consumption (l) | Cost (€) |
|----------------|-----------------|----------|
| Mini excavator | 253.80 | 523.08 |
| Dumper | 35.15 | 72.44 |
| Bulldozer | negligible | |
| Total: | 394.35 | 595.52 |



PILOT TEST FOR OBTAINING ENVIRONMENTAL AND ENERGY-MANAGEMENT DATA - RESULTS

CO2 emissions from electric machines

| | Consumption (kWh) | Emissions (kg of CO ₂) |
|-------------------------|-------------------|------------------------------------|
| All the machines (B:SM) | 409.12 | 122.74 |
| Excavator | 359.55 | 107.87 |
| Dumper | 35.15 | 10.55 |
| Bulldozer | negligible | |

CO2 emissions from conventional machines

| | Consumption (l) | Emissions (kg of CO ₂) |
|----------------|-----------------|------------------------------------|
| Mini excavator | 253.80 | 708.10 |
| Dumper | 35.15 | 98.07 |
| Bulldozer | negligible | |
| Total: | 394.35 | 806.17 |

Noise from electric machines

| Machine | Type | Measuring points (dB) | | |
|------------------|----------|-----------------------|-----------|--------------------|
| | | Lateral | Posterior | Balcony simulation |
| Hydraulic Hammer | Electric | 100.8 | 93.6 | 94.7 |
| Bulldozer | Electric | 89.3 | 89.3 | 83.3 |
| Dumper | Electric | 68.6 | - | 68.9 |
| Mini excavator | Electric | 71.9 | 71.0 | 70.3 |

Noise from conventional machines

| Machine | Type | Measuring points (dB) | | |
|------------------|--------|-----------------------|-----------|--------------------|
| | | Lateral | Posterior | Balcony simulation |
| Hydraulic Hammer | Diesel | 100.2 | 90.1 | 92.2 |
| Bulldozer | Diesel | 92.2 | 92.2 | 84.8 |
| Dumper | Diesel | 74.3 | - | 72.0 |
| Mini excavator | Diesel | 73.4 | 73.3 | 72.4 |



PILOT TEST FOR OBTAINING ENVIRONMENTAL AND ENERGY-MANAGEMENT DATA - CONCLUSIONS

- It is use of the charging station Plug has been satisfactory in the established configuration.
- The conclusion is reached that the Battery Voltlabor model ES 40 is not suitable for the established load configuration, being the Battery Emost model BUTLER S 50/25 which demonstrated good behavior at all times during the Work period.
- In the case of the mini-excavator, single-phase slow charging is insufficient, because it does not charge the machine's battery to 100%.
- The consumption data (kWh) obtained from B:SM and that obtained from each electric machine are quite close with negligible minimal difference.
- As for the operators, it has been easy to adapt to these machines, and they have not expressed any problems during their use.
- The sonometric results show no significant differences between the electric and conventional machines. This can be attributed to the fact that the ambient noise is high and the operations of the machines are those that produce the highest values of noise, and not so much the operation of these.
- A clear difference is observed regarding the cost of electricity consumption and the cost of fuel consumption, the latter being considerably higher, around four times the cost of electricity consumption.
- The increase in rent is largely due to the use of the Battery (accumulator). In cases where these are not necessary and there is access to energy on site, the cost increase is reduced to around 4%.



Thank you for your attention

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**Ajuntament
de Barcelona**