Preparing Melbourne's Electrical Supply for the 2006 Commonwealth Games

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Presented by:
Michael Farr, Manager Networks Queensland, Sinclair Knight Merz

Written by:
Keith Frearson, Executive Consultant, Sinclair Knight Merz
Neil Watt, Manager Network Development, Citipower

- *Abstract* -

The biggest event ever staged in Victoria, the 2006 Commonwealth Games presented an enormous challenge to the CitiPower and Powercor Australia distribution business, owner operator of the electricity distribution networks which served almost all of the Games venues. CitiPower Powercorp Australia responded to the event by forming a specific operational management structure to supplement the normal business operations, and long term planning. In the lead up to the event 16MVA of additional capacity and over 10MVA of portable generation was installed.

During the eleven days of the event in March 2006, CitiPower and Powercor Australia maintained the power supply to all venues with loss of service.

This outcome was due to extensive pre-planning, risk analysis and a carefully defined operational plan. Collaborative relationships were formed with the event organisers and government bodies that resulted in CitiPower and Powercor Australia playing a leadership role in defining and then meeting power requirements. These relationships will endure and aid future endeavours.

This paper looks at the risks, impact and expectations on a power utility as it responds to a significant multinational and globally broadcast event taking place within its supply area over an extended period. It summarises the lessons learned through what proved to be an extremely successful response by CitiPower and Powercor Australia to its service delivery responsibilities.

1. Introduction

Held over 11 days in March 2006, the Melbourne Commonwealth Games was the biggest event ever staged in Victoria. The following statistics give an indication of the size of the event:-

- 71 nations or territories participating
- 7,200 athletes and officials
- 3,100 media representatives
- 1.6 million tickets sold
- 90,000 visitors

All the major venues were in the CitiPower network area in the inner suburbs of Melbourne. Three of the other six venues were located in the Powercor supply area in regional cities around Victoria.

CitiPower and Powercor Australia are two of the five electricity distribution businesses supplying the State of Victoria. Although they operate separate networks, the companies operate largely as a single entity. They are jointly owned by the Hong Kong-based Cheung Kong Group, and locally listed Spark Infrastructure.

Games venues were supplied at high voltage (11kV in CitiPower and 22kV in Powercor) and other smaller venues at low voltage (415V/240V). The Sub-transmission network supplying this system is run at 66kV for both CitiPower and Powercor.

This was the first time that all major venues were operating at full capacity at the same time together with an extensive open space cultural program attracting around 100,000 people nightly. It was comparable to having the Austrlaian Fottball League Grand Final, the Formula 1 Grand Prix, and the Australian Tennis Open all at the same time continuously everyday for 2 weeks. The Melbourne CBD was an extremely busy place during this time!

What are seldom recognised are the power infrastructure impacts and the requirements to support such an event. It is only when supply fails that the power utilities are noticed. In this day and age, reliable electrical supply is taken for granted.

Melbourne 2006 and the Office of Commonwealth Games Coordination (OCGC) were the event organisers; they engaged three contractors. These three contractors were allocated different aspects of the Games organisation including major venue supply arrangements, broadcasting, public domain areas and project management. CitiPower/Powercor had to deal with all three contractors separately.

This paper looks at the management of electricity supply for this event in terms of power infrastructure assets, incident management, resources, service levels, and business reputation. By outlining the process that was adopted to deal with the risks identified, distribution businesses that face similar events in the future can usefully draw upon this experience.

2. Risks and Assessment

Research began some 18 months prior to the Games into what organisers and government expected from CitiPower and Powercor. For example, what loads could be expected at major venues? Organisers were not ready for questions like this, but this did not stop the proactive approach.

The Sydney-based electricity distributor Energy Australia was contacted regarding their experience with the 2000 Olympic Games. This aided the preparation process as critical risks were highlighted.

Extensive analysis was conducted of critical high voltage feeders supplying all venues, existing asset capacity, contingencies and resources. This analysis provided the basis for a games specific risk management assessment and external experts (engaged through the Sydney and Athens Olympic Games) were also engaged to critique and enhance these plans.

System stress tests were conducted to establish a load benchmark prior to load build up and to verify loads connected. This involved major venues turning on all their electrical equipment at the same time.

