Supplementary Information 1 (SI-2)

Life Cycle Assessment of mortars with fine recycled aggregates from industrial waste: evaluation of transports impact in the Italian context

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Analysis of alternative scenarios of transport

The following figures shows the environmental impacts related to the considered categories of REF1 and DELTA mortars ("a" figures), and of REF2 and HP mortars ("b" figures), through graphs in which the environmental impact (Y-axis) is a function of the delivery distance of aggregates (X-axis: 0 km, 100 km, 200 km, 300km, 400 km and 500 km). The resulting impact of the "local" scenario case is also reported as a diamond shaped indicator, in correspondence with the distances considered in that specific scenario.

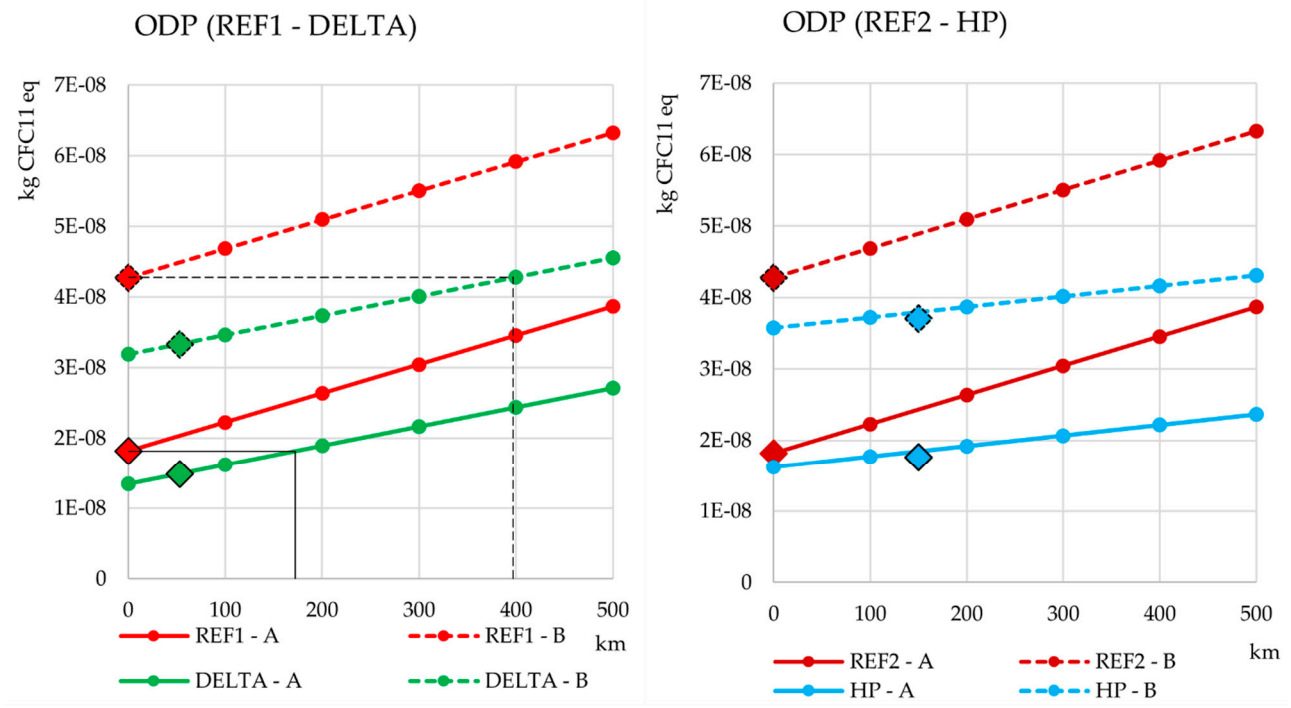
For all the analyzed environmental categories, the general trend of impacts is that already observed for GWP (and reported in the article):

- as expected, the environmental impact increases with the increase of the delivery distance of aggregate transports
- for the same transport scenario (A or B), and at the same distance of the natural/recycled aggregate to the mortar production factory (value in the X-axis), mortars with recycled aggregates (DELTA and HP) are always those with the lowest impact.
- The lines slope of reference mortars (REF1 and REF2) is always higher than that of mortars with recycled aggregates, due to the weight of the aggregates themselves (being transports calculated in kg x km).

The graphs in the following figures (a) also report solid and dashed black lines, representing the limit conditions where reference mortars, produced in the same place of natural aggregates (0 km scenarios), entail the same impact of mortars with recycled aggregates from DELTA factory delivered at higher distances. This convenience evaluation is only possible for DELTA mortar, which totally entails recycled aggregates, while is infeasible for HP mortar which always includes a half of natural aggregate. The comments provided in the following sections then highlight, for each environmental category, the limit transport distance at which the use of recycled aggregates from DELTA is still convenient.

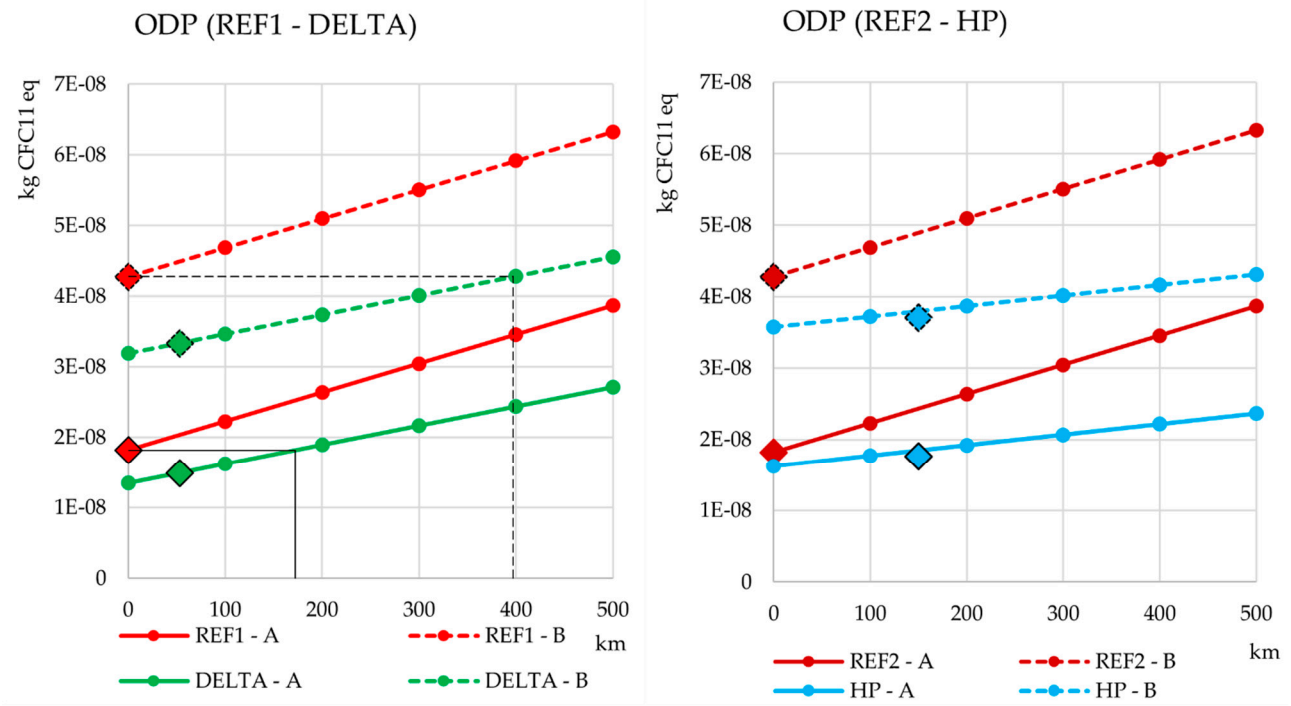
1. Depletion potential of the stratospheric Ozone Layer (ODP)

For this category, the use of natural aggregate is convenient from an environmental point of view only if the distance between the mortar factory and the recycled aggregate DELTA is more than 172 km for scenario A (black solid line) and more than 397 km for scenario B (black dotted line) (



(**a**) (**b**)

Figure S1 (a)).

