

ENERGY ADVISORY COMMITTEE

Loss of Electricity Supply Incident Affecting Italy on 28 September 2003

This paper informs members of the investigation findings on the blackout incident that occurred in Italy on Sunday, 28 September 2003 as reported by the Union for the Coordination of Electricity Transmission or UCTE (the “UCTE report”¹), the Swiss regulatory authority (the “Swiss report”²), and the Italian and French regulatory authorities (the “Italian-French report”³).

Background

2. Italy’s electric power system is interconnected with that of France, Switzerland, Austria and Slovenia through 380 kV and 220 kV circuits. A rather significant proportion of the electricity demand in Italy had been supplied by imports from these neighbouring countries, e.g. the average electricity import in both 2002 and 2003 stood at about 17% of Italy’s total annual electricity consumption⁴. This import level is not uncommon for economies that rely on external support to meet their local electricity demands.

3. The transmission system operators (TSOs) in all the affected countries (i.e. Austria, France, Italy, Slovenia and Switzerland) are members of UCTE, which is an association of TSOs in 23 countries across continental Europe. UCTE is responsible for coordinating the operation and development of electricity transmission grid in and among its member countries. In the aftermath of the 28 September 2003 blackout, a UCTE Investigation Committee⁵ was set up to conduct an independent investigation of the incident. The Committee issued an interim report in October 2003, and then a final report in April 2004.

4. In November 2003, the regulatory authority of Switzerland, Swiss

¹ Based on the interim report issued in October 2003 and the final report issued in April 2004 by UCTE.

² Based on the report issued in November 2003 by the Swiss Federal Office of Energy.

³ Based on the report issued in April 2004 jointly by AEEG (the Italian regulatory authority for electricity and gas) and CRE (the French regulatory authority for energy).

⁴ Source: data published in the webpage of the Italian transmission system operator GRTN

⁵ Apart from the 5 countries involved, i.e. Austria, France, Italy, Slovenia and Switzerland, the UCTE Investigation Committee also consisted of members from 4 other countries, namely Belgium, Germany, Spain and the Netherlands.

Federal Office of Energy (SFOE) issued its investigation report on the incident. In April 2004, the regulatory authorities in Italy and France, namely the Autorita per l'energia elettrica e il gas (AEEG) and the Commission de regulation de l'energie (CRE) respectively, issued a joint investigation report on the incident. As a result, there were three separate reports on this incident, viz. the UCTE report, the Swiss (SFOE) report and the Italian-French (joint AEEG-CRE) report.

The Incident

The Blackout

5. On 28 September 2003 at about 3:00 a.m. local time, Italy was importing electricity from its neighbouring countries at about 7,000 MW (or 25% of its electricity demand at that time), mostly from Switzerland and France. At 3:01 a.m., a 380 kV overhead transmission line in Switzerland (the Lukmanier line) tripped out. The Lukmanier line was connected at Lavorgo to a 380 kV interconnector with Italy (the Lavorgo-Musignano line). The cause of tripping the Lukmanier line was alleged to be due to flashover to trees. Several attempts made by the automatic re-closing facilities of the Lukmanier line to reconnect were unsuccessful. A manual re-closing attempt made at 3:08 am also failed.

6. Following this tripping, the adjacent transmission lines took up shares of the interrupted loading, thus causing overloading of a 380 kV overhead transmission line between Sils and Soazza in Switzerland (known as the San Bernardino line). The San Bernardino line was connected at Soazza to another 380 kV interconnector with Italy (the Soazza-Bulciago line).

7. At 3:11 am, the Swiss system co-ordination center requested the Italian system control center to reduce its electricity demand so as to help relieving the overloaded San Bernardino line. A reduction of the electricity import to Italy by some 300 MW, which was the excessive amount over the total scheduled power transfer at that time, was achieved by 3:21 a.m. However, this power import reduction was apparently not sufficient to relieve the overload situation. At 3:25 a.m., the overloaded⁶ and sagging San Bernardino line tripped out due to flashover to trees.

8. After tripping of these two major lines, the remaining transmission lines in that area were overloaded, including the interconnectors across the

⁶ The San Bernardino line was operating at 110% of its normal capacity prior to tripping.

Switzerland-Italy and France-Italy borders. Cascade tripping of these interconnectors within about 12 seconds after tripping of the San Bernardino line had resulted in the Italian power system losing all of its power import and being completely separated from the European power grid.

9. The loss of power import to Italy had resulted in a significant supply deficiency and system voltage instability, which led to tripping of many generators in Italy by automatic protection devices and worsen the supply deficiency. As a result, the system frequency dropped further and initiated automatic load shedding, which apparently was not sufficient to restore the system frequency and stability. Within half an hour, at around 3:28 a.m., 2.5 minutes after the Italian power system was isolated from the European power grid, the whole of Italy except the Island of Sardinia was without electricity supply, affecting almost the entire population of about 57 million.

10. Restoration of electricity supply after the blackout began at around 3:42 a.m. by reconnecting the San Bernardino line, followed by the 220 kV and 380 kV interconnectors between Italy and Switzerland and Italy and France. Import from these neighbouring countries resumed and increased gradually from 2,100 MW at around 6:00 a.m. to 6,545 MW at around 4:00 p.m. Electricity supply to all Italian customers was fully restored at around 11:00 p.m. on that day.

Investigation Findings

11. Investigation showed that the Lukmanier line's flashover to trees occurred at 86% capacity loading. The UCTE report suggested that there could be a case of insufficient right-of-way maintenance, which is important to ensure that trees or other objects near a transmission line do not encroach into the safety clearance of the line. However, the Swiss report alleged that, according to its investigation, the concerned Swiss system operator complied with its regulation on right-of-way maintenance.