CitiPower's Board of Directors was committed to doing their part to contribute to making the the Games a success and endorsed fully the management approach and Operational Plans that were developed to minimise outages and optimise response during the event.

The fact that normal average outages were reduced by half for the period showed that good management and not just good luck delivered these results.

Key Focus Areas

It was important to ensure that attention was paid to more than just the electrical assets. Thus the business's strategies targeted:-

- Assets – for capacity, maintenance and system integrity
- Image – for reputation and media
- Incident management – for 24/7 responsiveness
- People – for resources to provide the enhanced service level
- Service – to ensure we continued to meet customers' normal daily needs during the event
- Stakeholders – for successful relationships and meeting their expectations

With these focus areas in mind, careful attention was given to planning and operational phases. The business's protocols and procedures for the Games period had to be clearly defined to ensure a very systematic approach for this project. Load augmentations and pre-emptive maintenance certainly needed to be completed well before the Games start as well as accreditation and access issues.

Learning from the 2000 Olympics

CitiPower/Powercor met with Energy Australia to share its Olympic experience. From this, the following “learnings” were identified:-

- Security of supply to high profile events and broadcast facilities is critically important
- Minimise other works during Games to lessen the risk of voltage fluctuations
- Communication strategy to Games Control and Venue Management
- Site lockdowns and venue access restrictions must be well managed (personnel & equipment)
- Use existing processes that work well
- Be prepared for last minute requests and changes

Key Risk Areas

From the key focus areas and “learnings” from Energy Australia, the main risk areas were specifically identified as:-

- **Opening & closing ceremonies –** these events would present the greatest load, crowd volume, dignitaries, and media attention.
- **Damage to underground assets** – was a possibility when temporary facilities (marquees, tents, etc) were being erected using ground driven stakes. This was mitigated with daily patrols of assets during the Games setup phase.
- **Overall system load –** presented high risk due to variable factors such as weather. The previous year’s system maximum demands were also in March (the time of the Melbourne Games). The co-incidence of load during the Games was also unknown. System stress tests helped to give an idea of the expected load.
- **Asset failure –** due to overdue maintenance or inspections. All venue feeder maintenance and vegetation management were brought forward and all loads continuously monitored.
- **Access to assets** – an issue for the lead up to and during the event. Appropriate accreditation for staff and vehicles was essential and proved to be the most challenging.

CitiPower Powercor did not want a situation where a simple fuse failure would interrupt critical equipment during the opening ceremony for minutes which would be broadcast around the world.

Historical Melbourne CBD Supply Failure

The Melbourne central business district (CBD) electricity supply suffered two outage incidents in 2001 which prompted a review of the network design – particularly the appropriateness of the security standard. The review was carried out jointly by Sinclair Knight Mertz (SKM) and Citipower.

In both events initial plant outages were followed by secondary faults a number of days later that resulted in loss of supply to areas of the CBD. The review found that there was little or no flexibility to reconfigure the 66kV sub-transmission network after an outage (either planned or unplanned) and this lack of flexibility was one of the major reasons behind the two outages. To provide improved network flexibility would effectively require the network to be designed to a higher security standard.

The key finding of the review was that although Citipower was following their current (N-1) Planning Criteria, if the CBD sub-transmission network had been designed to higher security/planning standards (eg "N-1 Secure" or "N-2"), the CBD outages of 2nd January and 9th November 2001 could have been either avoided or reduced in severity.

SKM recommended that elimination of multiple transformer-ended feeder configurations by adding new switchgear at several critical sites. With the existing configuration, a single 66kV circuit supplies a number of transformers at different substations but with only one circuit breaker – at the source. All switching and isolation is usually achieved by means of manually operated isolators. A forced outage would take out a number of 66/22kV transformers albeit at different locations (see figure below). The network has been designed with an "N-1" security standard so that the loss of any single transformer does not cause customer supply interruption. The design has usually proved adequate in the past, however, in the event of a prior transformer outage, a subsequent fault elsewhere in the network could cause tripping of an additional 66/22kV transformer and result in total loss of a substation (due to overloading of the remaining transformer).

