The design optimization of an axial flux permanent magnet synchronous machine with a coreless stator and double external rotor is accomplished by using evolutionary optimization with a genetic algorithm and an analytical evaluation of objective functions. On the basis of eight variable geometry parameters, five objective functions are optimized in order to determine the maximum volume torque density and weight torque density, the minimum volume and weight of permanent magnets per Newton-meter, and the minimum machine price per Newton-meter. Based on the geometric parameters for minimum machine price per Newton-meter, a prototype is built for the rated torque. Optimized and analytically evaluated machine characteristics are validated with a finite-element method (FEM) and the measurements of a prototype. Evolutionary optimization with the analytical evaluation of objective functions significantly shortens the computational time required for design optimization in comparison with the FEM.