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The Petty projection inequality states that among all convex bodies of given volume, the ones whose polar projection bodies have maximal volume are precisely the ellipsoids. Lutwak, Yang, and Zhang introduced the (symmetric) analogues of the projection body operator within the L_p Brunn-Minkowski theory and proved the L_p analogue of the Petty projection inequality for these operators. Moreover, they established affinely invariant L_p Sobolev inequalities which have these (symmetric) L_p Petty projection inequalities at their core. These sharp Sobolev inequalities are stronger than the classical ones of Aubin and Talenti. Recent advances in valuation theory revealed that there is a whole family of L_p analogues of the projection body operator. We present the L_p Petty projection inequality for each member of this family and show that these inequalities yield affinely invariant asymmetric L_p Sobolev inequalities. All of these new asymmetric inequalities strengthen and imply their symmetric counterparts. (Received August 13, 2008)