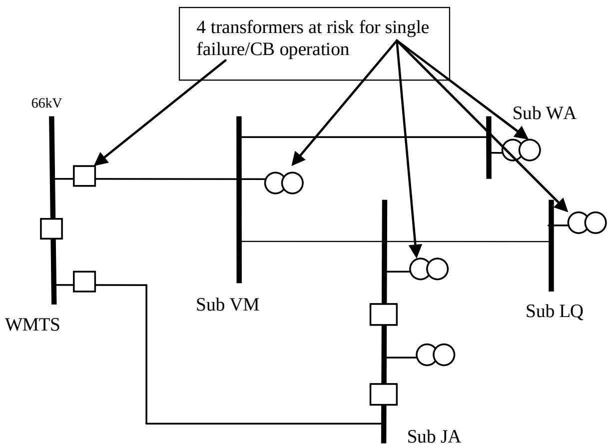

Figure 1. Multiple transformer-ended feeder configuration

The improved 66kV switching capability could only be achieved by rebuilding or refurbishing existing substations at considerable expense because of space limitations.

It was also recommended that additional 66kV ties between 220/66kV Terminal Stations be created to provide improved load transfer capability. These ties would ensure supply reliability in the event of a catastrophic failure of a 220/66kV transformer and would support the move to the recommended higher security standard.

Comparison of Melbourne CBD Supply Security

In 2003, SKM conducted a confidential survey of eight national and international cities which could be considered, by the nature of their population, electrical loading and business activities to be "similar" to Melbourne. These cities all had CBD's with electrical loading of between 200MW and 700MW (Melbourne). The electricity systems supplying these cities were then ranked from "most secure" to "least secure" on the basis of their current documented security criteria, and on the actual compliance with that criterion as represented by an assessment of the load (MW) at risk under specified N-1 contingency conditions.

The CBD of Melbourne ranked second lowest on the "security of supply" scale of those cities surveyed, even though it had the highest CBD load (700MW) of those cities.

3. Infrastructure Impact

Load Requirements

Once individual Games venue loadings were provided, a number of network augmentation projects were carried out. These projects were identified early and construction was completed 3 months before Games start.

The projects carried out were for two specific and distinct reasons:

i. **Increase security of supply to major venues:** Installing significant standby or alternate supply capabilities and introducing additional backup feeders.
ii. **Increase available capacity at the main venues:** Upgrading transformers or installing additional transformers.

The CitiPower CBD high voltage network is arranged such that 11kV feeders are able to run to their maximum capacity. These feeders are then arranged into groups where each feeder group has its own dedicated standby feeder. A feeder group can consist of up to 10 feeders in some cases. In the event of a contingency, the standby feeder will be switched in to support the load from a faulted feeder.

The standby arrangements at each Games venue existed but were extensively reviewed. An example of one of the projects identified was the introduction of a second standby feeder into the MCG. Initially, one feeder was providing backup for the feeder group consisting of nine 11kV feeders.

This situation was deemed to be high risk as this particular feeder group supplied 4 major Games venues in close proximity to each other. In the event of a contingency, the single standby feeder would not be able to provide support for the remaining venues if another contingency occurred. This was a new scenario as not all venues have previously operated concurrently. Therefore a second standby feeder was introduced from a separate zone substation. This increased reliability especially in the case of the 6 MCG lights supplied at 11kV. The newly introduced standby feeder then continued beyond the lights to support the other venues.

