

Figure 1. System boundaries of the examined biorefinery at full-scale. Black-boxes correspond to processes excluded from the system boundaries.

Figure 2. Plant flow chart of the barley straw and brewer's spent grains based biorefinery.

Figure 3. Distribution of contributions to the environmental profile per areas involved (including ancillary activities) in the whole production system. Acronyms: AP - acidification potential, EP- eutrophication potential, GWP - global warming potential, ODP - ozone layer depletion potential, HTP - human toxicity, FEP - freshwater aquatic ecotoxicity potential, MEP - marine aquatic ecotoxicity potential, TEP - terrestrial ecotoxicity and POP - photochemical oxidation potential.

Figure 4. a) Distribution of contributions from production stages directly involved in xylooligosaccharides production. b) Distribution of impacts from Area 3 – XOS purification. Acronyms: AP - acidification potential, EP- eutrophication potential, GWP - global warming potential, ODP - ozone layer depletion potential, HTP - human toxicity, FEP - freshwater aquatic ecotoxicity potential, MEP - marine aquatic ecotoxicity potential, TEP - terrestrial ecotoxicity and POP - photochemical oxidation potential.

Figure 5. a) Distribution of contributions from production stages directly involved in bio-ethanol production. b) Distribution of impacts from Area 4 – fermentation. Acronyms: AP - acidification potential, EP- eutrophication potential, GWP - global warming potential, ODP - ozone layer depletion potential, HTP - human toxicity, FEP - freshwater aquatic ecotoxicity potential, MEP - marine aquatic ecotoxicity potential, TEP - terrestrial ecotoxicity and POP - photochemical oxidation potential.

Figure 6. a) Effect from steam production into the global environmental profile of the baseline scenario; b) Comparative profile resulting from the sensitivity assessment; c) Comparative environmental profiles in terms of global warming potential associated with different routes of oligosaccharides production. A - González-García et al. (2016); B - González-García et al., (2018); C – Gullón et al. (2018); D - current study. Acronyms: AP - acidification potential, EP- eutrophication potential, GWP - global warming potential, ODP - ozone layer depletion potential, HTP - human toxicity, FEP - freshwater aquatic ecotoxicity potential, MEP - marine aquatic ecotoxicity potential, TEP - terrestrial ecotoxicity and POP - photochemical oxidation potential.

