



Agriculture and climate change report

Technical appendix: Energy

Calculating the baseline of agriculture emissions

The agriculture emissions baseline is calculated based on the Food and Agriculture Organization's Agriculture Emissions Database (Agriculture Total, FAOSTAT, FAO, accessed July 2019, fao.org/faostat), with the following minor adjustments:

- Adapted emissions to reflect AR5 GWP values (*Climate change 2014: Synthesis report*, Intergovernmental Panel on Climate Change, 2015, ar5-syr.ipcc.ch, p. 87)
- Cross-checked with crop and livestock demand estimates contained within FAO's database ("Food and agriculture projections to 2050," Global Perspectives Studies, FAO, 2018, fao.org; see also *The future of food and agriculture: Alternative pathways to 2050*, FAO, 2018, fao.org) and the McKinsey Food Demand Model. This resulted in minor adjustment to emissions expected to be driven by crop agriculture production area (up 9 percent by 2030 and up 13 percent by 2050)
- Given that FAO's estimates for emissions from "energy use in agriculture" were discontinued from 2013 forward, we used 2007–12 compound annual growth rates (CAGRs) by region (Brazil, Europe, China, India, and the rest of Asia) and energy source (electricity, fuel oil, natural gas) to project emissions forward to 2015. Forecasts to 2050 were based on discrete CAGRs (2012–30 and 2030–50) for agricultural acreage projections (*The future of food and agriculture: Alternative pathways to 2050*, FAO, 2018, fao.org)

Key assumptions, by MACC measure

All assumptions made for each part of the marginal abatement cost curve (MACC) are based on published literature.

● 100-year GWP²

■ 20-year GWP²

Zero-emissions on-farm machinery and equipment

696

715

Baseline applicable emissions,
MMT CO₂e, 2050 [A]

Source: McKinsey baseline model (via FAOSTAT data): GHG emissions from energy use on farm (excluding in fisheries, for irrigation, and electricity)

75

Incremental lever implementation, % [B]

Source (current and incremental implementation): To determine tractor life span as proxy for farm equipment; thus replacement rate, see Ricardo Muñoz et al., "Estimation of the lifespan of agricultural tractors using a diffusion model at the aggregate level," *Ciencia e investigación agraria*, December 2012, Volume 39, Number 3, pp. 557–62; to estimate year of TCO-parity for agriculture equipment, see Markus Forsgren, Erik Östgren, and Andreas Tschiesner, "Harnessing momentum for electrification in heavy machinery and equipment," May 2019, McKinsey.com

100

Greenhouse gas reduction factor,¹ % CO₂e [C]

Source: To determine tractor life span as proxy for farm equipment, thus replacement rate, see Ricardo Muñoz et al., "Estimation of the lifespan of agricultural tractors using a diffusion model at the aggregate level," *Ciencia e investigación agraria*, December 2012, Volume 39, Number 3, pp. 557–62; to estimate year of TCO-parity for agriculture equipment, see Markus Forsgren, Erik Östgren, and Andreas Tschiesner, "Harnessing momentum for electrification in heavy machinery and equipment," May 2019, McKinsey.com

522

537

Emissions reduction potential,
MMT CO₂e [A × B × C]³

236

229

Lever implementation cost savings, \$/tCO₂e

Source: To identify capex/opex costs for BEV vs ICE at point of TCO-parity, see Markus Forsgren, Erik Östgren, and Andreas Tschiesner, "Harnessing momentum for electrification in heavy machinery and equipment," May 2019, McKinsey.com; to identify relative weight of opex/capex on farms, see "Commodity costs and returns," United States Department of Agriculture Economic Research Service, accessed July 2019, ers.usda.gov; for share of tractor costs attributable to battery, see Michael Fries et al., "An overview of costs for vehicle components, fuels, greenhouse gas emissions and total cost of ownership update 2017," UC Davis, February 2018, steps.ucdavis.edu; for projected development of BEV battery prices, as proxy for capex, see *Electric vehicle outlook 2019*, BloombergNEF, accessed July 2019, bnep.com

¹ Difference due to greenhouse-gas reduction factor, % rounding.

² Global warming potential.

³ A × B × C doesn't always equal the exact final emissions abatement number due to GHG reduction/applicability percentage rounding.