12. The general and long-standing operation principle adopted by the UCTE is the internationally recognised N-1 security rule, which sets out the basic requirement that a single incident should not jeopardise the secure operation of any interconnected power systems. When considering the initiating event of losing the Lukmanier line, the N-1 security rule would imply that the power system should remain in a stable condition after the incident. There were however different views in the UCTE report and the Italian-French report on the N-1 security state prior to tripping of the Lukmanier line. The UCTE report suggested that corrective measures were available to return the power system to a stable state after losing the Lukmanier line, by shutting down

the pump loading in the Italian power system⁷. However, the Italian-French report considered it not appropriate to rely on external measures (i.e. pump loading reduction in Italy), which had not been agreed in advance among the interconnected parties concerned, to correct internal problems occurred in Switzerland (as both the Lukmanier line and the San Bernardino line are located in Switzerland).

13. Immediately after tripping of the Lukmanier line, the interrupted power flow was automatically and instantaneously redirected to other transmission lines operating in parallel causing overload on some of them. Among them, the San Bernardino line, due its close proximity, carried the heaviest overload. The UCTE Investigation Committee estimated that such overload would cause the temperatures of line conductors to exceed the allowable limits, thus resulting in their sagging beyond design values and exposing the lines to risks of flashover. The UCTE Investigation Committee was of the view that failure to correct such overloading conditions was one of the root causes of this blackout incident.

14. The Swiss system operator had spent about 10 minutes to attempt re-closing the Lukmanier line and, upon failure of such attempts, requested its Italian counterpart to decrease electricity import by 300 MW, which was the excessive capacity over total scheduled power transfer at that moment. The Swiss report and the Italian-French report held different views in this respect. The Swiss report regarded such excessive capacity as a contributory factor to the incident, but the Italian-French report considered it to be the normal discrepancy between scheduled and actual power flows. Nevertheless, it was demonstrated that the reduction of 300 MW power import by the Italian system operator in about 10 minutes after receiving the request from its Swiss counterpart was not sufficient to return the power system to stable state. The UCTE report concluded that both the Swiss and Italian system operators were unaware of the severity at that moment.

15. There were also issues of communication between the Swiss and Italian system operators, and responsibility for restoring the power system security. The Italian operator alleged that the Swiss operator did not inform them about the overloading conditions of the San Bernardino line after tripping of the Lukmanier line, but only asked for a reduction of electricity import by 300 MW, which was subsequently found to be insufficient for restoring the power system to stable state.

⁷ The UCTE report pointed out that the Italian power system had about 3,500 MW of pump loading at that time, which could be shut down in approximately 5 minutes by order of the system operator, and therefore concluded that such measures, if implemented, would be sufficient to return the system to a stable state.

16. Another finding in the UCTE report was about the cause for unsuccessful isolated operation of the Italian power system after its disconnection from the European power grid. The UCTE report suggested that this was mainly due to failure in controlling the system voltage within predetermined limits during isolation of the Italian power system from its neighbouring countries, which eventually led to rapid tripping of many generators in Italy by automatic protection devices.

Investigation Recommendations

17. The recommendations of the UCTE report in addressing the main causes of this blackout incident could be grouped into 3 main areas –

- (a) Actions by UCTE (including its working groups, TSOs, etc.) include –
 - setting up or updating where necessary the emergency procedures, and making them mandatory and integrated into operator training;
 - reviewing relevant rules, in particular the N-1 criteria;
 - strengthening transmission congestion forecast;
 - enhancing exchange of data between operators;
 - determining minimum requirements for equipment (e.g. control setting for generators, etc.);
 - agreeing on appropriate frequency control strategies; and
 - accelerating installation of wide area measurement system⁸.
- (b) Actions on a national level include –
 - enforcing national grid codes which are harmonised at UCTE level; and
 - adopting defensive and restoration plans and other relevant practices, e.g. audited tree trimming practices, etc.
- (c) Interfaces with regulatory framework include –
 - empowering TSOs, developing market rules and incentives to ensure system adequacy and attract investments.

⁸ Wide area measurement system is stability analysis tool adopted by the UCTE, with time synchronised logging devices for recording system data across interconnected power systems.

18. The Italian-French report also recommended that the UCTE rules should be more detailed and compliance made legally binding, subject to independent assessment and control; co-ordination of TSOs be enhanced; and coherent regulatory framework be enforced across the European power grid.

19. The Swiss report shared some of views in the UCTE and Italian-French reports, and in addition, included recommendations with regard to the Swiss electricity supply industry, such as reforming the Swiss network management and regulatory arrangement; enactment of comprehensive law on reforming the Swiss electricity supply industry; establishing strong electricity regulator; strengthening its role and participation in the European electricity market; etc.

Observations

20. The cause of the incident could be averted, e.g. through better right-of-way management, enhanced awareness together with proper co-ordination and communication among interconnected parties to effectively mitigate transmission line overload, etc.

21. Apart from real-time operation, well co-ordinated and effective planning process is also important to ensure the reliability of interconnected power systems. In addition to the co-ordinated planning process among interconnected parties, proper training of the personnel involved to implement the procedures effectively would also be essential.

22. The power system in Hong Kong is not as complex and massive as the interconnected power systems involved in this incident. Nevertheless, effective planning and operation co-ordination are useful lessons from this incident.

Advice Sought

23. Members are invited to note the content of the paper.