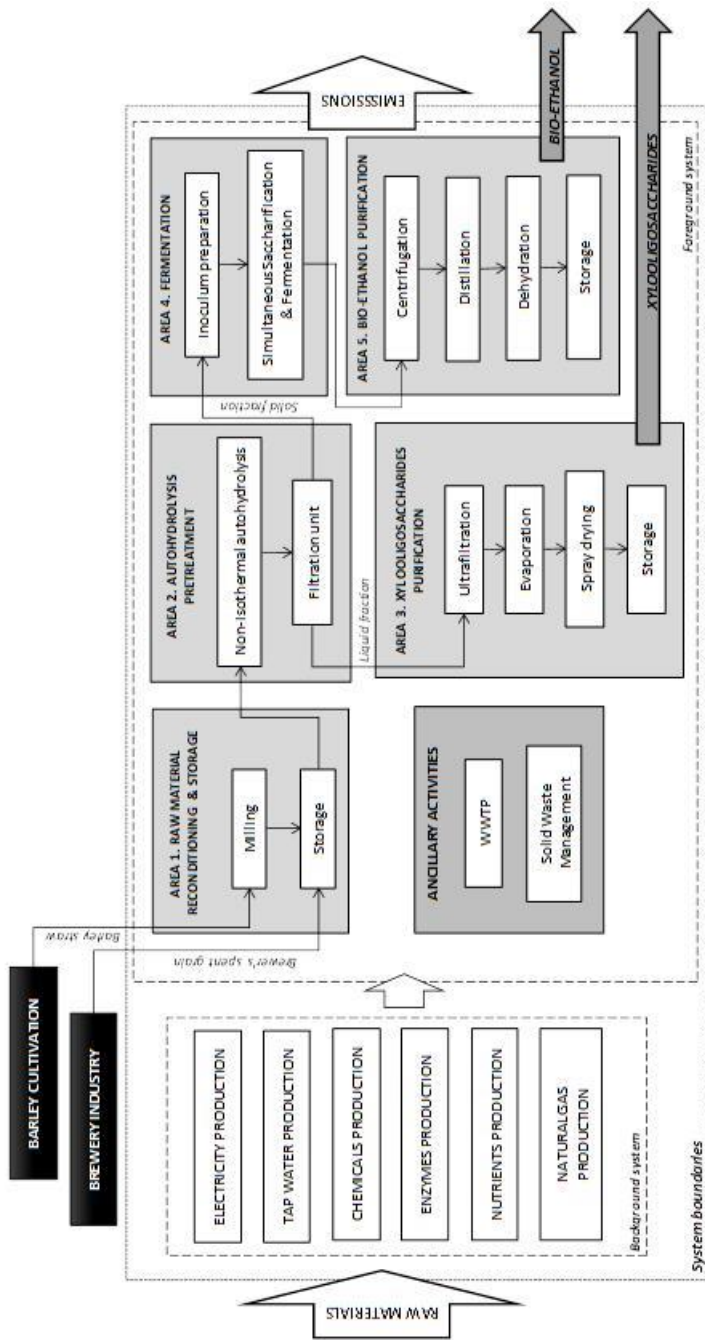


Figure 1

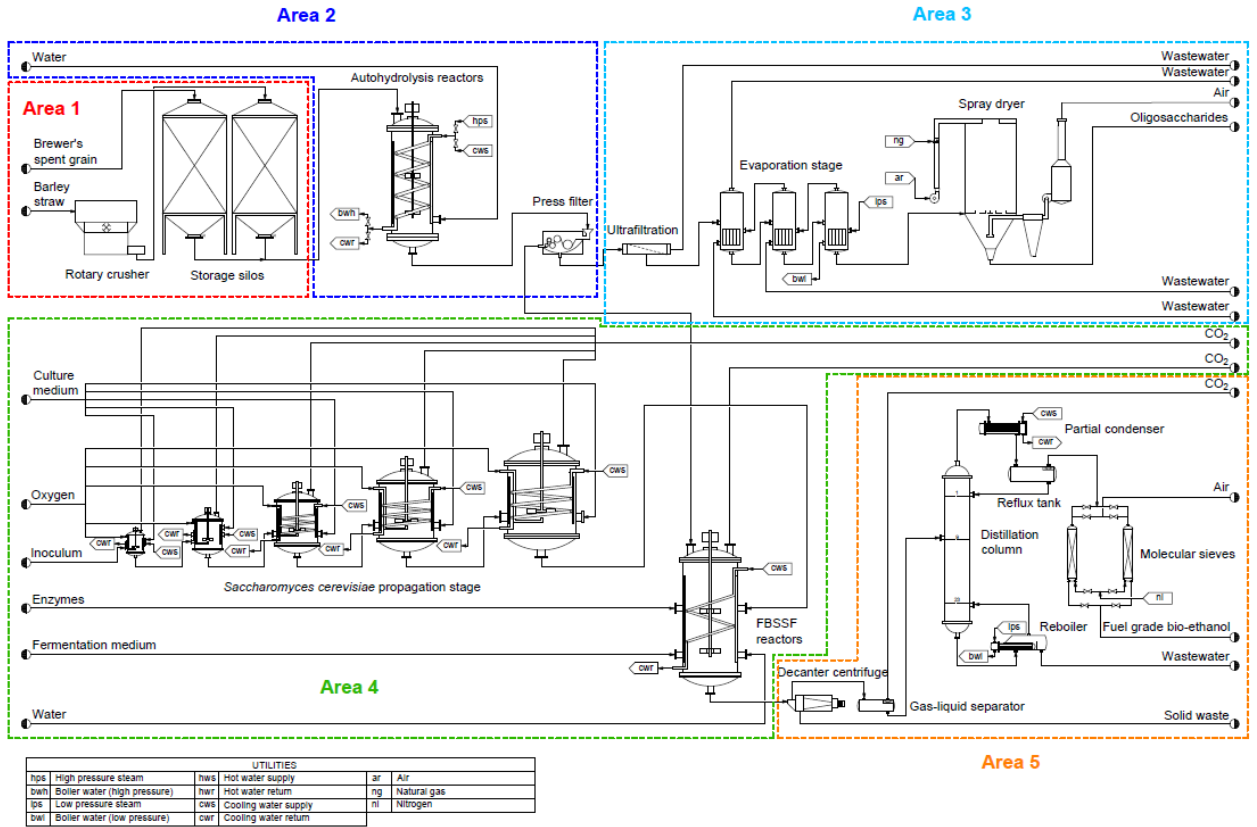