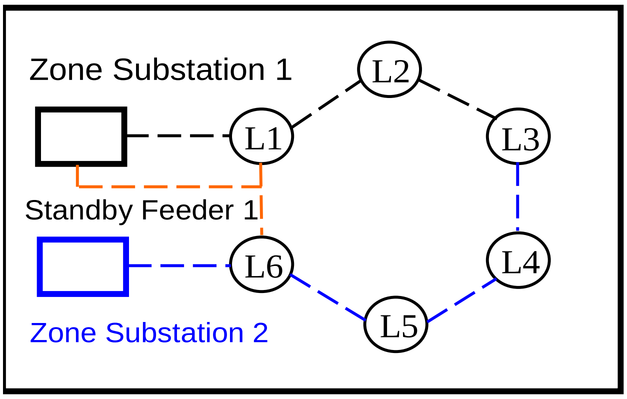

Figure 2a. Existing MCG lights arrangement

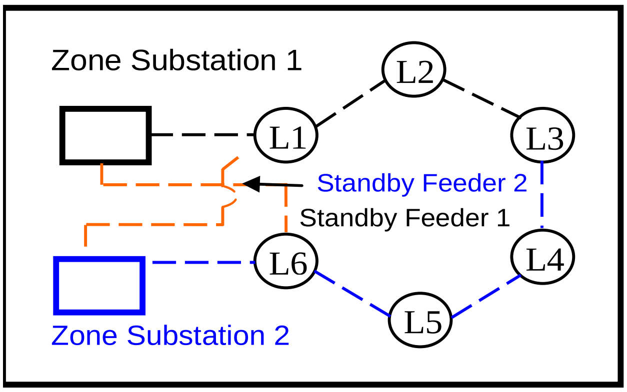

Figure 2b. Altered MCG lights arrangement

It was observed that although the load estimates provided by the Games consultants seemed appropriate, they did not take into account harmonic components. The significant amount of extra lighting and computers/laptops present at venues (due to extensive broadcasting facilities) would add at least 10% to the load figures provided due to the harmonic content. With this in mind, additional capacity was installed through the use of extra transformers and by upgrading existing transfomers.

Other works included installing two 1.5 MVA kiosk substations along the nearby Yarra River for dispersed cultural events. These kiosks supplied low voltage distribution boards that supplied cables running underwater to supply the extensive Flotilla Parade of 71 fish along the Yarra River representing the competing nations. The kiosks also provided supply to numerous big screens and other performing arts facilities. Prior to the Games there were no installed assets in this area, and now these kiosks remain after the Games to support future events.

For low voltage-supplied venues, it was confirmed that each venue substation had a suitable low voltage inter-connector to an adjacent substation. This ensured that in the case of a transformer fault, limited supply could still be provided whilst the equipment was being repaired.

Inspection and Maintenance

Asset maintenance was a high priority. All scheduled inspections were confirmed to be within policy. Additional substation, public lighting and reliability patrols were organised on a daily basis. These patrols identified any structure being erected in the vicinity of overhead assets (“no go zones”). Corona (ultraviolet) and infrared surveys of key assets were also conducted prior to the Games commencing.

All planned maintenance on assets supplying venues was undertaken earlier than planned including zone substation equipment, high voltage insulator washing and vegetation management.

A specific distribution substation maintenance checklist and audit regime targeted at all Venue feeders was established to deliver optimal asset performance. Substations were inspected to confirm Ring Main Unit types, high and low voltage switchgear currently installed, ventilation, condition of fuses, and mobile phone reception.

Work Restrictions

Many Games venues were “locked-down” one month before the start of the Games. This greatly affected access to assets in terms of routine maintenance, planned network and customer projects, and fault response.

CitiPower and Powercor self-imposed several work restrictions in order to mitigate the impact of Games restricted areas, risk of disruption to electricity supply and visual or traffic impact in key areas.. This included rescheduling planned works outside of the Games period, not working on feeders or zone substations supplying key venues, and restricting all planned works across CitiPower network near major venues or the CBD. These restrictions also catered for road event routes such as the Queen’s Baton Relay and several road-based event routes.

Works on sub-transmission lines were also restricted. Verification was sought and gained that no upstream transmission asset works (SP Ausnet) would affect zone substations supplying key Games events. Load shedding schedules were reviewed and revised in order to avoid impact on Games venues.

Some projects however were still permitted to go ahead provided they did not impact any Games venues or if they addressed a health & safety issue.

Enhanced Field Response

A roster of on site field technicians was organised to attend and monitor many venues in order to minimise switching times and to avoid access issues.

Whilst at these venues, the field technicians reported current, voltage and transformer temperatures on an hourly basis to the control room where this data was entered into a specially designed load monitoring model. This model contained a single line diagram of each major venue substation with the utilisation of each asset clearly visible at all times.

