Significant research efforts are currently being made worldwide to develop more efficient biomethane production processes from a variety of waste streams. The biomethanation of biomass-derived syngas can contribute to increasing the potential of methane production as it opens the way for the conversion of recalcitrant biomasses, generally not fully exploitable by anaerobic digestion systems. Additionally, this biological process presents several advantages over its analogous process of catalytic methanation such as the use of inexpensive biocatalysts, milder operational conditions, higher tolerance to the impurities of syngas, and higher product selectivity. However, there are still several challenges to be addressed for this technology to reach commercial stage. This work reviews the progress made over the last few years in syngas biomethanation processes in order to provide an overview of the current state of the art of this technology. The most relevant aspects determining the performance of syngas biomethanation processes are extensively discussed here, including microbial diversity and metabolic interactions in mixed microbial consortia, the influence of operating parameters and bioreactor designs, and the potential of modelling as a tool for the design and control of this bioprocess. © 2017 Society of Chemical Industry and John Wiley & Sons, Ltd