Figure 2

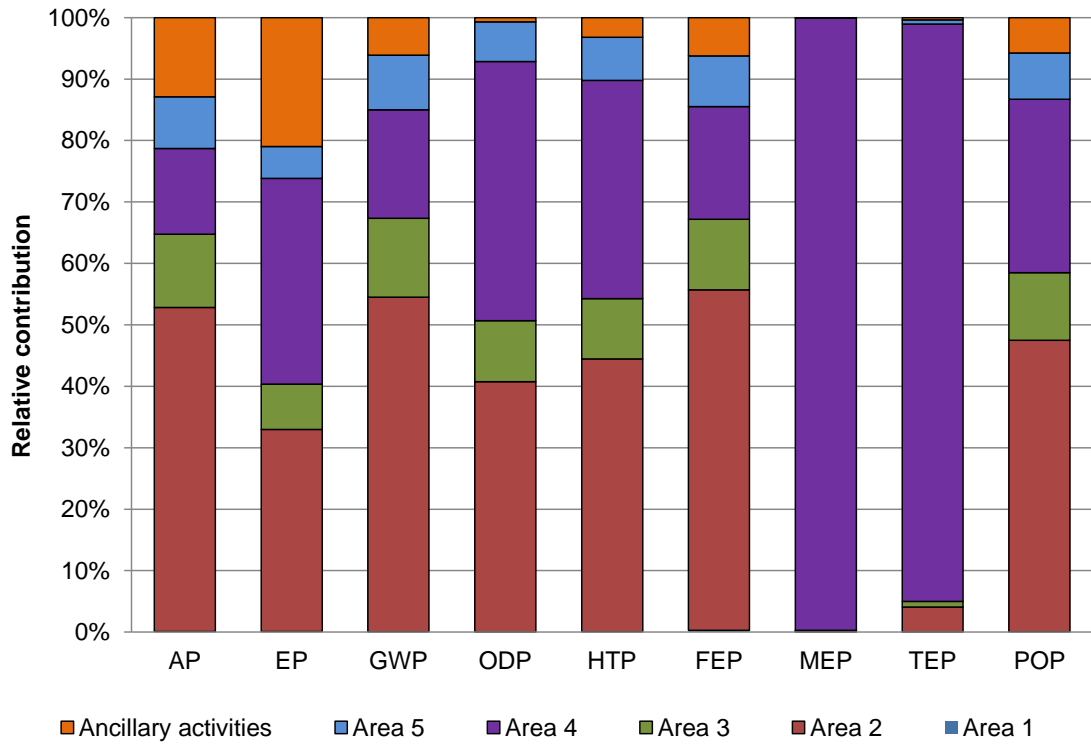


Figure 3

