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What is spinning reserve?

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Abstract

This document proposes a definition of spinning reserve. It also compares the amount asked by TSOs in several systems according to this definition.

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Abbreviations and acronyms

AGC: Automation Generation Control
ISO: Independent System Operator
LFC: Load-Frequency Control
NERC: North American Electric Reliability Council
PJM: Pennsylvania New Jersey-Maryland interconnection
TSO: Transmission System Operator
UCTE: Union for the Co-ordination of Transmission of Electricity

1 Introduction

The liberalisation of the electricity supply industry and the introduction of competitive markets for electrical energy have required the definition of ancillary services. The purpose of these ancillary services is to help maintain the security and the quality of the supply of electricity. In particular, control of the frequency requires that a certain amount of active power be kept in reserve to be able to re-establish the balance between load and generation at all times. In general, reserve can thus be defined as the amount of generation capacity that can be used to produce active power over a given period of time and which has not yet been committed to the production of energy during this period. In practice, different types of reserve services are required to respond to different types of events over different time frames. In particular, while the term "spinning reserve" is widely used in literature, this service can be defined in different ways. This may lead to some confusion.

To help reduce this confusion, this document proposes a definition of spinning reserve. It then provides the amount of spinning reserve required in several jurisdictions according to this definition.

2 Framework for defining reserves

This section outlines a framework that will help define spinning reserve.

2.1 Organisation of frequency control

The simplified scheme represented in Figure 2.1 illustrates the framework that is typically used for frequency regulation. This regulation usually involves three levels of controls. Using UCTE terminology [5], these levels are called Primary, Secondary and Tertiary. In large interconnected systems, all three forms of control are usually present. In smaller isolated systems secondary control may not exist as such. For the sake of simplicity, frequency regulation using demand-side action is not included in this diagram but could be considered without conceptual changes.

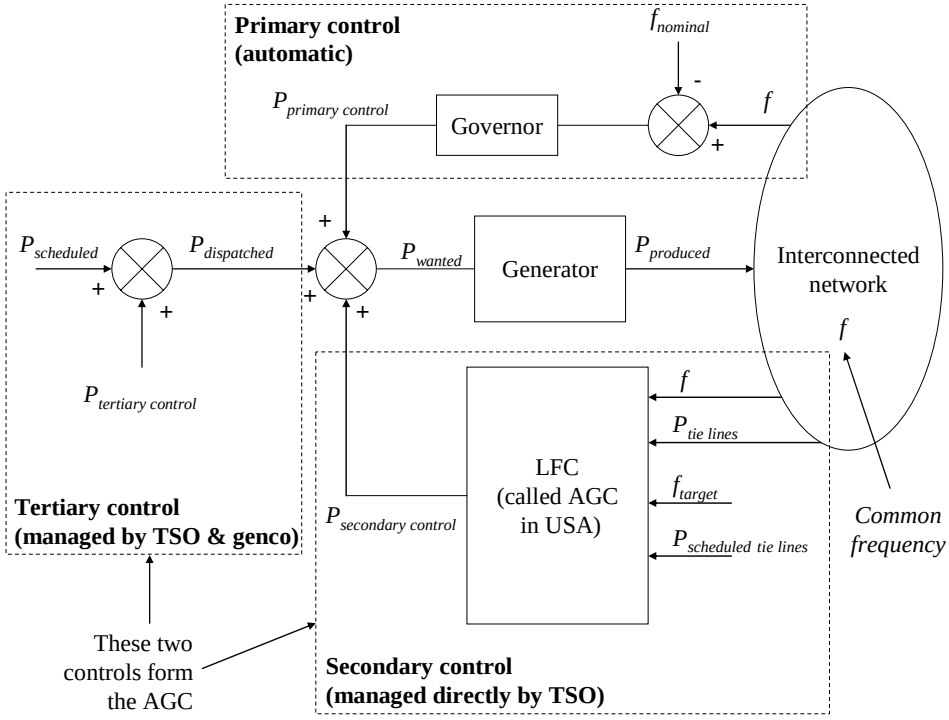

Figure 2.1: Framework for frequency regulation within the UCTE

Each control can be defined as follow [4]:

