INTERNATIONAL PERSPECTIVS ON POWER GRID INTERCONNECTIONS

Ivar Wangensteen
The Norwegian University of Science and Technology

1 INTRODUCTION

The benefits of establishing international interconnections and regional power pooling arrangements can in many cases be substantial. This paper describes some of these benefits on a general basis with emphasises on the benefits of interconnections between hydro and thermal systems. International interconnections in a competitive environment can have motivations and consequences that are different from what we find in traditionally organised systems, which will be illustrated. Finally some examples will be mentioned.

2 GENERAL BENEFITS OF INTERCONNECTIONS

2.1 *Factors contributing to the benefits*

Several factors contribute to the economic benefit of an interconnection and pooling arrangement:
Non coincidental peak load (Example: the England-France interconnection)

- Operational benefit (merit order loading)
- Merit order investments, i.e. the cheapest projects first.
- Scale economy. Large projects have often low unit cost but are too large for the local market.
- Lower total investment.
- Lower total reserve requirement (which contributes to lower investment).
- Use of hydro as a cheap FCR (Frequency Control Reserve).
- Use of hydro as a cheap load following.

2.2 *Reserve requirement*

As general (slightly simplified) rule, the requirement for short term (spinning) reserve in a generating system is set by the largest unit in the system. The system should be able to cover demand even if an outage of the largest unit should occur.

It follows from this that the total short term reserve requirement for each subsystem is reduced when several subsystems are integrated into one. It is also obvious that several <u>small</u> subsystems have more to gain with respect to reserve requirement than large subsystems. This depends on the fact that in a small system, the largest unit is probably larger in relation to total system capacity than in a large system.

3 BENEFITS OF INTERCONNECTING HYDRO AND THERMAL SYSTEMS

3.1 *Capacity and energy constrained systems*

A thermal electricity system is always capacity constrained, whereas a hydro system can be either capacity constrained or energy constrained[1]. In any case, there will be an economic benefit in linking the two systems together.

1) Capacity constrained hydro system

This means that there is water available to increase the power generation in off-peak periods. The demand is variable, and the system is designed to cover peak demand. In off-peak periods there is spare capacity and water available.

In an extreme case there is sufficient water to run the plants at full capacity all the time. In many cases a hydro generation system in an early stage of development will be capacity constrained.

The benefit of connecting such a hydro system to a thermal one is an increased hydro generation in off-peak periods at almost zero cost. That will replace thermal generation and thereby save fuel in the thermal system. The net effect is a reduced operation cost in the total system.

There can be some investment savings obtained in the generating system in this case. That depends on the fact that peak demand in different areas are normally not exactly coincident.

2) Energy constrained hydro system

The basic concern in an energy constrained system, is the amount of water available. As precipitation is variable and stochastic, a hydro system can have surplus in one rainy year, and still have problems in a dry year. An energy constrained hydro system will normally have a surplus of capacity.

The benefits of close interplay between a thermal power system and a predominantly hydro-based power system, includes the following main elements:

- Reduced operation costs in the thermal system due to import in peak (high cost) periods an export in off peak (low cost) periods.
- Reduction or postponement of investments in new peak power capacity in the thermal generating system.
- Reduced investment in the hydro system due to the possibility to import in a dry year.

3.2 *Use of Hydro as low cost Frequency Control Reserve*

There is almost no operation cost connected to the provision of frequency control reserves in a hydro system. In a thermal system additional operational cost (fuel cost) for keeping reserves stand by is estimated to 1-3% of total operation cost.

That gives an indication of what savings can be obtained if hydro can be used to cover the requirement for FCR.

---

[1] The terms "capacity constrained" and "energy constrained" refer to what are the binding constraints in an optimisation of the generating system. In a hydro system it can be the amount of water available during a certain period of time, for example one year. In that case it is energy constrained.

3.3 *Load following*

With respect load following, hydro generation has some inherent advantages compared with thermal units. The start up cost of a coal fired unit is about 100 times higher than for at comparable hydro generator. Start up and load up times are considerably smaller for hydro units than for thermal ones.

These features contribute to cost savings if hydro and thermal systems are integrated.

4 INTERCONNECTIONS IN A DEREGULATED ENVIRONMENT

Motivations and consequences related to an interconnection can be affected by deregulation. One motivation for interconnection in a competitive environment (from a societal point of view) is its contribution to increased competitive pressure. This will in most cases contribute to improved efficiency.

One important aspect in a competitive setting is how different factors affect market price. If one country has a surplus of cheap electricity and correspondingly low prices and another country has comparatively high generation cost and high prices, it is evident that an interconnection will affect the price level in the two countries. On the low price side the price will go up and on the high price side the price will go down. So generators in the low price country will probably benefit from an interconnection and generators in the low price country will suffer. The consequences for the electricity consumers will be vice versa.

5 EXAMPLES

Some examples of international interconnections are described. Some of these are implemented and some have only been studied. The examples are:

- Scandinavia
- The Baltic Ring Project
- England – France
- Columbia – Venezuela
- The Greater Mekong Subregion