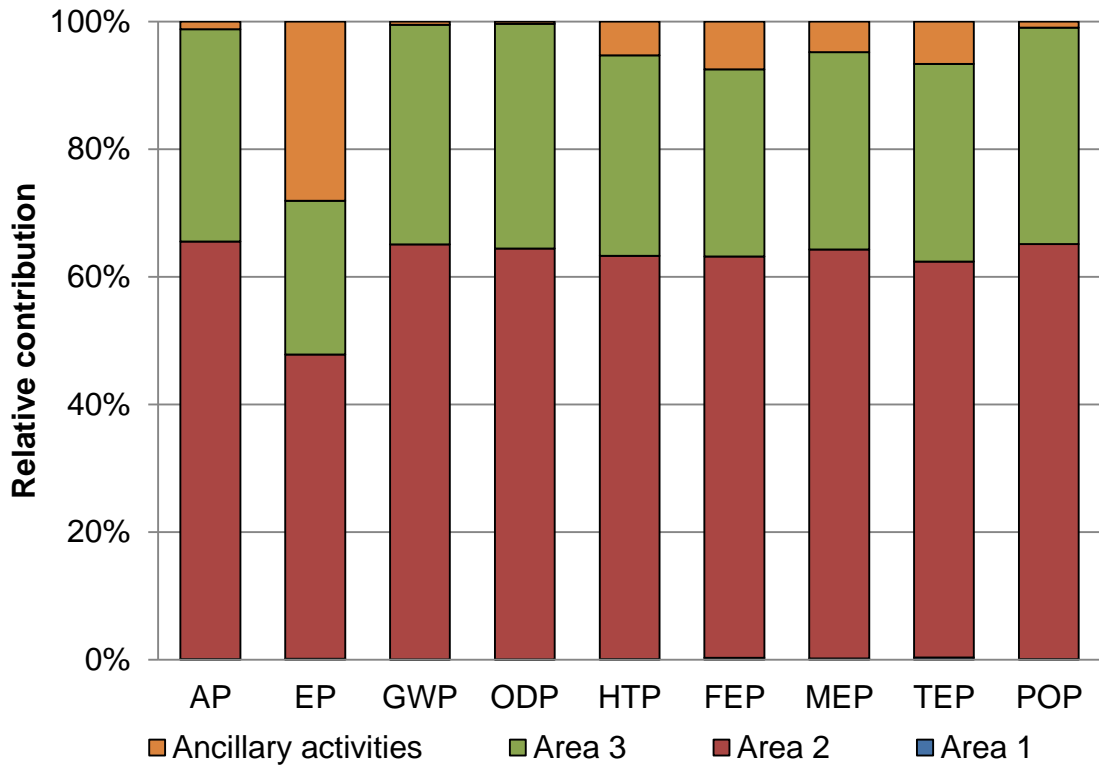


Figure 4a

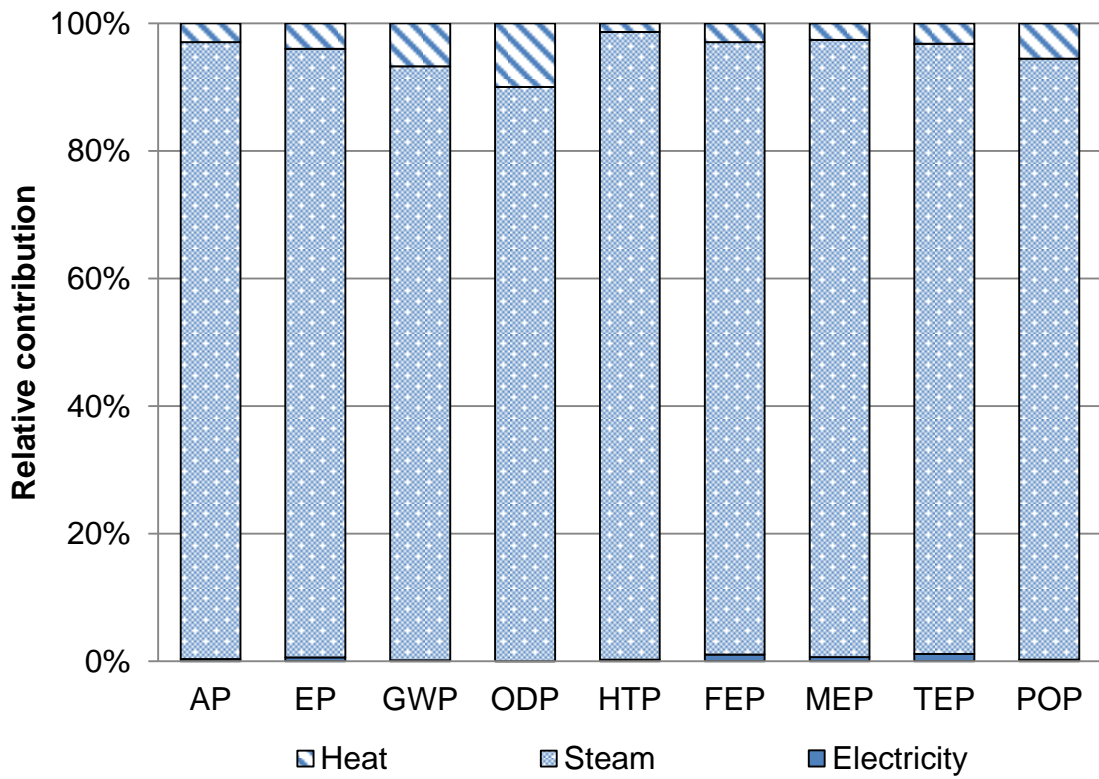


Figure 4b

