Loviisa-2 (left) and -1
(Photo: Seija Niinimäki)

Organizing outages at Loviisa

BY DICK KOVAN

Extensive planning and preparation ensure that Loviisa's annual refueling outages are conducted safely and on schedule.

THE ROLE OF outage manager at the Loviisa nuclear power plant, explained Tore Vonka, is mainly a supervisory one. As shown in the Controlling Model diagram (see Fig. 1), his role can best be described as "control and coordination." This description also reflects the general approach adopted for managing outages at Loviisa, which calls for "early and detailed outage planning." Furthermore, while outside contractors are used for peak work loads during outages, the planning, coordination, and monitoring of the outages is the plant personnel's responsibility.

The Loviisa nuclear power plant houses two Russian-designed VVER-440 pressurized water reactors. The reactors were put into operation in 1977 and 1980. Since then, upgrade programs have increased the capacity of both units to 510 MWe. According to Jari Snellman, who heads the maintenance organization, Loviisa is the

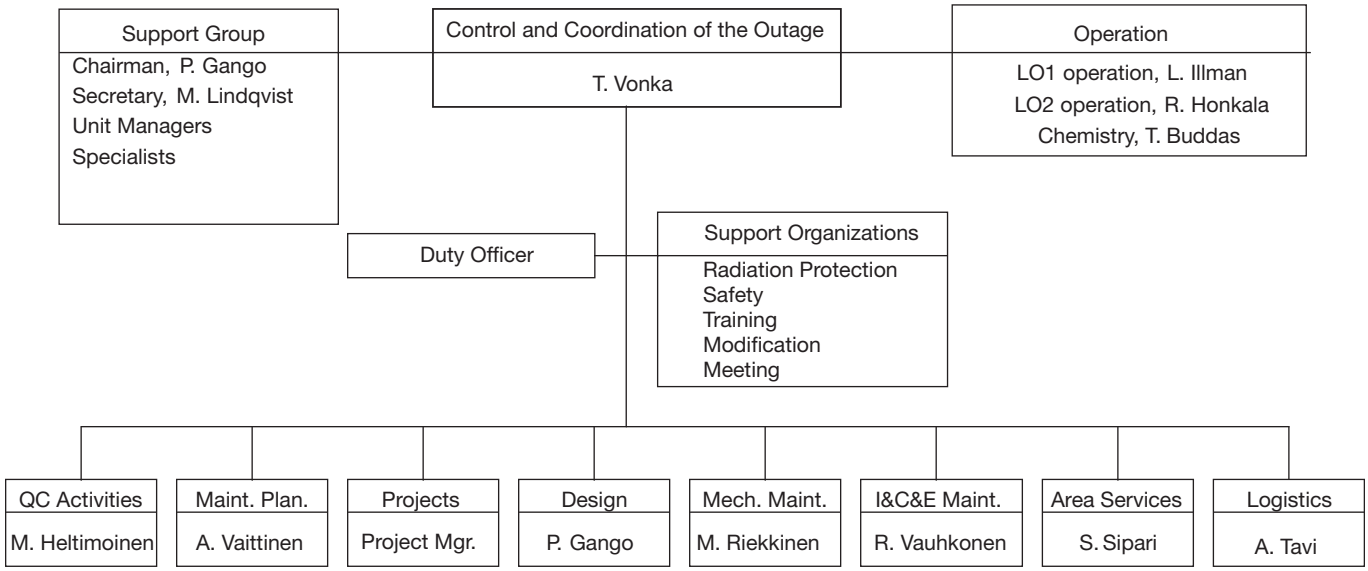


Fig. 1. Controlling model of the 2004 outage at Loviisa

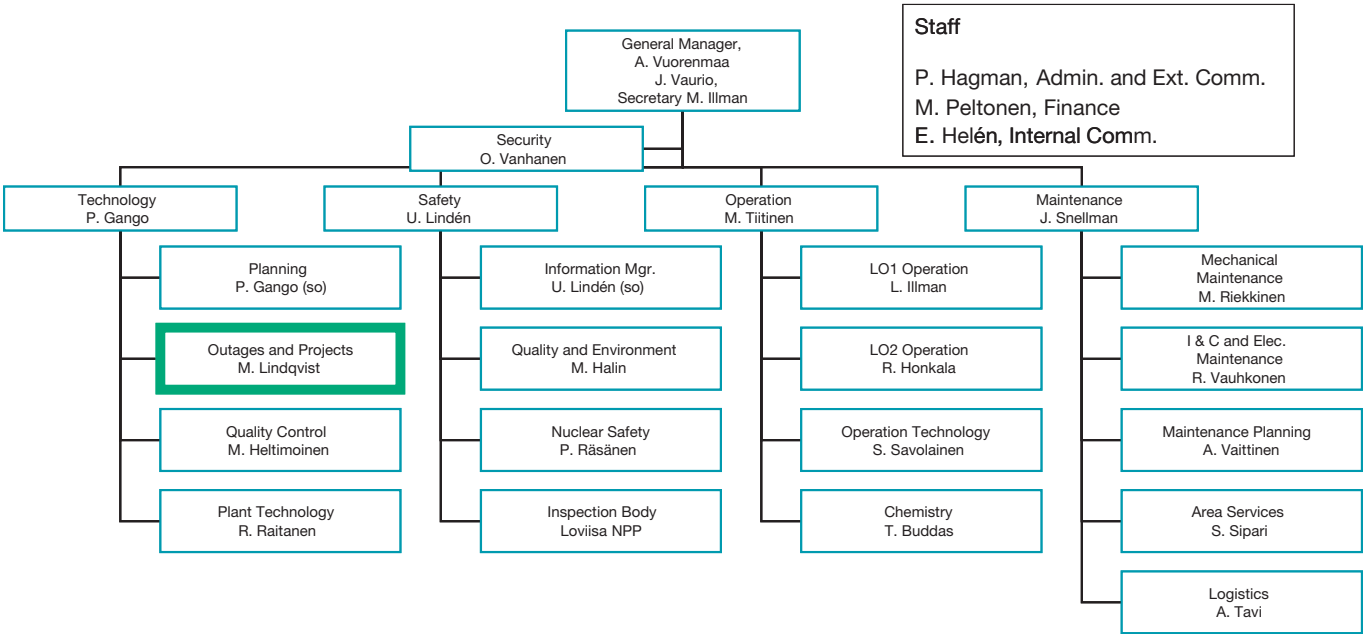


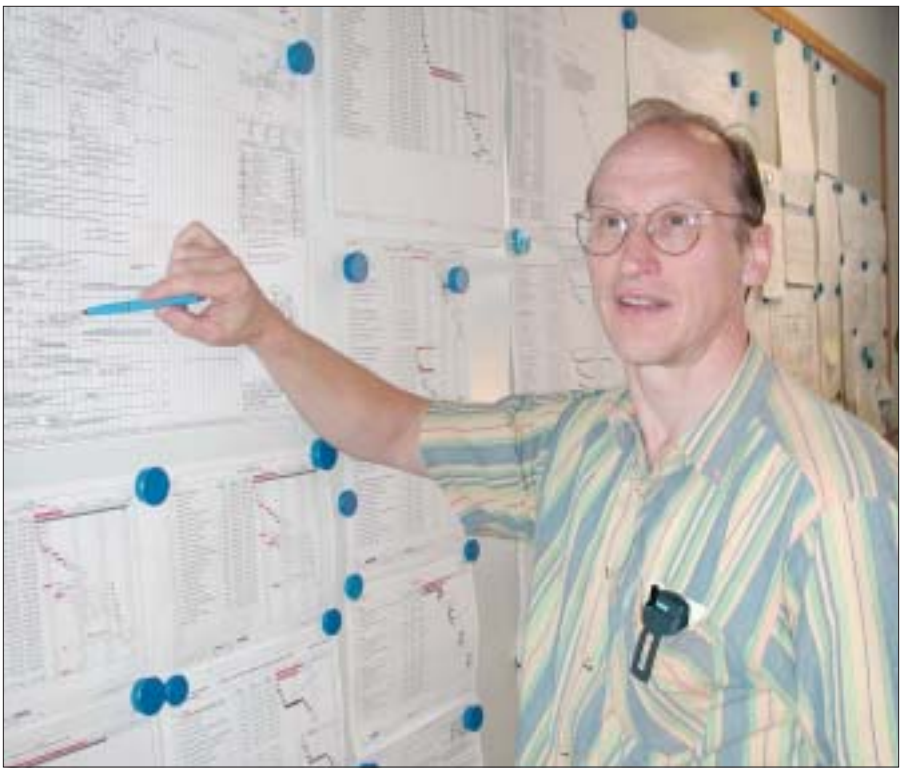
Fig. 2. Organization chart for Loviisa nuclear power plant

only VVER-440 plant in the world in which safety improvements designed to meet Western standards were made both in the construction phase and during operation. Availability of the Loviisa power plant has been consistently high throughout its life. The aim now is to operate the plant at least until the units have reached their 50th anniversary.