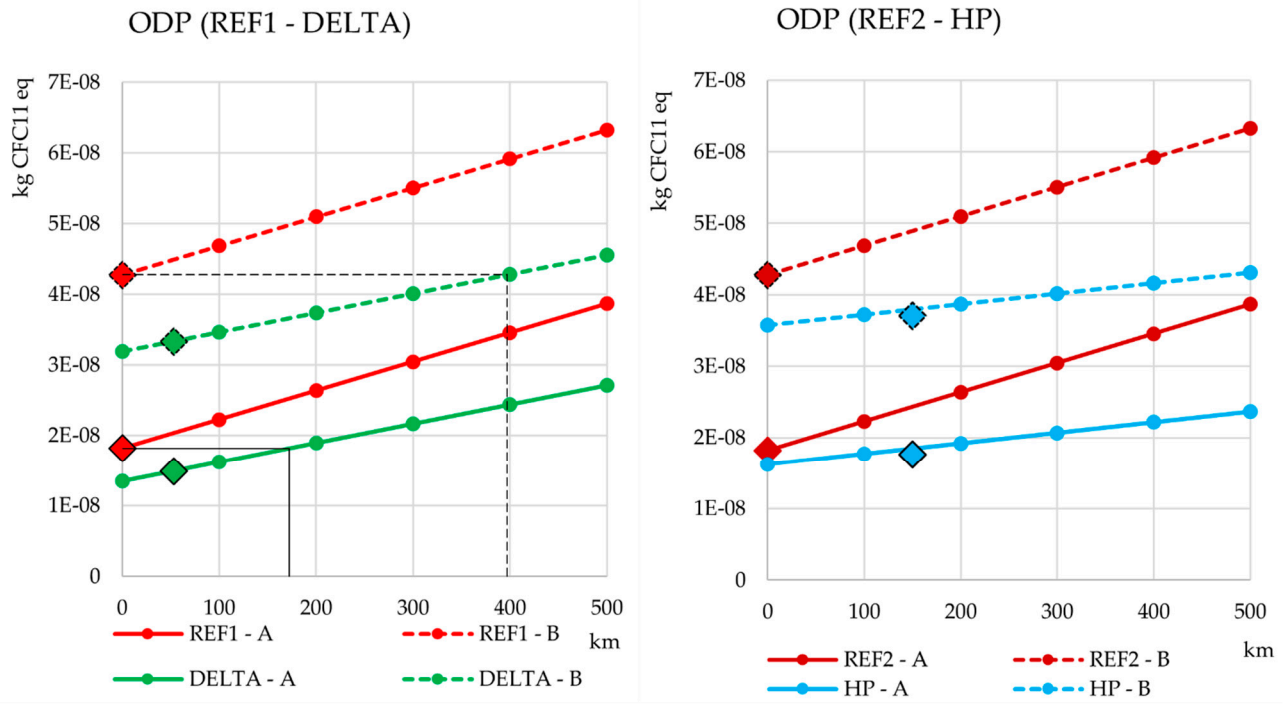


(**a**) (**b**)

Figure S1. Depletion potential of the stratospheric Ozone Layer (ODP), different scenarios of transport of: (a) Mortar REF1 and DELTA; (b) Mortar REF2 and HP

2. Formation potential of tropospheric ozone (POCP)

For this category, the use of natural aggregate is convenient from an environmental point of view only if the distance between the mortar factory and the recycled aggregate DELTA is more than 236 km for scenario A (black solid line) and more than 461 km for scenario B (black dotted line) (



(**a**) (**b**)

Figure S1 (a).

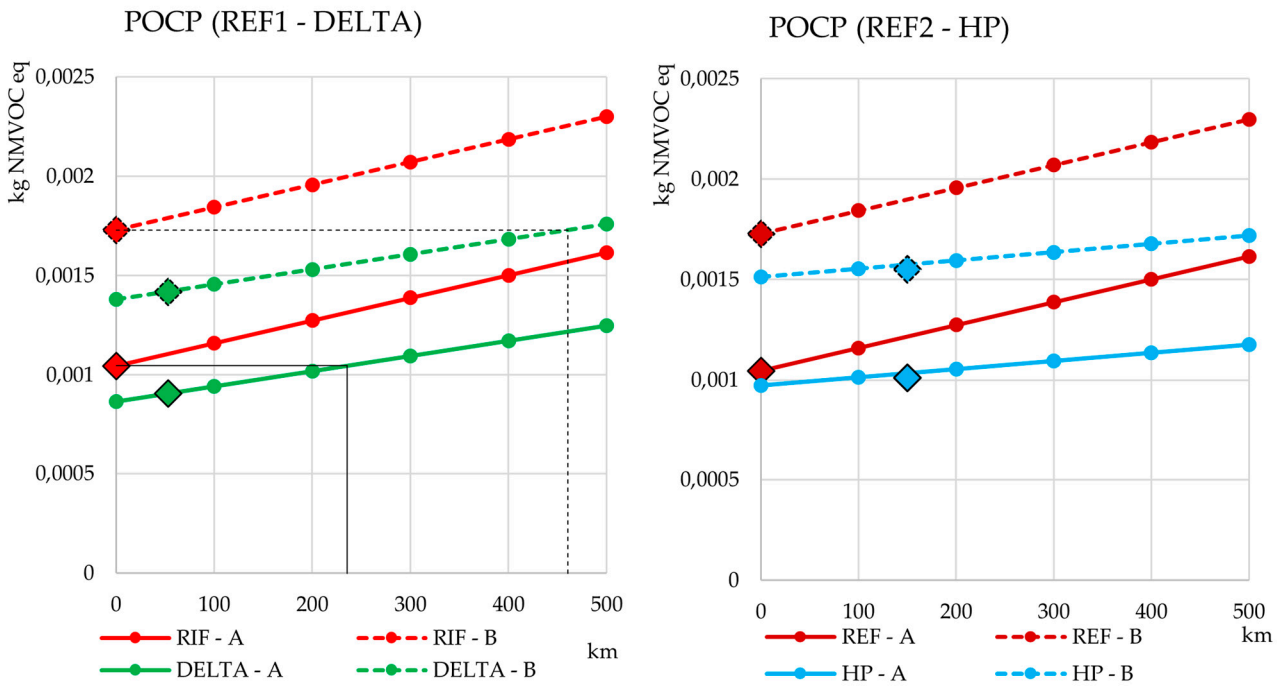
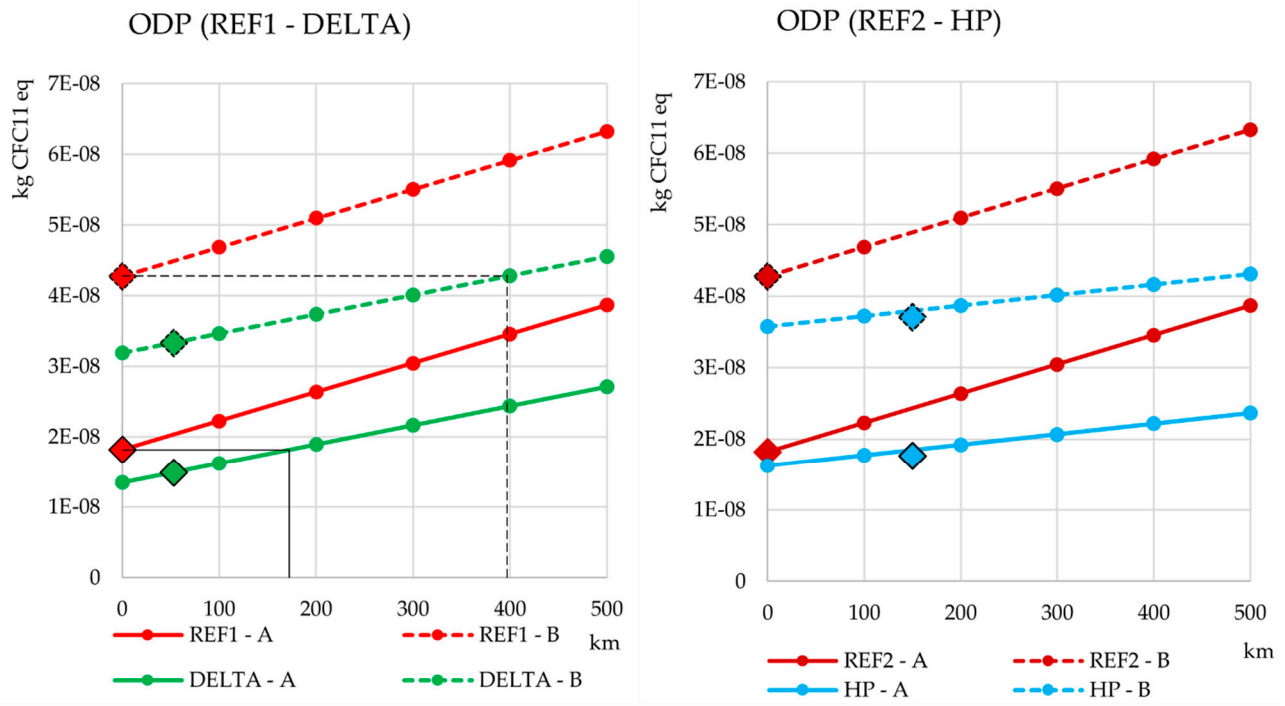


