In this thesis, we consider the control of two different industrial applications that belong at either end of the electricity grid; a power consumer in the form of a commercial refrigeration system, and wind turbines for power production. Our primary studies deal with economic model predictive control of a commercial multi-zone refrigeration system, consisting of several cooling units that share a common compressor, and is used to cool multiple areas or rooms, e.g., in supermarkets. Substantial amounts of energy are consumed in refrigeration systems worldwide and there is a strong motivation for introducing more energy efficient as well as cost reducing control techniques. At the same time, the power grid is evolving from a centralized system with rather controllable production in the conventional power plants to a much more decentralized network of many independent power generators and a large penetration of renewable, fossil-free energy sources such as solar and wind power. To facilitate such intermittent power producers, we must not only control the production of electricity, but also the consumption, in an efficient and exible manner. By enabling the use of thermal energy storage in supermarkets, we open up for exible power consumption schemes with the possibility of reducing operational costs and we develop and demonstrate prototype control technology that creates completely new business opportunities for selling regulating power to the grid. Moreover, this enables a larger penetration of wind energy in the power production and increases the potential market size for wind power generators and other renewable energy sources. Thus, we aim at promoting the use of environmentally sustainable power production technologies while creating new business opportunities for both power consumers and producers of renewable energy.

The second application, wind turbines, takes us to the production side of the power grid. The key concern here is to improve the quality and integrability of power delivered to the grid from large parks of wind turbines. Our goal is to reduce the fluctuating nature of the power output and to meet tightened demands from the grid by enabling a more intelligent control of both the individual turbine level, at the park controller level, and in cooperation with exible power consumers or other means of energy storage. The possible interaction and synergies of the two applications are obvious reasons to consider both in this thesis, and as we will see, the similarities in our formulations of the different control problems allow us to apply almost identical techniques despite the lack of immediate similarity.

For control of the commercial refrigeration application as well as the wind turbine application, we propose an economic optimizing model predictive controller, economic MPC. MPC is a feedback control technique that is characterized by its explicit handling of constrained control problems in which a model is used to predict the future behavior of a system along with forecasts of future disturbances. At each time step the values of the control inputs are computed by solving an open-loop nite time optimal control problem over a dened prediction horizon. Only the rst step in this optimal open-loop sequence is implemented as a control command. Feedback is obtained by solving the open-loop problem repeatedly, in a receding horizon fashion, as new predictions become available. Our investigations are primarily concerned with: 1) modeling of the applications to suit the chosen control framework; 2) formulating the MPC controller laws to overcome challenges introduced by the industrial applications, and defining economic objectives that reect the real physics of the systems as well as our control objectives; 3) solving the involved, non-trivial optimization problems eiciently in real-time; 4) demonstrating the feasibility and potential of the proposed methods by extensive simulation and comparison with existing control methods and evaluation of data from systems in actual operation.

We present contributions on:
- Economic MPC for commercial refrigeration systems, including
  - Linear economic MPC formulations that utilize the exibility in refrigeration systems to counteract fluctuations in the balance between power consumption and production.
- Economic MPC with probabilistic constraints, ensuring a robust performance and constraint satisfaction in spite of inaccurate system models and forecasts.
- Nonlinear economic MPC, relecting the nonconvexity in the realistic description of temperature dependent efficiencies in the refrigeration cycle.
- Nonlinear economic MPC with uncertain predictions and the implementation of very simple predictors that use entirely historical data of, e.g., electricity prices and outdoor temperatures.
- Economic MPC for wind turbines, including
  - Optimal steady-state calculation for wind farms.
  - Nonlinear economic MPC for individual turbines.
- Change of variables and convex formulations of economic MPC for individual turbines.
- Tractable optimization methods for the MPC problems, including
  - Sequential convex programming (SCP) for specic nonconvex problems originating from our studies of commercial refrigeration as well as from our studies concerning wind power.
  - Successful demonstration of the SCP approach on three different problems the commercial refrigeration system with linear dynamics and constraints and a nonconvex objective, the individual wind turbine with nonlinear dynamics and constraints, and the static optimization of the wind farm with a black-box model.

The major contribution is the formulation of these problems and the demonstrations to show that the SCP method can be used for their solution. We demonstrate, i.a., substantial cost savings, on the order of 30 %, compared to a standard thermostat-based supermarket refrigeration system and show how our methods exhibit sophisticated demand response to real-time variations in electricity prices. Violations of the temperature ranges can be kept at a very low frequency of occurrence inspite of the presence of uncertainty. For the power output from wind turbines, ramp rates, as low a 3 % of the rated power per minute, can be effectively ensured with the use of energy storage and we show how the active use of rotor inertia as an additional energy storage can reduce the needed storage capacity by up to 30 % without reducing the power