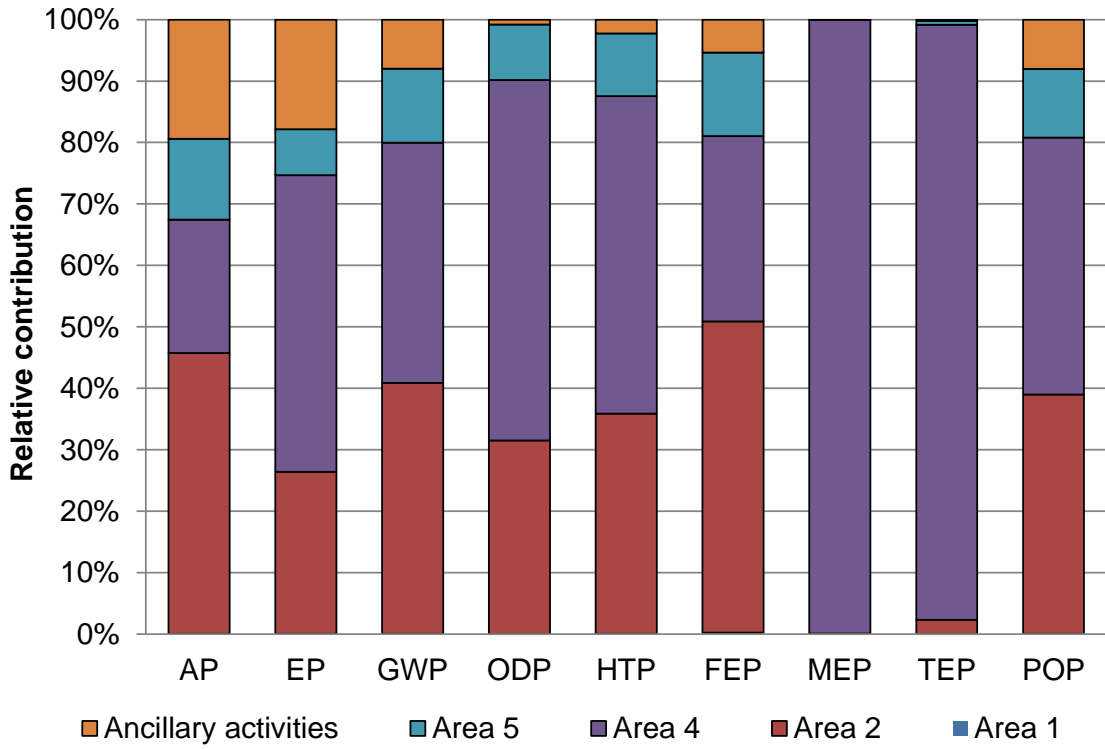


Figure 5a

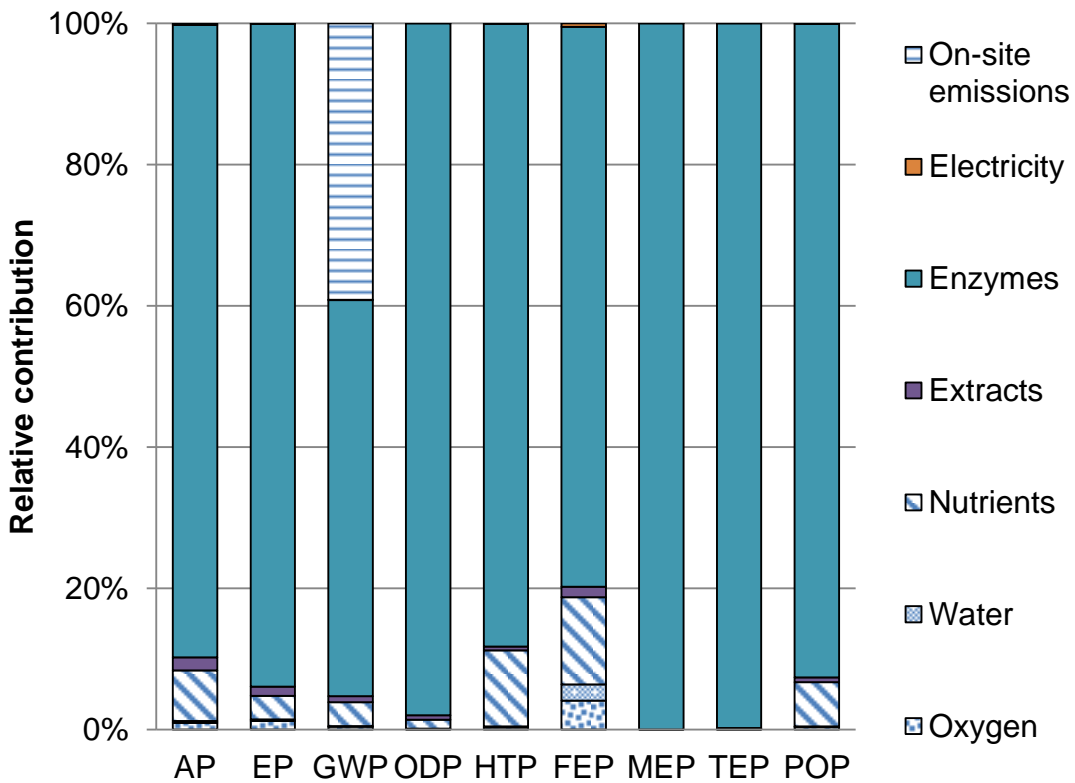