Figure S2. Formation potential of tropospheric ozone (POCP), different scenarios of transport of: (**a**) Mortar REF1 and DELTA; (**b**) Mortar REF2 and HP

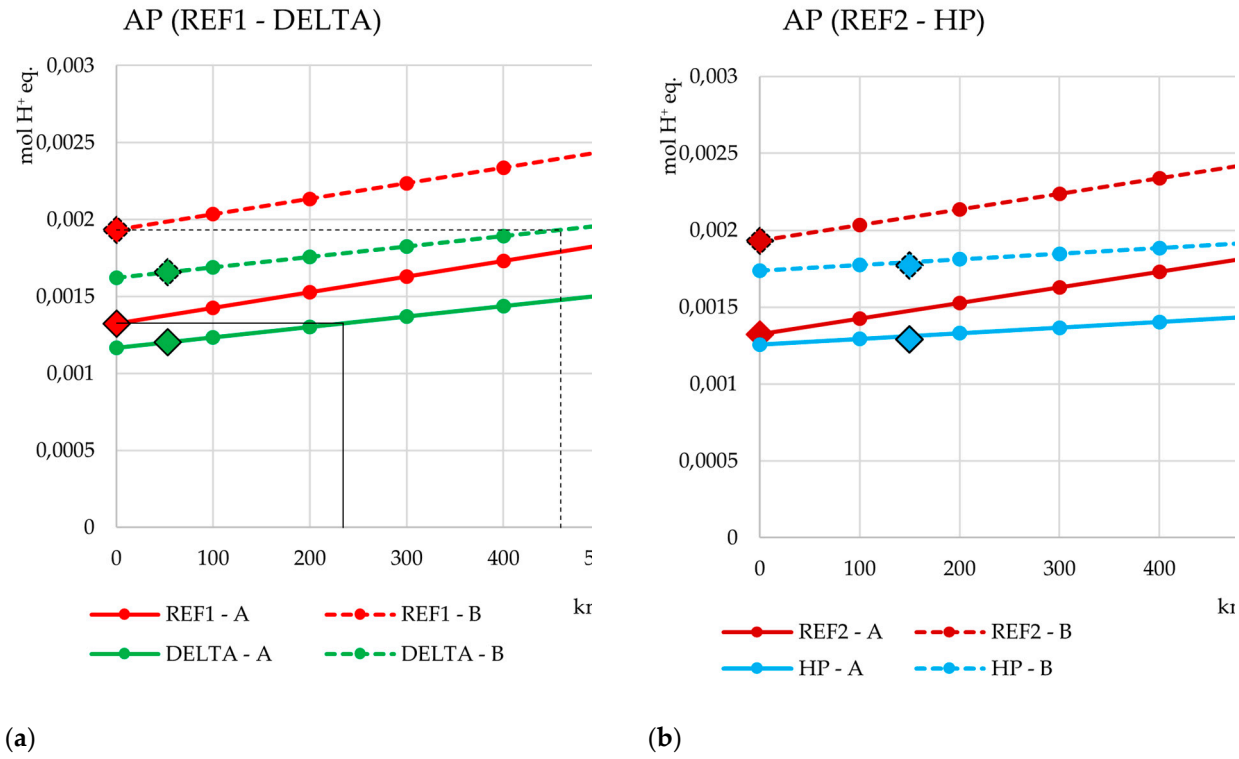
3. Acidification Potential (AP)

For this category, the use of natural aggregate is convenient from an environmental point of view only if the distance between the mortar factory and the recycled aggregate DELTA is more than 234 km for scenario A (black solid line) and more than 459 km for scenario B (black dotted line) (



(**a**) (**b**)

Figure S1 (a)).

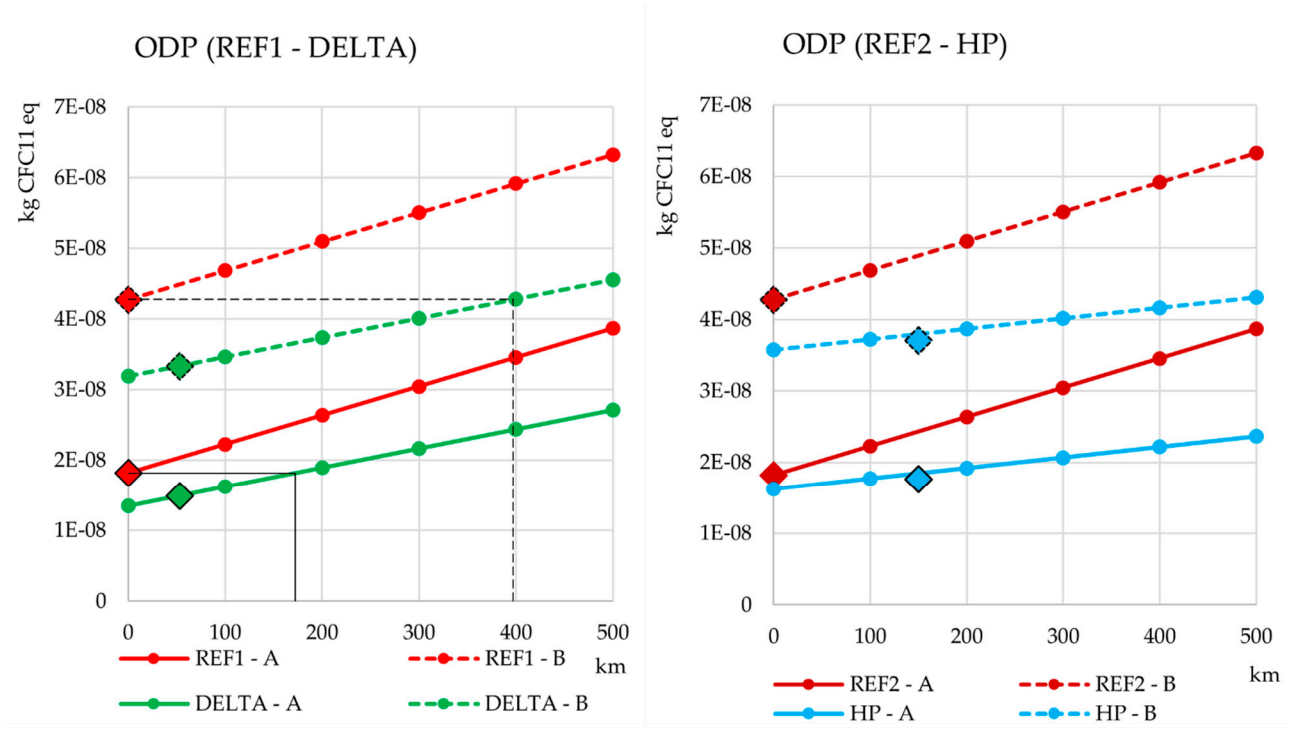


(**a**) (**b**)