The plant is owned by Fortum Corporation, which also holds 26.6 percent of Finland's other nuclear generator, Teollisuuden Voima Oy, which operates two reactors at Olkiluoto and is building a third unit. Fortum also has shares in the Forsmark and Oskarshamn plants in Sweden.

The outage manager's position comes under the Outages and Projects group within the Technology unit, as shown in the Loviisa organization chart (see Fig. 2). Technology, whose basic role is asset management, is responsible for all design and planning activities, with support from Fortum Nuclear Services. This includes planning outages, renovations, and plant life management.

Loviisa operates on an annual refueling cycle, with one-third of the core replaced each year. The outages for both units take place between July and September, when energy consumption is relatively low.



Tore Vonka, outage manager at Loviisa (Photo: Seija Niinimäki)

Outage strategy

When operation of the plant began, said Vonka, there were three types of outages: normal refueling, four-year, and eight-year. Starting in 1997, a new strategy was devised in order to introduce short refueling outages, to be carried out every other year (the odd-numbered years). The duration of eight-year outages was also extended to accommodate all maintenance and major plant projects. The strategy also required maintenance schedules to be changed to fit in the new outage cycle. The four types of outages now carried out are: short; normal; inspection (every fourth year); and extended inspection (every eighth year). Both plants now follow an eight-year outage cycle, as follows: short; normal; short; inspection; short; normal; short; and extended inspection. The basic scope for each type of outage is the following:

■ *Short refueling outage (every other year–18 days)*—The critical path of the short outage is cooldown of the plant; dismantling of the reactor; changing of one-third of the fuel; assembling of the reactor; startup of the plant. All the preventive and corrective maintenance, together with periodic testing, must be carried out within this schedule. About 1700 work orders are done during a short outage, of which preventive maintenance work accounts for about 1100 and corrective maintenance about 600.

■ *Normal refueling outage (24 days)*—For a normal refueling outage, the critical path is set by the steam generator inspections or maintenance work, not fueling operations. The critical item could be a single modification or some renewal work that could not

Russian subcontractors overhauling one of the turbines during a 2004 outage at Loviisa (Photo: Seija Niinimäki)

be carried out during a short outage. Work carried out in a normal outage includes inspecting the tubes in two steam generators using the eddy current method. About 2300 work orders are done during a normal outage, of which about 1300 are part of preventive maintenance and the rest are mainly corrective maintenance work.

■ *Inspection outage (every fourth year–34 days)*—The critical path for the inspection outage is determined by the main reactor activities: cooldown of the plant; dismantling of the reactor; evacuation of the core into the fuel pool; inspection of the reactor pressure vessel (RPV); fuel loading; assembling of the reactor; and startup of the plant.

The RPV is visually inspected using a remote television camera. This involves lifting the reactor internals out of the reactor to get the TV camera inside. The steam generators are also inspected visually. A large number of the primary- and secondary-circuit pressure vessels are also inspected and turbine and generator maintenance performed.

An inspection outage will include about 3300 work orders. While most (about 1700) involve preventive maintenance work, the relative amount of corrective maintenance increases due to the findings of the inspections.

■ *Extended inspection outage (every eighth year–42 days)*—For the extended inspection outage, a pressure test of the RPV and the primary circuit, a full inspection of the RPV and reactor internals, and a tightness test of the containment are added to the normal 34-day inspection outage critical path.

The RPV is inspected using ultrasonics, eddy current, and visual inspection. The pressure test of the primary circuit is carried out at 178 bar and in the secondary circuit at 73 bar. There is also an ultrasonic inspection of the steam generator primary collectors, and an eddy current inspection of the tubes in three steam generators, as well as a visual inspection inside the steam generators. There are about 3500 work orders, of which about 1800 are corrective maintenance.