- ✓ *Primary control:* local automatic control which delivers reserve power in opposition to any frequency change;
- ✓ *Secondary control:* centralised automatic control which delivers reserve power in order to bring back the frequency and the interchange programs to their target values;
- ✓ *Tertiary control:* manual change in the dispatching and unit commitment in order to restore the secondary control reserve, to manage eventual congestions, and to bring back the frequency and the interchange programs to their target if the secondary control reserve is not sufficient.

2.2 Reserves and generator capacity

In theory, a generating unit could participate in all three levels of control. Figure 2.2 illustrates how its capacity would then be divided. In practice, a generating unit might provide only one, two or none of these reserve services.

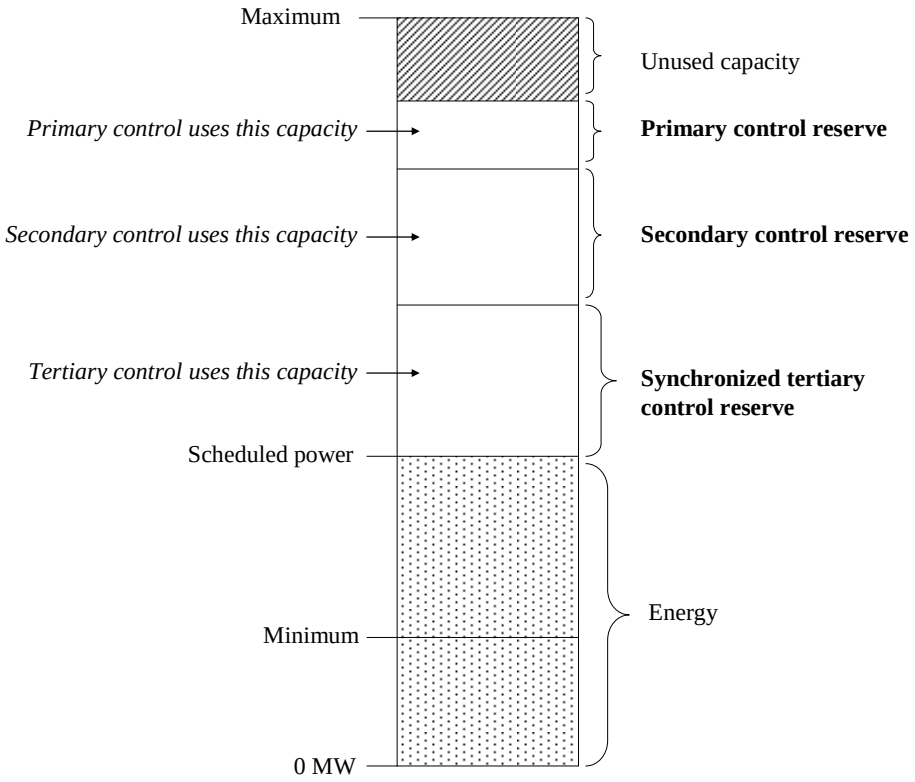

Figure 2.2: Allocation of the capacity of a generating unit that participates in all three levels of frequency control

3 Discussion on spinning reserve

This section tries to define the concept of spinning reserve.