Figure S3. Acidification Potential (AP), different scenarios of transport of: (**a**) Mortar REF1 and DELTA; (**b**) Mortar REF2 and HP

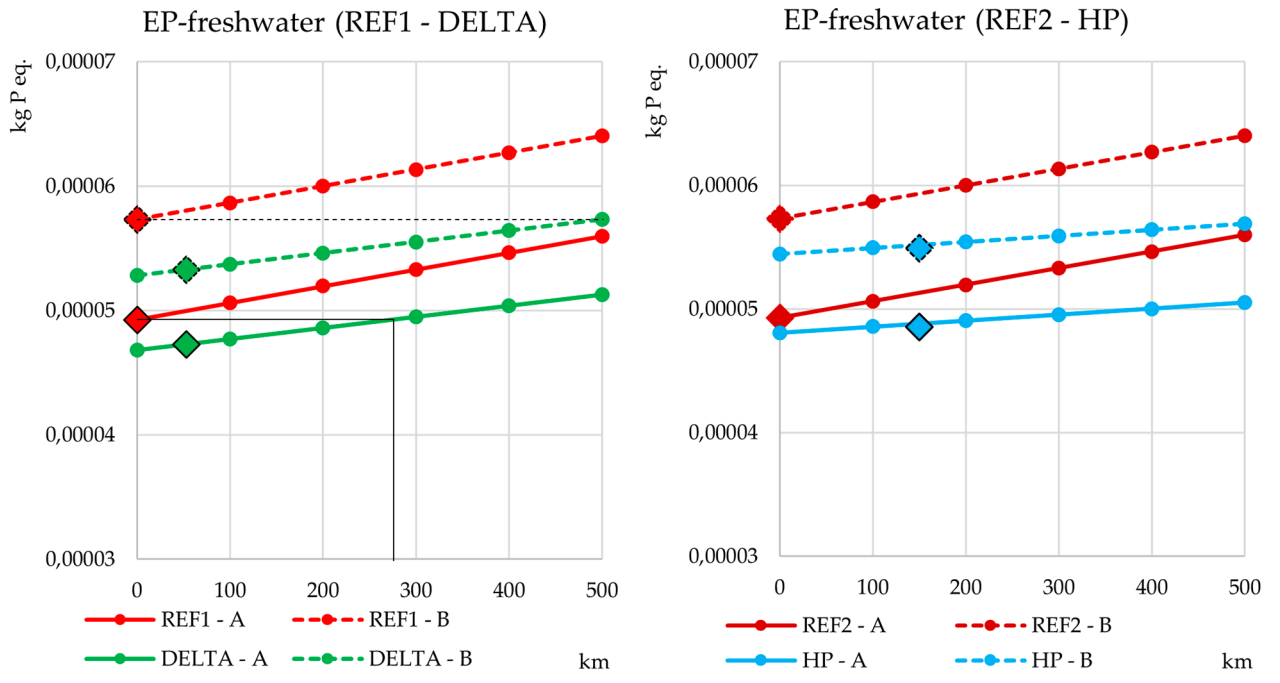
4. Eutrophication potential, fraction of nutrients reaching freshwater and compartment (EP-freshwater)

For this category, the use of natural aggregate is convenient from an environmental point of view only if the distance between the mortar factory and the recycled aggregate DELTA is more than 276 km for scenario A (black solid line) and more than 501 km for scenario B (black dotted line) (



(**a**) (**b**)

Figure S1 (a)).



(**a**) (**b**)

Figure S4. Eutrophication potential, fraction of nutrients reaching freshwater and compartment (EP-freshwater), different scenarios of transport of: (**a**) Mortar REF1 and DELTA; (**b**) Mortar REF2 and HP

5. Eutrophication potential, fraction of nutrients reaching marine and compartment (EP-marine)

For this category, the use of natural aggregate is never convenient from an environmental point of view (Figure 5). Indeed, as already demonstrated in the analysis of the local scenario, the benefits of nonoccurrence of waste landfill disposal are so significant to even provide total environmental benefits.

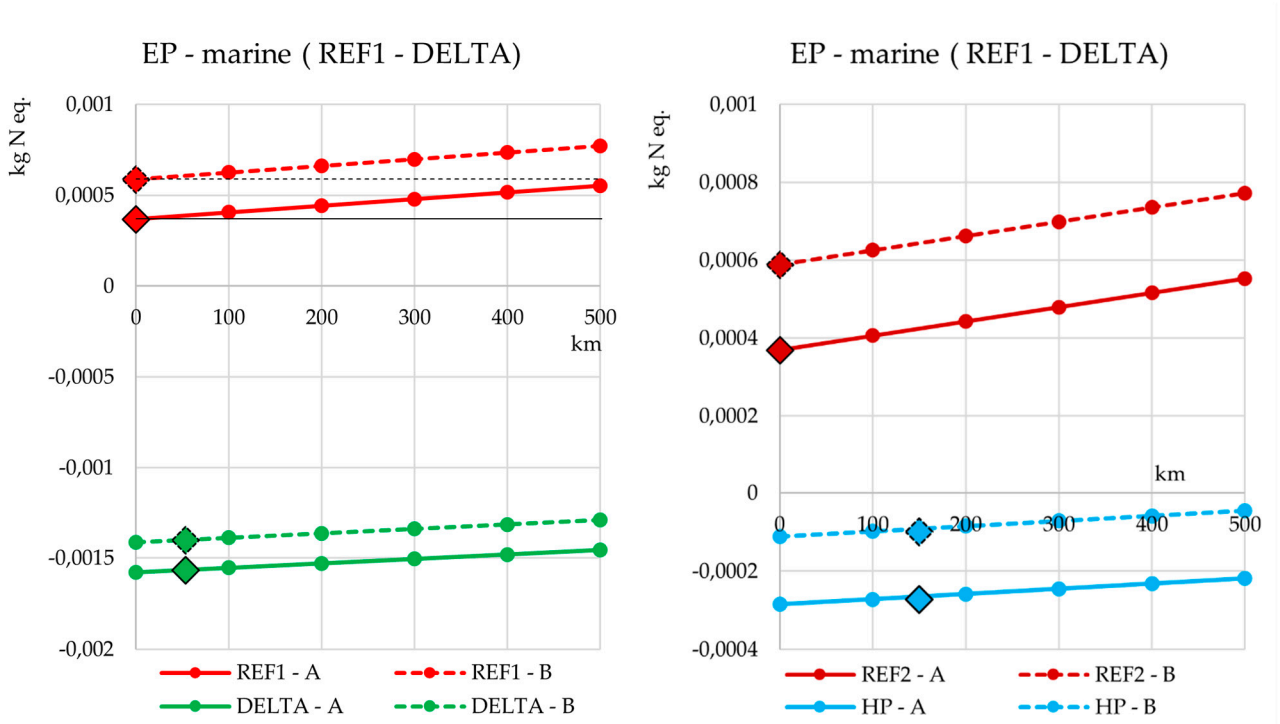
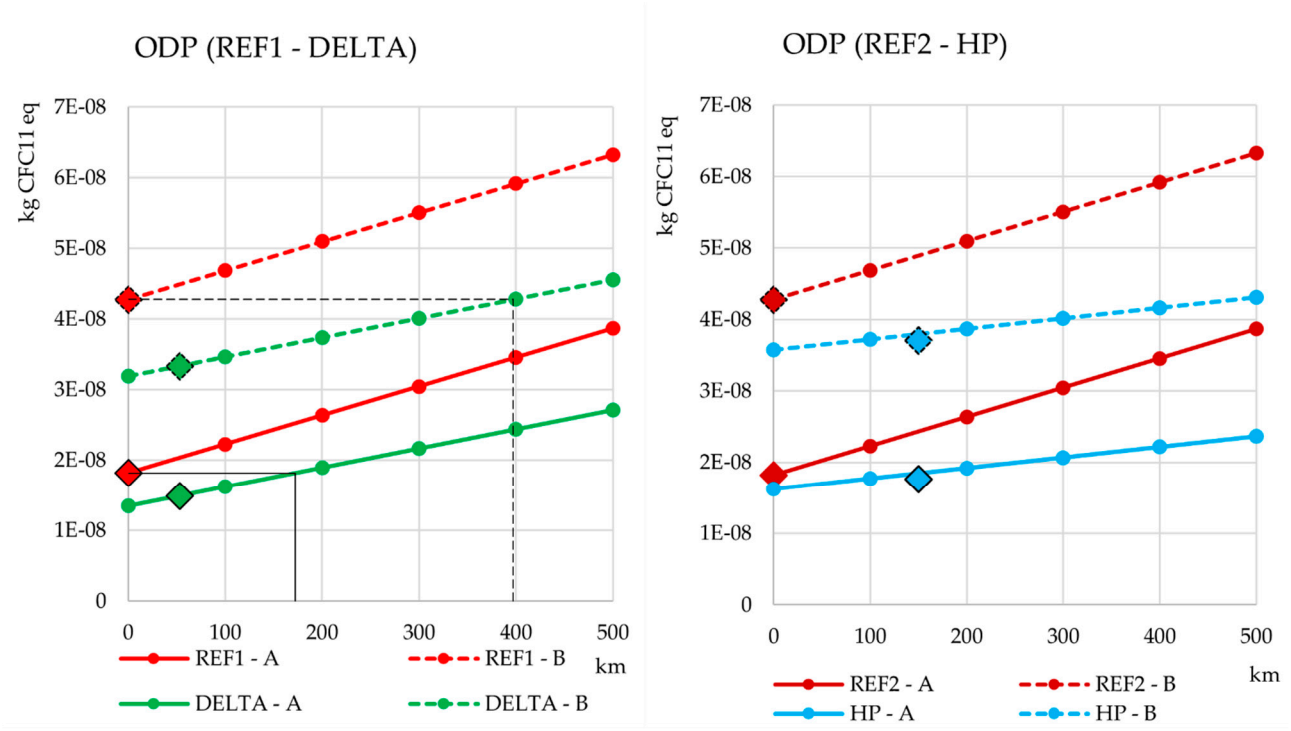