The inspection outages involve a number of "every-fourth-year" activities, including work on systems needed to ensure residual heat removal from the reactor during outages, which can be done only when the fuel is removed and the system drained. Lengthy jobs, such as turbine and generator work, are done during the extended inspection outages, Vonka said. Last year's extended outage on Unit 1 included renovations on the high-pressure side of one of the turbines, overhaul of a generator stator, removal of a rotor for inspection, and renewal of an excitation system.

Outage planning

During normal operation, outages are discussed during Loviisa's schedule review meetings, as well as monthly outage planning meetings, which begin about 10 months before the next outage. The outage meetings are chaired by the head of the Outage and Projects group and involve 25–30 people, including representatives from the main units: technology, safety, operation, maintenance, and security.

Discussions deal with the following:

■ Main work activities with the people in charge.
■ The planning situation in all maintenance groups and the degree of preparedness of the design work.
■ Demands from the regulatory authority (STUK).
■ Manufacturing of replacement components.
■ Special tools.
■ Choice and availability of subcontractors.
■ New work orders related to the critical path or activities influencing the overall outage time.
■ General arrangements (press releases, internal information channels, subcontractor facilities, incentive schemes, etc.).
■ The following year's outage.

The first decisions are on the main work to be undertaken, including any major modifications and renovations as defined in the Loviisa Long Term Plan, along with the normal outage program. Preliminary work orders are developed, bids are sent to contractors, in-house inventory of spare parts that are needed for the outage are checked

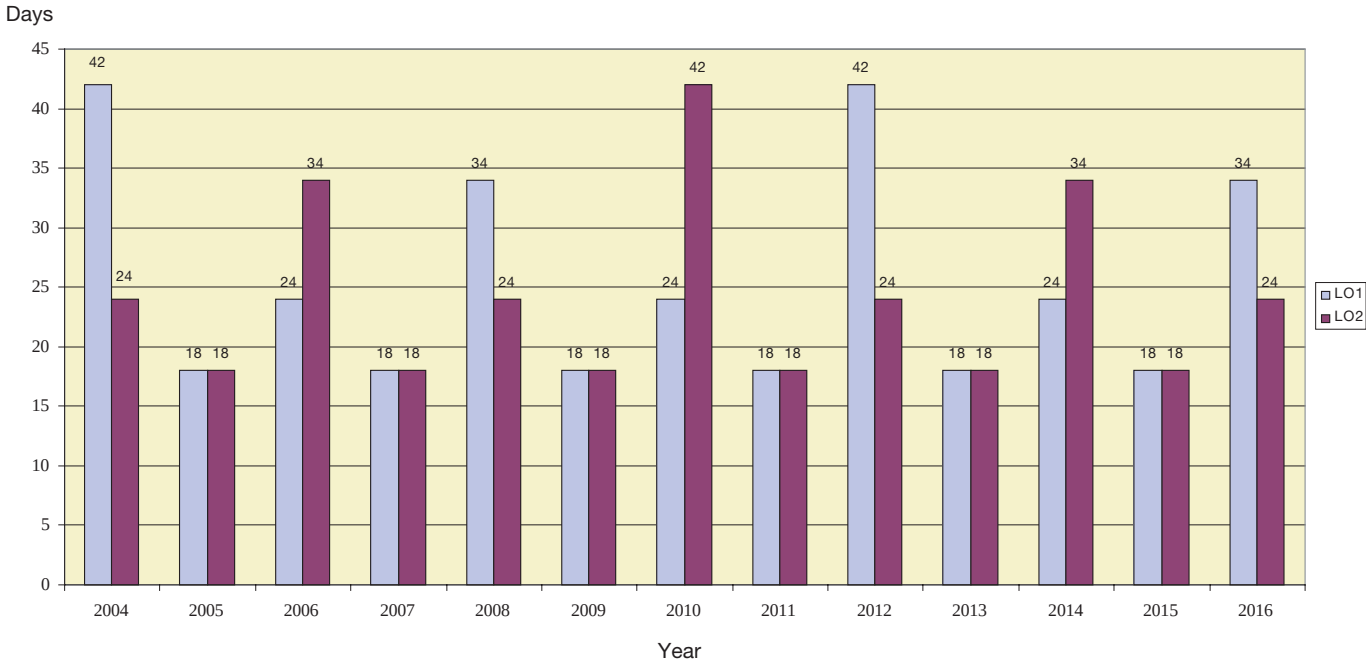


Fig. 3. Planned outage durations at Loviisa, 2004–2016

and any missing items ordered, and a preliminary allocation of resources made. The overall schedule and main work are frozen three months before the start of the outage.

