Plane-parallel electron chambers show a replacement correction factor, P_{repl}, different from unity at low energies and / or phantom depths other than the depth of dose maximum, d_{max}. We analyse this behaviour with Monte-Carlo simulation (EGS4) and ionization dosimetry. Simulations are performed for nominal energies of 6, 4, and 2 MeV, respectively, and in-phantom depths smaller, equal, and larger (e.g. R_{50}) than d_{max}, and thus cover mean energies at depth, E_z, down to 1 MeV. We vary plate-separation from 1 to 2 mm and guard-ring width from 0 to 3 mm, a range found in typical commercial electron chambers, such as the Markus, Roos, NACP, and Attix chambers. At the small energies considered the chamber volume extends over a larger portion of the depth-dose curve, leading to dose gradients in the air volume which differ strongly from those in the chamber wall. One effect of this is, with 4 MeV at R_{50}, a 40% (10%) drop in dose due to backscatter in a chamber with 3 mm guard-ring and of 2 mm (1 mm) plate separation, resulting in P_{repl} of 1.08 (1.02). For guard-ring widths of zero to <2 mm the in-scatter from the side-wall has also a small effect below E_z = 6 MeV. From these results and dosimetric measurements of a variety of chamber modifications a new chamber was designed with a 1 mm plate separation, 2 mm guard-ring and a sensitive volume of 20 mm^3 which shows a flat energy response at all depths and relevant energies and high resolution.