Figure 5b

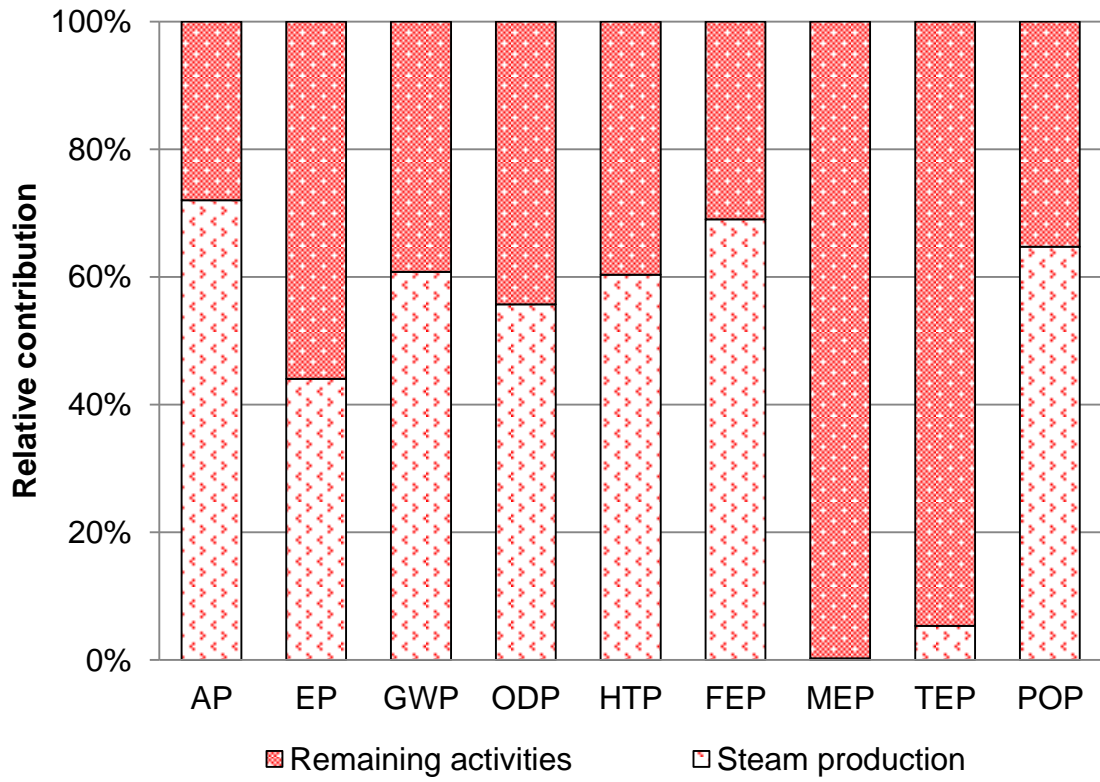


Figure 6a

