As the world progresses towards a cleaner energy future with more variable renewable energy sources, energy system models are required to deal with new challenges. This article describes design, development and applications of the open source energy system model Balmorel, which is a result of a long and fruitful cooperation between public and private institutions within energy system research and analysis. The purpose of the article is to explain the modelling approach, to highlight strengths and challenges of the chosen approach, to create awareness about the possible applications of Balmorel as well as to inspire to new model developments and encourage new users to join the community. Some of the key strengths of the model are the flexible handling of the time and space dimensions and the combination of operation and investment optimisation. Its open source character enables diverse, worldwide applications for exploratory energy scenarios as well as policy analysis as the applications outlined demonstrate. The existing functionality and structural suitability for extensions make it a useful tool for assessing challenges of the ongoing energy transitions. Numerous model extensions have been developed as different challenges to the energy transition have arisen. One of these includes the option of running the model with unit commitment. To meet new challenges, further development is needed and consequently the article outlines suggestions for future development, such as including transport of local biomass as part of the optimisation and speeding up the model.