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Energy

Modelling Generation Capacity Margin as a Dynamic Control Problem

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Introduction

The generation capacity (or plant) margin is a key indicator of system security of supply risk. The current UK electricity generation framework has no set standard for the future plant (or planning) margin and the need for new plant is determined by market forces.

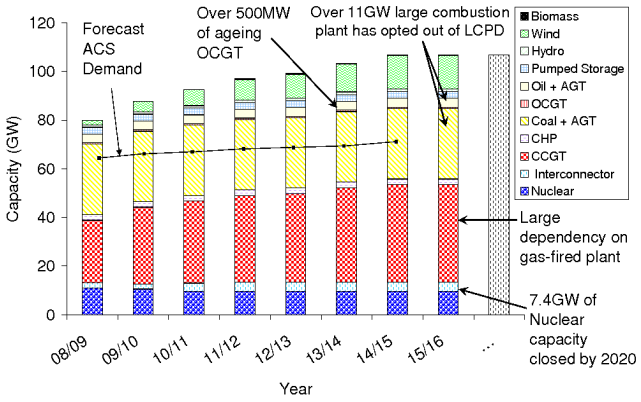

Fig. 1: GB Existing and planned generation. Source NGC SYS

A number of generating units are approaching the end of their design lifetimes (fig. 1). Electricity generation is prone to investment cycles due to its capital-intensiveness and the long lead time and lumpiness of new generation. Will this pattern continue in the long term and what are the implications on future security of supply?

Objectives

The main objective of this project is to establish whether the current UK market framework is capable of inducing optimal investment in generation capacity in a long term time-frame (~30-40 years).

Investment can be viewed as a negative feedback control mechanism with energy prices acting as a feedback signal (fig. 2).

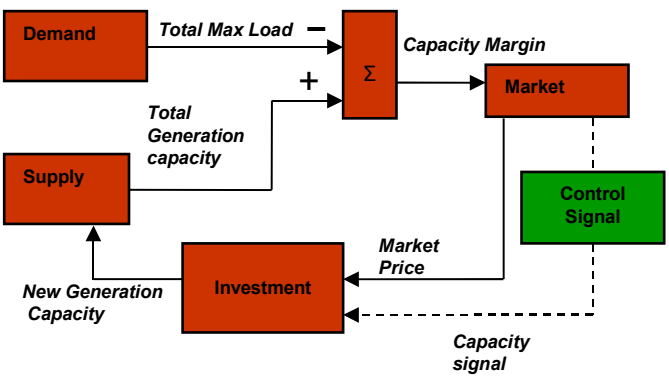

Fig. 2: Electricity investment as a control problem

If required, an appropriate stabilising signal will be designed to enforce any reliability requirement. Transmission capacity and connection issues will also be considered.

In addition to traditional plant investment, this work will focus on wind investment and its impact on the security of supply and long term market dynamics.

Methodologies

Control Engineering techniques, such as state-space design and robustness, will be called upon to model market dynamics and to design an appropriate stabilising signal.

$$\frac{dx}{dt} = Ax + Bu$$
$$y = Cx + Du$$

Stochastic Processes will be employed to model the expectation and volatility surrounding long term uncertainties such as demand and market price.

$$D_t = f(t) + X_t$$
$$dX_t = \mu(X_t)dt + \sigma(X_t)dW_t$$

Economics underpins this work. Essentially, this project aims to solve an large-scale power systems economic problem concerned with the proper functioning of a generation investment market (fig. 3).

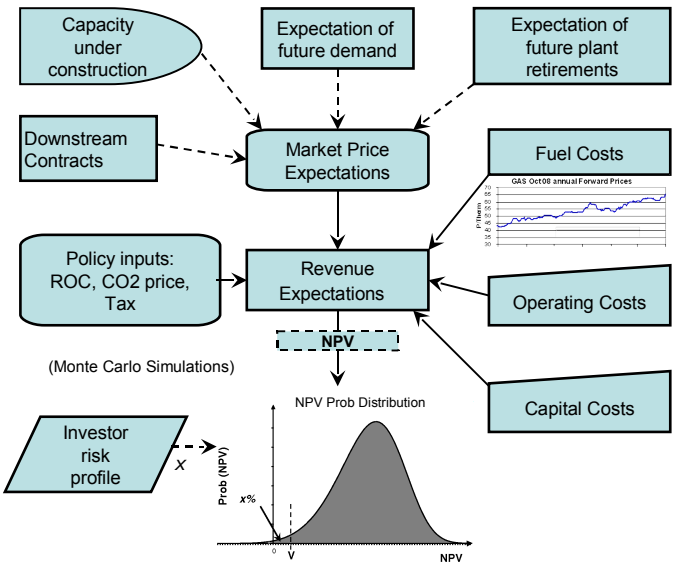

Fig. 3: The Investment Decision Process

Achievements & Future Work

- A detailed review of many liberalised market frameworks and existing capacity mechanisms has been carried out.
- Techniques for determining the security of supply risk (e.g. LOLP) have been assessed, and the contribution from high penetrations of wind power output to these security calculations is being considered.
- Construction of the long term dynamic control model (including the investment decision process) using Simulink® is underway.
- Simulations to establish the influence of capacity instruments on the damping of capacity and price fluctuations.
- Development of an appropriate damping signal and analysis whether it can be misused for gaming.

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