Figure S5. Eutrophication potential, fraction of nutrients reaching marine and compartment (EP-marine), different scenarios of transport of: (**a**) Mortar REF1 and DELTA; (**b**) Mortar REF2 and HP.

6. Eutrophication potential, Accumulated Exceedance (EP-terrestrial)

For this category, the use of natural aggregate is convenient from an environmental point of view only if the distance between the mortar factory and the recycled aggregate DELTA is more than 206 km for scenario A (black solid line) and more than 431 km for scenario B (black dotted line) (



(**a**) (**b**)

Figure S1 (a)).

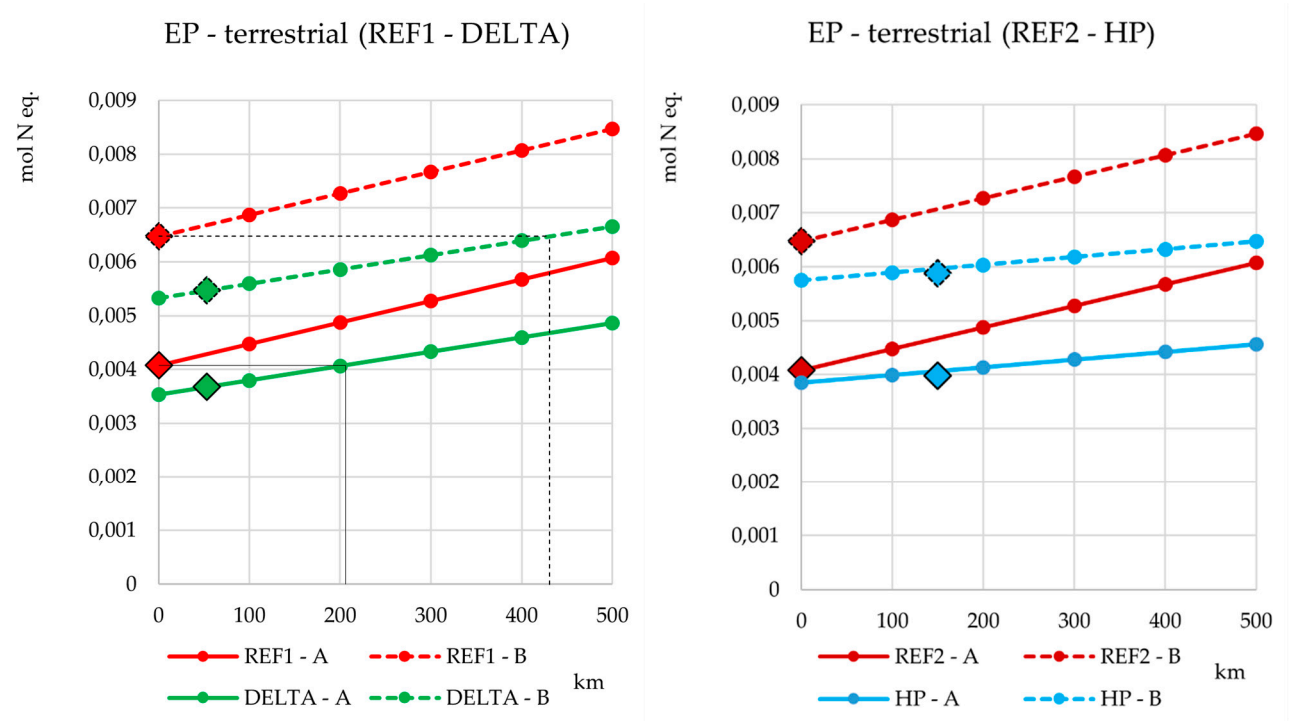
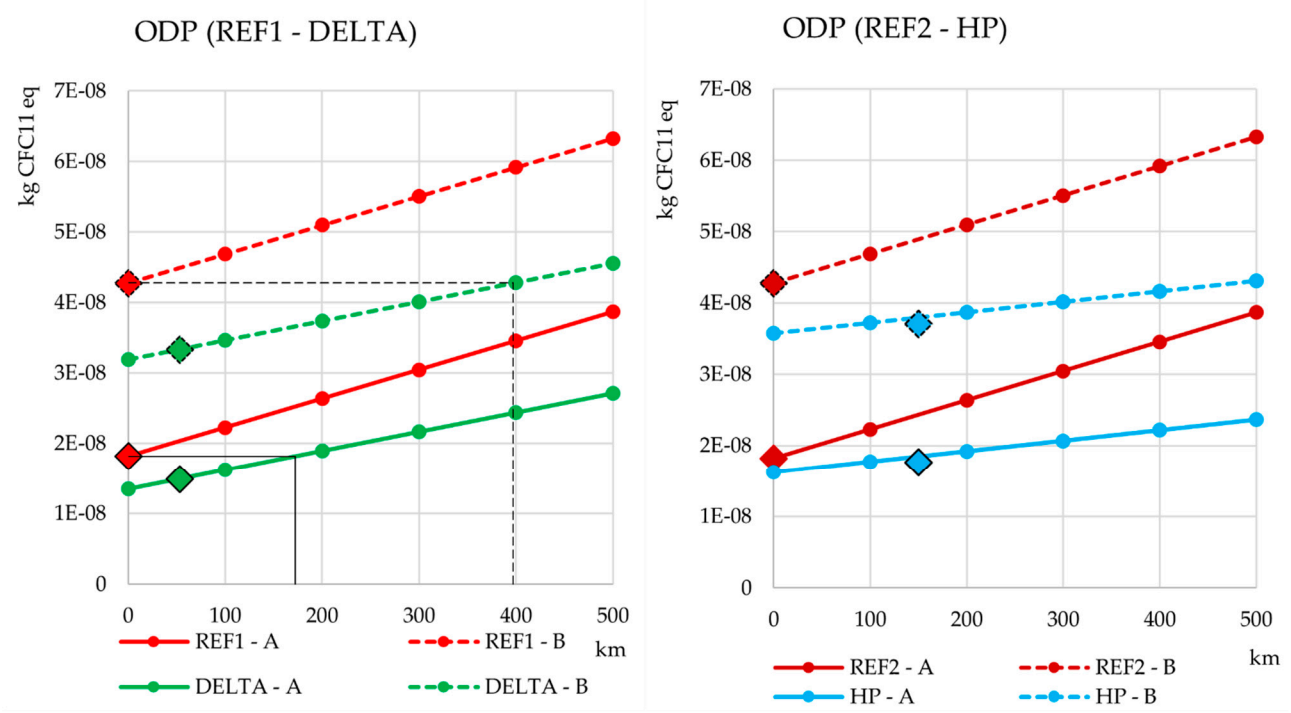


