The most pressing challenges regarding the use of ammonia for CO2 capture are the precipitation limitation and the energy penalty of solvent regeneration. Precipitation-free operation is a vital task since solids may cause the shutdown of the plant. Precipitation and slurry formation can be avoided by increasing temperature and L/G ratio but this leads to higher heat consumption, jeopardizing the economic feasibility. Here we developed, investigated, and optimized a novel CO2 capture process design using aqueous ammonia as solvent. The proposed configuration replaces the traditional stripper for solvent based CO2 capture with a thermal decomposition reactor. The overall energy penalty is reduced at the expense of introducing a solid handling section which consists of a saturation reactor, a crystallizer and a belt filter. The feasibility of the present approach is demonstrated by simulation. Flow-sheet calculations are performed in Aspen Plus using the extended UNIQUAC thermodynamic model for vapor-liquid-solid equilibria and for thermal properties calculation of the CO2-NH3-H2O system. The simulation results show that the specific regeneration duty of the novel capture alternative is comparable with existing aqueous ammonia CO2 capture processes. Moreover, the thermal reactor can operate at 1 bar and 86 °C, therefore the NH3 regeneration temperature is reduced by approximately 50 °C. The integration of low- and mid-temperature waste heat becomes possible which can greatly improve the economics of the process. The present capture alternative is especially convenient for power plants but is also beneficial for the cement, steel and aluminum industry. Special attention is given to the ammonia slip prediction. The calculations substantiate that the slip above the absorber is 0.1 mol % after washing with the rich solution and it reduces below 100 ppm by washing with low temperature water.