This paper puts forward a novel design method of permanent magnet synchronous generator (PMSG). The most significant advantage of this method is that the output power of PMSG can be prominently improved without increasing any material costs. The main difference from the traditional design scheme is that the volume of permanent magnet (PM) remains unchanged during the entire design procedure. And the maximum output power scheme is found out just by optimizing the PM's shapes with the change of mechanical pole-arc coefficient. In other words, this method aims to obtain the maximum PM utilization design scheme that can produce more “effective” magnet field so that it can generate the larger output power. The dimension parameters of PMs with different shapes are calculated by the equivalent analytic geometry method. To verify its availability, this novel method is performed on four common types of PMSGs with different rotor structures, and their satisfactory performance results are obtained. The comparison with the traditional machine design scheme is also presented to illustrate the innovation and priority. The finite-element analysis method based on Ansoft/Maxwell is applied for the electromagnetic models' building and simulation.