Oxygen defective cerium oxides exhibit a non-classical giant electromechanical effect that is superior to lead-based electrostrictors. The main principle of such response is governed by the re-orientation of cerium-oxygen vacancy pairs (Ce_{Ce}-$V_O^{\cdot\cdot}$) in the host lattice. In this work, we report the key-role of acceptor dopants, with different size and valence (Mg^{2+}, Sc^{3+}, Gd^{3+}, and La^{3+}), on polycrystalline bulk ceria. Different dopants tune the electrostrictive properties by changing the electrosteric dopant defect interactions. We find two distinct electromechanical behaviors: when the interaction is weak (dopant-vacancy binding energy ~0.3 eV), electrostriction displays a high coefficient (M33), up to 10^{-17} m^2/V^2, with strongly time-dependent effects. In contrast, we observe no time-dependent effects when the interaction becomes strong (0.6 eV).