Figure S6. Eutrophication potential, Accumulated Exceedance (EP-terrestrial), different scenarios of transport of: (**a**) Mortar REF1 and DELTA; (**b**) Mortar REF2 and HP

7. Abiotic depletion potential for non fossil resources (ADP-Mineral & Metals)

For this category, the use of natural aggregate is convenient from an environmental point of view only if the distance between the mortar factory and the recycled aggregate DELTA is more than 95 km for scenario A (black solid line) and more than 320 km for scenario B (black dotted line) (



(**a**) (**b**)

Figure S1 (a)).

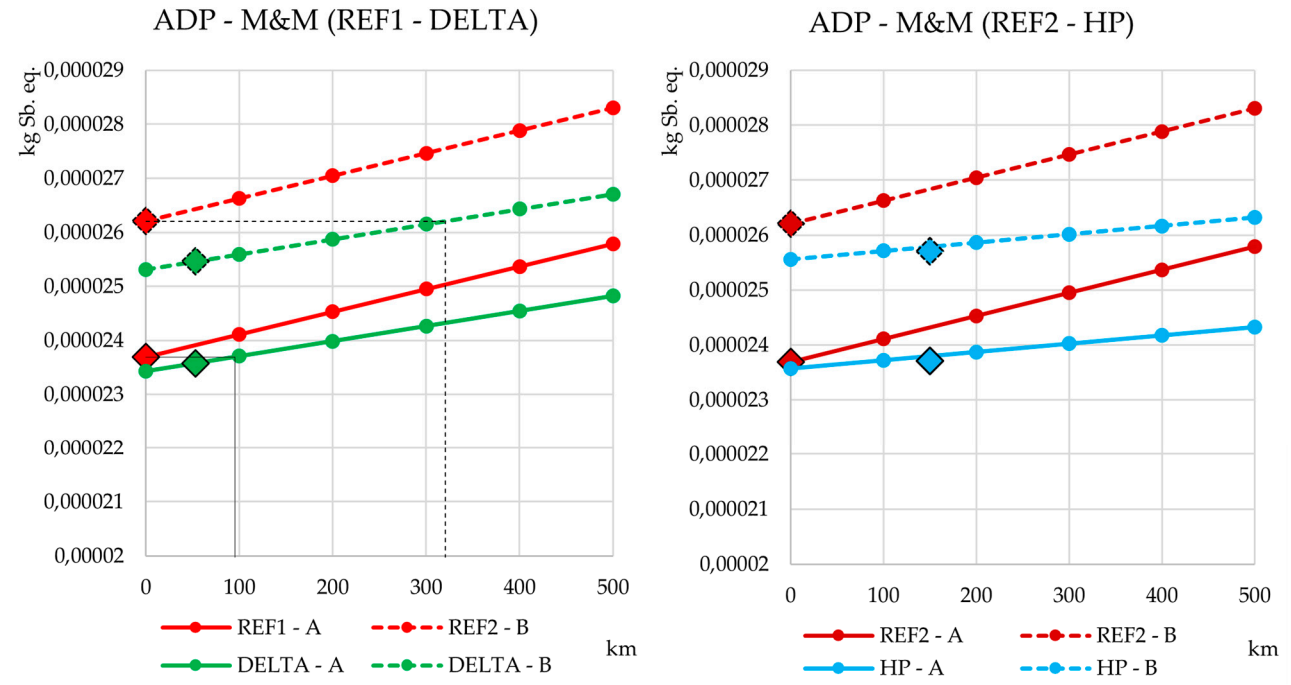
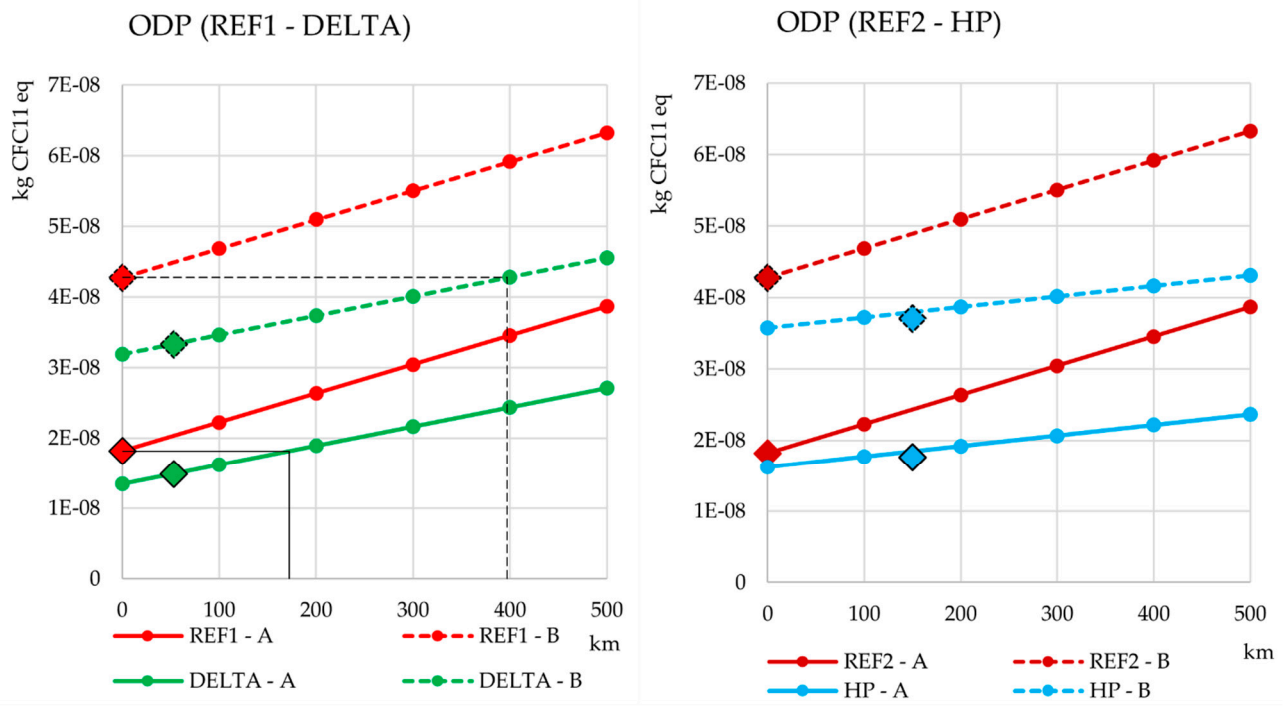


Figure S7. Abiotic depletion potential for non-fossil resources (ADP-Mineral & Metals), different scenarios of transport of: (**a**) Mortar REF1 and DELTA; (**b**) Mortar REF2 and HP

8. Abiotic depletion for fossil resourced potential (ADP-fossil)

For this category, the use of natural aggregate is convenient from an environmental point of view only if the distance between the mortar factory and the recycled aggregate DELTA is more than 212 km for scenario A (black solid line) and more than 437 km for scenario B (black dotted line) (



(**a**) (**b**)

Figure S1 (a)).