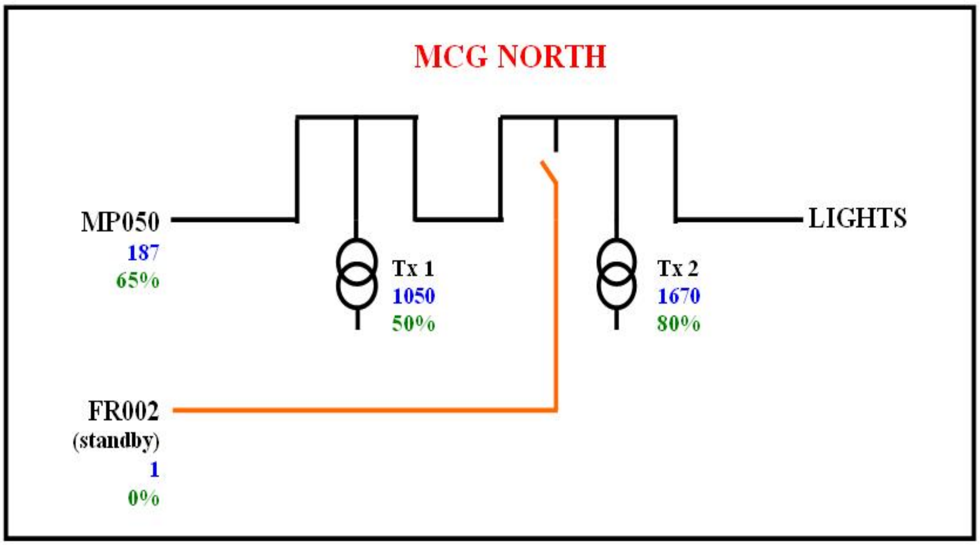

Figure 3. MCG North single line diagram

This data was linked to a self-updating graph to give a full load profile at anytime, at any venue.

Alarm and critical alarm levels were marked on the graph. This greatly improved system status reporting as well as the ability for the control room to identify overloads before critical limits were reached.

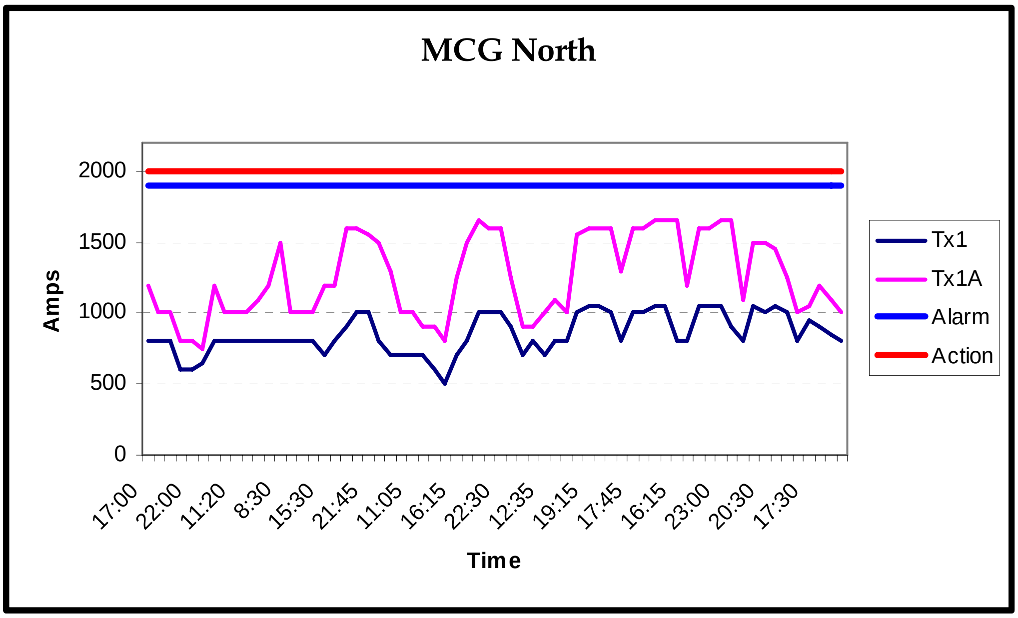

Figure 4. MCG North load profile

Additional dedicated fault response units (flying squads) were also deployed during the games period. This was done in conjunction with ensuring spare equipment was placed at strategic sites as well as having standby generators available. The access restrictions imposed by Venues meant that bringing in large equipment such as transformers in response to a significant outage would be extremely difficult. It was determined that standby generators would be of greater value and these were designated at specific locations.

Public lighting and general asset patrols were also undertaken daily during the Games period.

Other Activities

Extra efforts to aid the business during the Games period also included information technology and telecommunications support for the Operations base. This included a ban on system changes by other CitiPower business units (Information Technology, Telecommunications, and the Customer Call Centre) for the duration of the Games.