3.1 Current difficulties

Many authors use the term "spinning reserve" without defining it because they assume that its meaning is obvious and unambiguous. However, a partial survey of the literature produces very different definitions:

- ✓ Hirst and Kirby [2]: "generators online, synchronized to the grid, that can increase output immediately in response to a major outage and can reach full capacity within 10 minutes";
- ✓ Wood and Wollenberg [7]: the total synchronised capacity, minus the losses and the load;
- ✓ Zhu, Jordan and Ihara [8]: "the unloaded section of synchronized that is able to respond immediately to serve load, and is fully available within ten minutes";
- ✓ British Electricity International [1]: "the additional output which is part-loaded generating plant is able to supply and sustain within 5 minutes. This category also includes pumped-storage plant […] operating in the pumping mode, whose demand can be disconnected within 5 minutes";
- ✓ UCTE [6]: tertiary reserve available within 15 minutes "that is provided chiefly by storage stations, pumped-storage stations, gas turbines and by thermal power stations operating at less than full output (responsibility of the TSO)";
- ✓ NERC [3]: "Unloaded generation that is synchronized and ready to serve additional demand".

These definitions disagree (or remain silent) on some important issues:

- ✓ Who provides spinning reserve? Is it limited to generators or can the demand-side participate?
- ✓ What is the time frame for responding to a request? When should it start and end?
- ✓ How is this reserve activated? Does it happen automatically or is it only done at the request of the Transmission System Operator (TSO)?

Therefore, it seems to be interesting to propose a definition which could fit any system.

3.2 A general definition

In order to get a general definition of spinning reserve, it seems to be essential to remove the idea of time. In fact, each system has its particularities. However, in any system, there is a system operator. Therefore, this concept can be used within the proposed definition. Lastly, it seems to be interesting to get detached from the terms such as "generator" or "demand-side", which can introduce more ambiguities.

We therefore propose the following definition: *the spinning reserve is the unused capacity which can be activated on decision of the system operator and which is provided by devices which are synchronized to the network and able to affect the active power.*

3.3 Consequences of the spinning reserve definition

Some important comments should be made on this definition:

- ✓ The beginning of the reserve deployment or the reserve deployment duration does not appear in the definition, as they are not relevant for a general definition of the spinning reserve. In fact, each country has its own definition (e.g. secondary control reserve has to

be fully available in 8 minutes in France and in 5 minutes in the USA [4]), depending on parameters such as the size of the synchronous network or the market structure;

- ✓ The primary control reserve, which is not controlled by the TSO, has to be excluded from the spinning reserve. Moreover, the self-regulating effect of the loads, which has an effect similar to the primary reserve, is also excluded from the spinning reserve. In fact, these two items are more important for network stability than for balancing consumption and production;
- ✓ Secondary control reserve should be considered as spinning reserve. In fact, the power deployed by the TSO through this reserve equilibrates the consumption and the production and has to be kept as long as required;
- ✓ Spinning reserve includes also synchronized tertiary control reserve, as this reserve is deployed on the instruction of the TSO;
- ✓ If a generator decides not to provide reserve, its spare synchronized capacity is *not* spinning reserve, as it cannot be activated by the system operator. However, in many systems, generators have to bid all their spare synchronized capacity in the balancing mechanism. Therefore, in this case, the system operator has the possibility to call all the synchronized capacity;
- ✓ A consumer can provide spinning reserve, if it agrees to be disconnected or to reduce its load upon request by the TSO. Pump loads are prime candidates for the provision of spinning reserve from the demand side.

3.4 Reserves and generator capacity

Based on the previous discussion, the spinning reserve for a generating unit is represented in Figure 3.1.