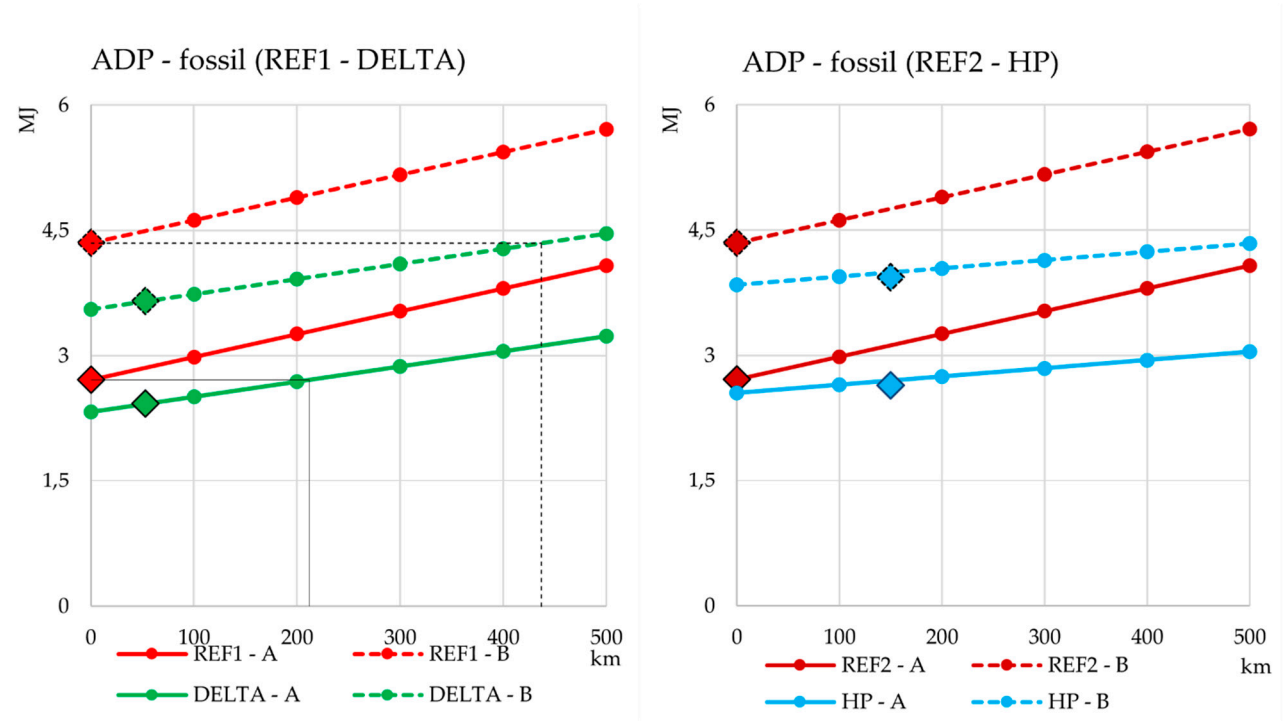
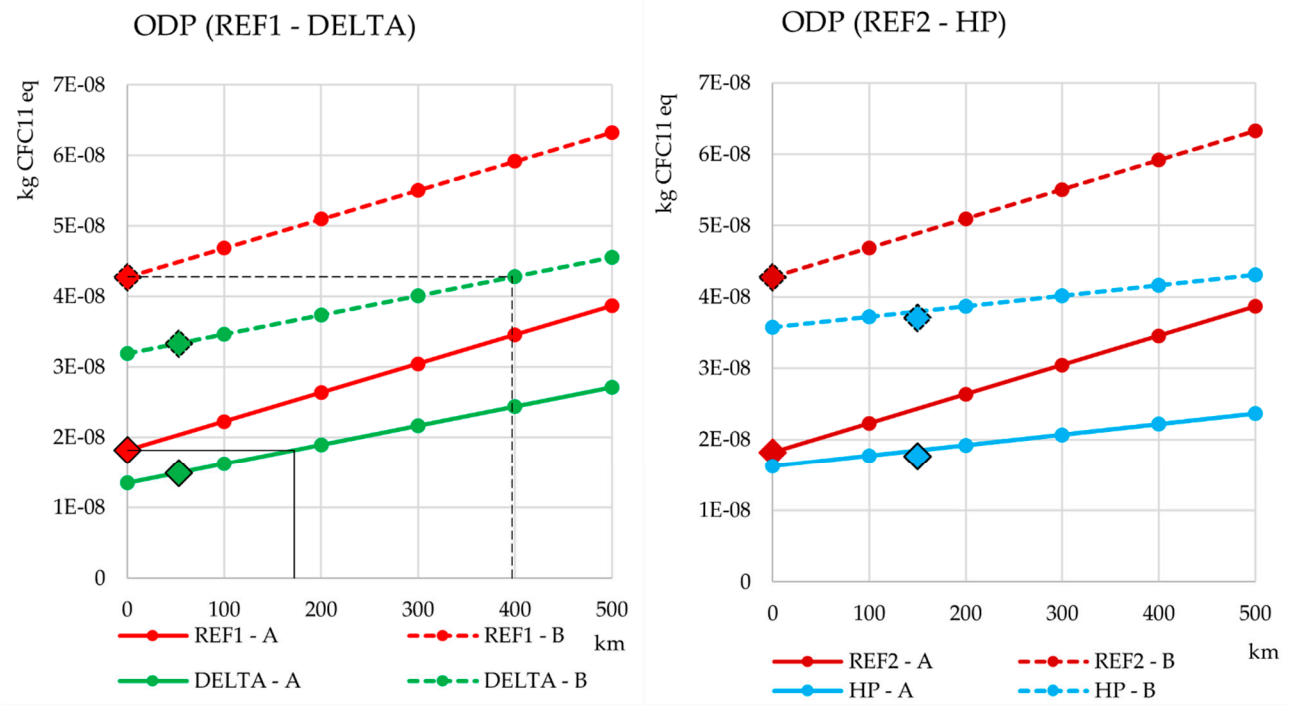


Figure S8. Abiotic depletion for fossil resourced potential (ADP-fossil), different scenarios of transport of: (**a**) Mortar REF1 and DELTA; (**b**) Mortar REF2 and HP

9. Use of Non-Renewable Primary Energy Resources (PE-NRe)

For this category, the use of natural aggregate is convenient from an environmental point of view only if the distance between the mortar factory and the recycled aggregate DELTA is more than 212 km for scenario A (black solid line) and more than 437 km for scenario B (black dotted line) (**Figure S1**a).



(**a**) (**b**)

