Development of sustainable power plants has gained focus in the recent years and utilization of biomass resources are seen as a pathway towards a sustainable combined heat and power (CHP) production. Biomass resources are distributed, thus decentralized biomass conversion would avoid extensive cost for biomass transportation. Traditional decentralized CHP plants suffer from low net electrical efficiencies compared to central power stations, though. Especially small-scale and dedicated biomass CHP plants have poor electrical power yield. Improving the electrical power yield from small-scale CHP plants based on biomass will improve the competitiveness of decentralized CHP production from biomass as well as move the development towards a more sustainable CHP production. The aim of this research is to contribute to enhanced electrical efficiencies and sustainability in future decentralized CHP plants. The work deals with the coupling of thermal biomass gasification and solid oxide fuel cells (SOFCs), and specific focus is kept on exploring the potential performance of hybrid CHP systems based on the novel two-stage gasification concept and SOFCs. The two-stage gasification concept is developed and demonstrated at the Technical University of Denmark and performs with a high cold gas efficiency, 93% (LHV), and a clean product gas suitable for electrochemical conversion in SOFCs. A zero-dimensional component model of an SOFC, including an electrochemical model, is developed and calibrated against published data from Topsoe Fuel Cells A/S. The SOFC component model predicts the SOFC performance at various operating conditions and is suited for implementation in system-level models using the simulation software DNA. Furthermore, it is used for issuing guidelines for optimal SOFC operation. A system-level modelling study of three conceptual plant designs based on two-stage gasification of wood chips with a thermal biomass input of ~0.5 MWth (LHV) is presented. Product gas is converted in a micro gas turbine (MGT) in the first plant design, in SOFCs in the second, and in a combined SOFC-MGT arrangement in the third. The plant scenarios are investigated by system-level modelling combining zero-dimensional component models including the developed SOFC component model. The SOFCs convert the product gas more efficiently than the MGT, which is effected by the net electrical efficiency of the gasifier and MGT system in opposition to the gasifier and SOFC configuration – \( \eta_{el}=27\% \) versus \( \eta_{el}=43\% \) (LHV). By combining SOFCs and a MGT, the SOFC off gases are utilized in the MGT to generate additional power and the SOFCs are pressurized, which improves the efficiency to as much as \( \eta_{el}=55\% \) (LHV). Variation of the different operating conditions reveals an optimum for the chosen pressure ratio with respect to the resulting electrical efficiency. Furthermore, the SOFC operating temperature and fuel utilization should be maintained at a high level and the cathode temperature gradient maximized. Based on 1st and 2nd law analyses, the plant layout of the SOFC-MGT scenario is optimized obtaining a net electrical efficiency of \( \eta_{el}=58\% \) (LHV). The performance gain is mainly ensured by an improved heat exchanger network. The optimization effort only required the installation of one additional component, an extra product gas preheater, ensuring reduced exergy destructions in several components and an increased TIT, thus boosting the MGT power output.