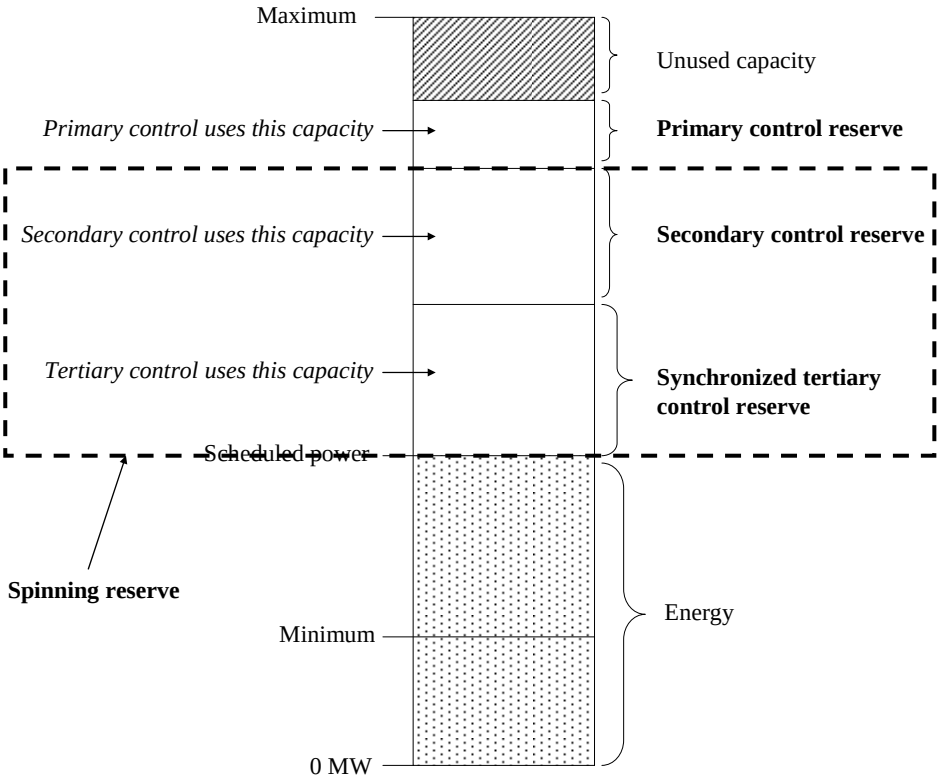

Figure 3.1: Representation of the spinning reserve of a generating unit that participates in all three levels of frequency control

3.5 Amount of spinning reserve in different countries

According to the definition given in Section 3.2 and [4], Table 3.1 lists how (positive) spinning reserve requirements are calculated in different systems.

Table 3.1: Calculation of spinning reserve requirements in different systems

Country	*Calculation of the amount of spinning reserve*
UCTE	No specific recommendation. The recommended maximum is $\sqrt{10L_{max\ zone} + 150^2} - 150$
Belgium	UCTE rules. Currently at least 460 MW by generators.
France	UCTE rules. Currently at least 500 MW.
The Netherlands	UCTE rules. Currently at least 300 MW.
Spain	Between $3\sqrt{L_{max}}$ and $6\sqrt{L_{max}}$
California	$50\% \times \max(5\% \times P_{hydro} + 7\% \times P_{other\ generation}; P_{largest\ contingency}) + P_{non-firm\ import}$
PJM	1.1% of the peak + probabilistic calculation on typical days and hours

Where:

- ✓ L_{max}: the maximum load of the system during a given period;
- ✓ $L_{max\ zone}$: the maximum load of the UCTE control area during a given period;
- ✓ P_{hydro}: scheduled generation from hydroelectric resources;
- ✓ $P_{other\ generation}$: scheduled generation from resources other than hydroelectric;
- ✓ $P_{largest\ contingency}$: value of the power imbalance due to the most severe contingency;
- ✓ $P_{non\text{-}firm\ import}$: total of all the interruptible imports.

Lastly, negative spinning reserve was not taken in account in Table 3.1. However, it is essential for the stability of the network to be able to reduce the active power production in case of a high frequency. However, since most of the time reducing power production is easier than increasing it, this problem is not considered further.

4 Summary

This document proposes a definition of spinning reserve. The spinning reserve is the unused capacity which can be activated on decision of the system operator and which is provided by devices that are synchronized to the network and able to affect the active power. Therefore, spinning reserve corresponds to the UCTE secondary (automatic and central) and synchronized tertiary control reserves (manual and central).

This definition can be applied in most power systems. Therefore, it may be used to compare the spinning reserve requirements in different jurisdictions.

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