Figure S1

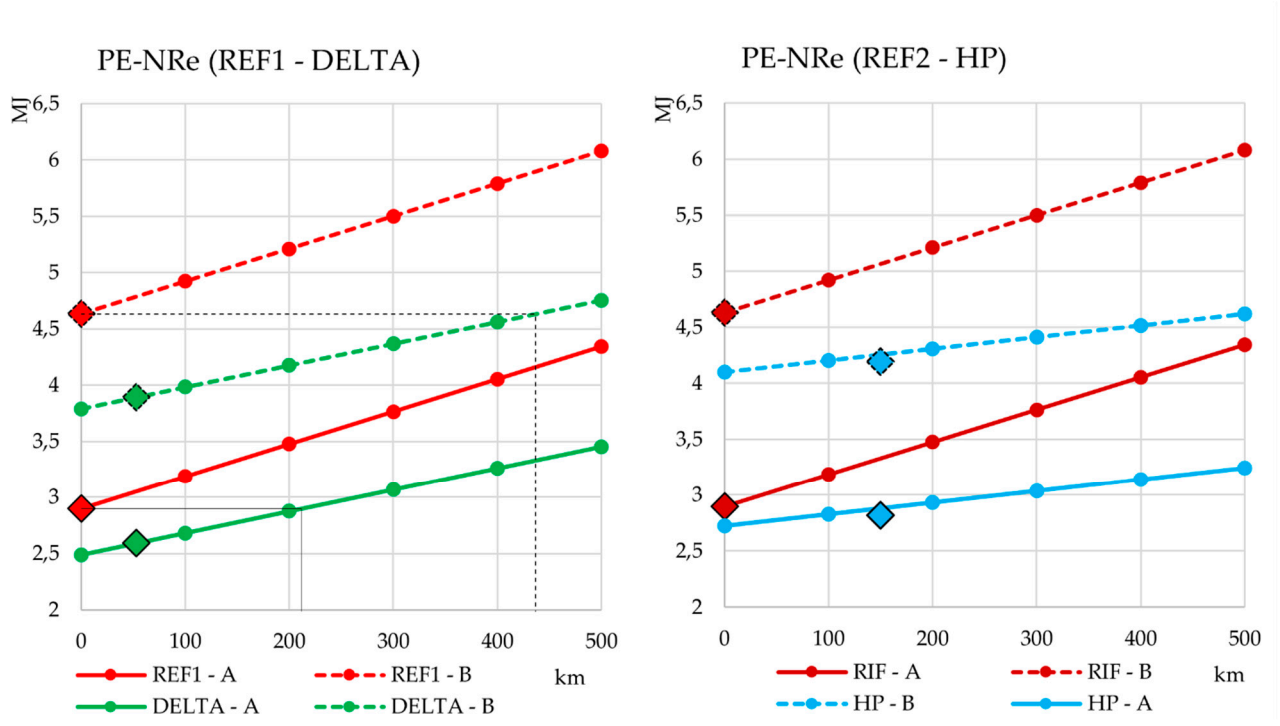
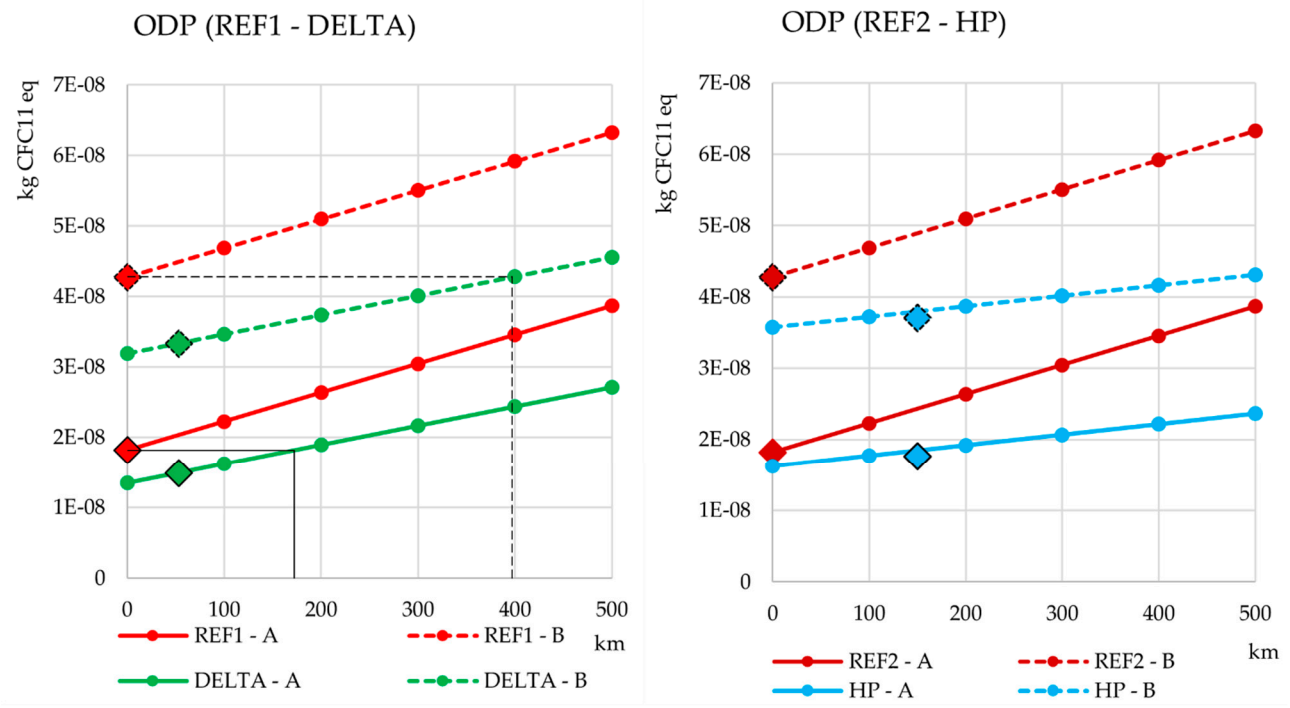


Figure S9. Use of Non-Renewable Primary Energy Resources (PE-NRe), different scenarios of transport of: (**a**) Mortar REF1 and DELTA; (**b**) Mortar REF2 and HP

10. Use of Renewable Primary Energy Resources (PE-Re)

For this category, the use of natural aggregate is convenient from an environmental point of view only if the distance between the mortar factory and the recycled aggregate DELTA is more than 2255 km for scenario A (black solid line) and more than 2480 km for scenario B (black dotted line) (**Figure S1**a)).



(**a**) (**b**)

Figure S1

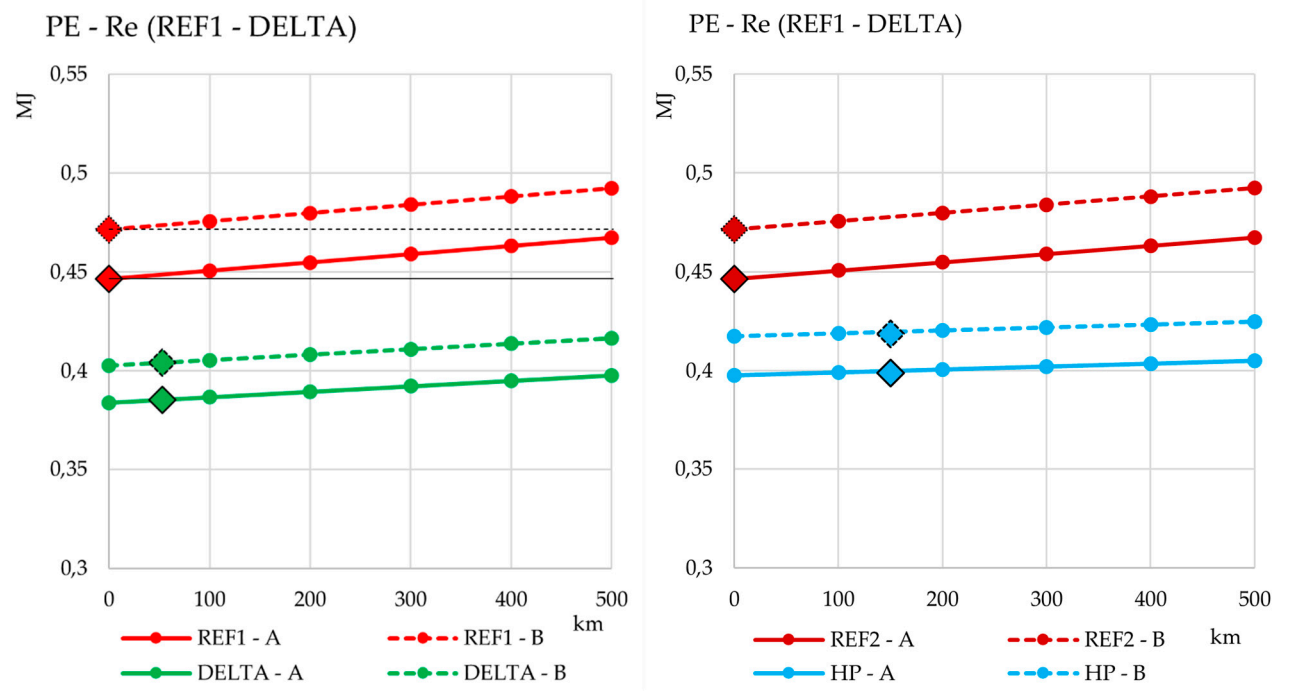


Figure S10. Use of Renewable Primary Energy Resources (PE-Re), different scenarios of transport of: (**a**) Mortar REF1 and DELTA; (**b**) Mortar REF2 and HP.