The Paris Agreement highlighted that pathways towards a future with fossil fuel independent societies require the transformation of all sectors to reduce the levels of greenhouse gas emissions. To this end, the industry sector, characterised by a high share of emissions and an intense and diversified energy demand, holds a paramount role. In the framework of assessing the transformation of the industry sector towards more sustainable alternatives, due to interdependencies within an energy system, the adoption of measures to reduce fossil fuel use in industry (e.g., efficiency, fuel substitution, electrification and energy cascading) can influence the operation and transformation of the energy system. To this end, the study proposes a method to simulate and optimise operational aspects of the industry sector at high level of details. The conceptual model is then integrated in an established bottom-up energy system model, creating a benchmark for analyses that can focus simultaneously on the impact of changes in the industry and in the energy sector on a system-wide scale. On the practical side, by means of a Danish case study, the paper sheds light on particular characteristics of the industry sectors, focusing on the structure of industrial energy use in regards to end-use processes, aspects of energy consumption, and measures for fossil fuel reduction. Considerations sparking from the analysis show the potential applicability of energy cascading, electrification and fuel substitution for industrial processes, engaging elements and technologies interlinked within the energy system. Given the theoretical approach proposed, similar considerations can be investigated for other case studies, exploiting the simultaneous optimisation of power, district heat, industry dispatches and characteristics. In this framework, the transformation of the energy use in industry sector can be simulated according to more stringent policies capping emission levels and specific support schemes, paving the way for carbon neutral societies and a more sustainable, yet resilient, future energy system.