The value of operational flexibility by adding thermal to hydropower – a real option approach

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(1) Overview

This paper aims to estimate the value of operational flexibility by controlling hydro and thermal power generation in the Norwegian context. The shortage of electricity supply has lead to a debate of how to increase generating capacity. (Ministry of Petroleum and Energy, 2006). Even if there are considerable potential in small scale hydropower projects, there is also a need for investments in alternative generation technologies. Incentives for such projects, such as Governmental subsidies, are at present a controversial and partly unsettled political issue.

The focus of the paper is to value the operational flexibility for a hydro based system by dispatching thermal power plants. A prominent argument in the debate of introducing and recommending alternative generating technologies is that such can be complementary to the hydro dominant Norwegian (and Nordic) system, thereby increasing the operational flexibility which intuitively should represent value.

(2) Methods

To quantify this value the switching option model of Kulatilaka (1988) is applied to minimize the alternative cost of hydro generation to the operational cost and fuel cost of thermal generation. The idea is that the different cost structure in the different generation technologies can lead to financial benefits in a flexible system. The relevant cost in thermo power generation is operational cost and fuel cost (gas, coal and nuclear), while it seems most appropriate to relate to the alternative cost of hydro generation; that is the cost for present generation which sacrifices later generation in peak price periods. This parameter follows a seasonal pattern and is very volatile. The alternative cost for hydropower operation is developed and modelled based on data from Nord Pool (the Nordic power exchange) and the regulator (NVE).

(3) Results

The introduction of nuclear and coal fired thermal power plants represent an approximately value per year of respectively NOK 35 and NOK 22 per MWh yearly generation capacity, while gas fired power plants only represent value in “dry” years when the alternative cost of hydro generation is especially high. The numerical calculations give the results shown in table 1.

The option values can be interpreted as the flexible value by introducing thermal power generation in a hydro based system in order to generate 1 kWh in a year. The option values are highest for nuclear due to the low operational cost, while the value is zero for thermal power plants fuelled by gas. This option value is the net present value of cost savings due to the possibility to switch to thermal generation in times when the alternative cost of hydro as a stochastically variable is higher than the operational cost of thermal generation.

Table1: The option value based on different types of thermal generation (per kWh yearly generation capacity).

Type of thermal generation	**Cost of thermal generation, C^{Th}**	***Value, yearly generation 1kWh***
Gas fired	$C^{Th} = NOK\,0.31/kWh$	NOK 0.000
Coal fired	$C^{Th} = NOK\,0.14/kWh$	NOK 0.0218
Nuclear	$C^{Th} = NOK\,0.08/kWh$	NOK 0.0354

The findings show that the complementary argument is valid and that the switching option aspect should be included in the economical assessments of alternative generation technologies.

(4) Conclusions

The numerical calculations of the switching option value show that there are significant option values when nuclear and coal fired thermal power plants are assessed, while there is no value for gas fired power plants because of the high fuel cost. Ignoring the option value aspect can lead to underinvestment in nuclear and coal fired thermal generation compared to gas fired plants. Despite that there are shortcomings and disputable assumptions; these option values should be taken into consideration in valuation assessments.

The value of a flexible system can justify and legitimate some governmental subsidies. This assumes that the alternative cost of hydro generation can be linked to a kind of deficit cost at system level (de Moraes Marreco & Tapia Carpio, 2006). If the estimations of the alternative cost of hydro are interpreted as so the calculations of this paper are partly a valid argument for subsidies of alternative power generation, which is dependent on such support for being profitable.

References

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