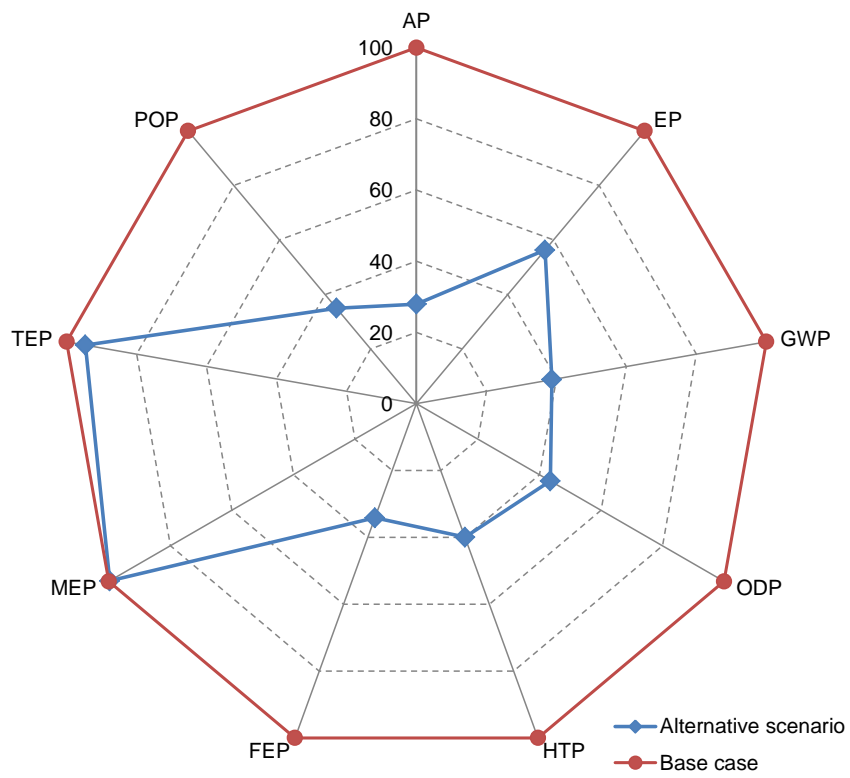


Figure 6b

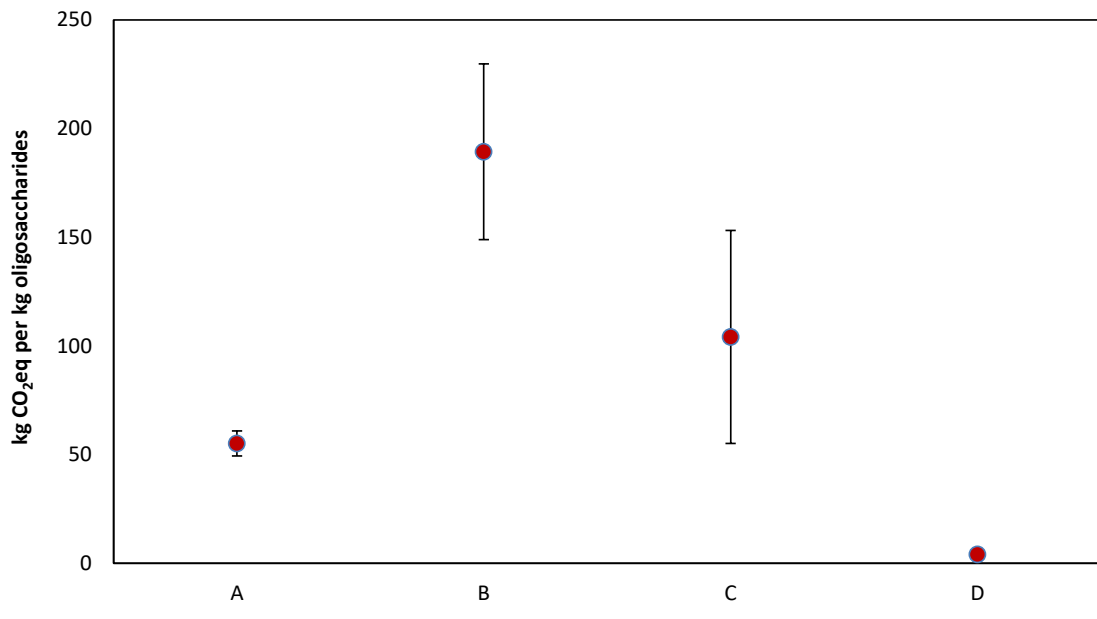


Figure 6c