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Design and Control of Energy Systems in Denmark - Challenges and Opportunities

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Abstract— **The Danish energy system has been a front-runner within integration of renewables for the last decades. Historically this has led to needs and new developments within design and control of production and supply systems, on individual plant level as well as on portfolio level. These developments include applications within adaptive control, multivariable control, portfolio balancing control and load planning systems. In future the needs for more detailed utilization of plant and system knowledge will grow further due to increased market and technology complexity. Improved utilization of hybrid knowledge, i.e. modelling on different timescales and modelling with diverse fidelity, contains large potential improvements in the design phase as well as in the operational phase. These challenges should be taken up in research and eventually be applied commercially.**

Keywords
Energy systems, control, design, performance, flexibility

I. Introduction

Denmark has been and still is a front-runner in the development of energy systems based on renewable resources like wind, solar, biomass, waste, etc. This has led to design and operational challenges due to increased complexity in terms of efficiency and stability. These challenges have also led to the need for development of new methods within integrated design, optimization and control. This paper resumes the past achievements and identifies the future needs within these fields, in which control and system R&D has unique challenges and opportunities.

The challenges within development of the Danish energy system and the corresponding control challenges are shown on a time line in figure 1. In system terms, development comes from a very controllable centralized situation with primary focus on production efficiency to a predicted future based on a very distributed uncontrollable system focusing on multi-product (power, heat, biofuels, etc.) flexibility. This system development has catalysed the needs within optimization and control, which initially focused on control of individual components (pumps, superheaters, turbines, etc.) and on a future which demands integrated optimization across complex plants.

In the 90s Danish energy production and supply were based on centralized fossil CHP (Combined Heat and Power) production. Most production capacity was large controllable units, and operational optimization was focusing on efficiency, availability and lifetime consumption. In terms of on-line optimization and control applications, R&D was focused on components or sub-processes within plants, most often SISO systems. An example is given in [1], which describes different approaches to superheater control, including fuzzy based

Control and IMC (Internal Model Control) of a superheater system.

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