Venue protection operating points were recorded to ensure a proactive response to potential overloads. Minimum operating settings for venue transformers were the main focus. Fuse sizing, condition, and stocks were reviewed for low voltage distribution substations given that fuse life deteriorates with high load and high temperature.

Onsite generation provided by M2006 at each venue was also verified prior to Games commencement.

The system stress tests of venue loads were conducted 2 months before and again 2 weeks before Games.

Incident Management

The CitiPower Network Contingency and Escalation Management Plan arrangements were enacted for the duration of the games. The Victorian electricity supply industry operates at contingency escalation levels from 0, to the most severe Level 5. For the period of the games, the CitiPower Network Management Team operated at a minimum Level 3 Escalation status, instead of the normal Level 0 or 1.

4. The Results

All the initiatives, guidelines, restrictions and work procedures during the games were put into an operation plan document.

After implementing this operation plan, the overall results were as follows:-

- **Demand** - 116.8 MW more than the same period last year
- **Energy** - 13,000MWhr more than the same period last year
- **Capacity** - 16.4 MVA installed and 10MVA portable
- **Assets** - 140 Maintenance activities brought forward.
- **Reliability (for the fortnight) -** Customers off supply 4,451 (average 7,011).
- **Staff** - 68 directly involved over the 2 weeks on rosters with another 115 indirectly involved in the lead up.

No outages were sustained at any of the main Commonwealth Games venues.

Legacy

As result of the projects carried out, the following network benefits were realised:-

- Enhanced infrastructure to major venues and open space areas
- Minimal outages
- Significantly enhanced reputation with Stakeholders
- Whole of business support
- Increased Revenue for the period

The Commonwealth Games also presented a chance to extensively test the CitiPower-Powercor network and its associated contingency plans. This in turn tested the processes and systems currently in place as to their effectiveness for network reliability.

5. Learnings for Others

- Ensure extensive pre-planning
- Engage all stakeholders and forge successful partnerships
- Ensure normal rosters and emergency plans are not compromised
- Pro-actively chase load requirements early
- Get a seat in the Games Central Operations Centre
- Lock in resources and schedules early
- Deploy a full time resource to manage the project and actions register
- Secure appropriate accreditation and access for staff and vehicles
- Define work restrictions and no-go areas
- Prepare for security lockdowns and road closures
- Prepare for last minute requests
- Confirm who is funding projects and get acceptance in writing
- Ensure all sites/assets are secured physically and monitored continuously
- Test emergency backup plans particularly communications
- Be aware of changes to venue control and command
- Test access, accreditation and contingencies as lockdowns occur
- Monitor load build up at all venues
- Conduct Desktop scenario exercises & system stress tests
- Establish clear responsibilities for the Games Management Team
- Operate at heightened Incident Escalation Levels
- Build on existing processes as much as possible rather than establish many new processes

Figure 5. The Yarra River during closing ceremony

6. Sources

This document is a summary of the following papers:

1) Watt, N 2006. “Planning and Managing the Electricity Supply for the 2006 Melbourne Commonwealth Games”, paper presented to the Electric Energy Society of Australia Annual General Meeting 2006.
2) Frearson, K & Watt, N. “Improving CBD Security of Supply”.

7. Appendices

Definition of Terms

The following provides a simple description of the terms used in discussing security and reliability.

Term	Description
N-1	The network can withstand the loss of any element and maintain supply to all customers.
N-1 secure	The network can withstand the loss of any element and maintain supply to all customers. In addition the network can be subsequently re-configured to withstand a further outage. During the time taken to re-configure, the network is at risk.
Modified N-2	The network can withstand the loss of a critical element together with the further loss of a non-critical element. This security standard has been applied to the Sydney CBD.
N-2	The network can withstand the loss of any 2 network elements and maintain supply to all customers. Very few networks have true N-2 security.
Satisfactory Operating State (Section 4.2.2 NEC)	Term used in National Electricity Code to describe a power system that is able to provide electricity in a stable manner and within the prescribed technical envelope (voltage, frequency, fault levels, ratings, etc). However, such a system may not cope with a network outage and is considered to be “at risk”.
Secure Operating State (Section 4.2.4 NEC)	As for “Satisfactory Operating State” but with the addition of a capability to withstand the occurrence of a single credible contingency. Such a system is considered to have a security standard of (N-1).