The development of information and communication technologies (ICT) provides the means for reaching global connectivity that can help humanity progress and prosper. This comes with high demands on data traffic and number of connected devices which are rapidly growing and need to be met by technological development. Massive MIMO, where MIMO stands for multiple-input multiple-output, is a fundamental component of the 5G wireless communication standard for its ability to provide high spectral and energy efficiency, SE and EE, respectively. The key feature of this technology is the use of a large number of antennas at the base stations (BSs) to spatially multiplex several user equipments (UEs).

In the development of new technologies like Massive MIMO, many design alternatives need to be evaluated and compared in order to find the best operating point with a preferable tradeoff between low cost and complexity. In this thesis, two alternative designs for signal processing and hardware in Massive MIMO are studied and compared with the baseline operation in terms of SE, EE, and power consumption. The first design is called superimposed pilot (SP) transmission and is based on superimposing pilot and data symbols to eliminate the need to reserve dedicated time-frequency resources for pilots. This allows more data to be transmitted and supports longer pilot sequences that, in turn, reduce pilot contamination. The second design is mixed analog-to-digital converters (ADCs) and it aims at balancing the SE performance and the power consumption cost by allowing different ADC bit resolutions across the BS antennas.

The results show that the Massive MIMO baseline, when properly optimized, is the preferred choice in standard deployments and propagation conditions. However, the SP alternative design can increase the SE compared to the baseline by using the Massive-MIMO iterative channel estimation and decoding (MICED) algorithm proposed in this dissertation. In particular, the SE gains are found in cases with high mobility, high carrier frequencies, or high number of spatially multiplexed UEs. For the mixed-ADCs alternative design, improvements in the SE and EE compared to the Massive MIMO baseline can be achieved in cases with distributed BS antennas where interference suppression techniques are used.