The basic priority for outage planning is to preserve safety-related functions. Based on this and the main activities required, a "process logic" is devised that effectively defines the outage's overall duration. A process logic diagram shows outage processes, which are those involving reactor systems and also the work being undertaken throughout the outage. All outage activities, such as fuel loading and maintenance on any system, are shown on the diagram in relation to reactor conditions—the coolant levels in the reactor, as well as in the primary, secondary, and auxiliary systems. With this diagram, staff can quickly see that work is being done at the appropriate time and with the plant in a safe condition. "We check the process logic at all times," said Vonka.

Vonka is responsible for developing the outage plan with the operation group managers. This includes determining the process logic, the shutdown and startup schedules, and the scheduled mimic diagram of the safety systems, which shows the state of the safety systems through the outage.

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The main activities undertaken in the outage are made up of work packages, which, like the "umbrella" concept used in many U.S. plants, define isolation areas where work can safely take place. Isolation typically involves closing valves surrounding the area, shutting off electrical power, and draining the system. A work package can be an area that is not isolated, in which case each activity will be isolated individually. In some cases, a work package can involve a single system, while work on some major systems may be divided among more than one package. For example, to retain sufficient heat removal capability, the feedwater system cannot be completely isolated at one time and is divided into several packages, one of which provides for separating and draining the feedwater tank for maintenance.

The process logic is built up from the different work packages, producing a work sequence. Time information in the work packages will be transferred to the work order system, ensuring that every activity in the outage gets a planned start and end time.

Once isolated, the work permits, which must be signed by the shift supervisor with the date and time, are released and the work carried out; when work packages are completed, the area is de-isolated and systems are commissioned. The packages are filed on the Computerized Maintenance Management System (CMMS) in the process computer system (PCS). The control room staff check work permits, coordinate the packages, and follow work progress. Operators have available on the PCS a special screen designed for outages containing parameters important for safety. There is also a colored process flow chart showing the safety systems in use during the outage attached to the panel in the Main Control Room (MCR).

Preparations before outages

Nearer to the time of the outage, the contracting arrangements are finalized. Contractors are chosen based on individual skills needed for the outage, price, and any existing partnership arrangements. There are typically 800–1000 mechanical, electrical, and instrumentation and controls (I&C) fitters or nondestructive testing inspectors from 50 to 80 different companies for an outage. Vonka noted that Loviisa uses Russian contractors for turbine and generator work. It also uses companies from other countries, including Germany, Croatia, and Spain.

Among other general arrangements that must be completed before the outage begins are accommodations for contractor personnel; an outage phone book, providing important numbers for all outage personnel; extra canteens; outage incentive and bonus schemes; and an outage information leaflet.

Outage documents have to be provided to the regulatory authority and a review meeting held, covering the following:

- Outage organization.
- Main safety-related and other work.
- The safety functions during the outage.
- Training arrangements of subcontractors.
- Radiation protection arrangements, dose estimations, and radiation protection of im-

portant work.

■ Security and fire protection arrangements.

■ Process logic, shutdown and startup schedules, residual heat removal diagrams, seawater diagrams, etc.

Just before the outage, all of the work orders for work package isolation will be checked and printed out, together with isolation tags used to tag out valves and to tag the switchboards and the control panel in the MCR.

Outage operations

About one month before the outage, the reactor begins a stretch-out operation. The outage shutdown begins on a weekend.

During the outage, the normal line organization is in place, but it will be strengthened with subcontractor staff. Some of the plant's own skilled fitters are nominated as foremen for the subcontractors.

There is an outage meeting every Tuesday and Friday during the outage, involving the same people as the outage planning meetings. During these meetings, the actual plant conditions are checked against the outage process logic diagram and the progress of main work is reviewed, with short explanations by line managers (operation, mechanical, I&C and electrical, radiation protection, security, industrial safety, and others). This includes an update on the progress of the work orders that have been issued, finished, or yet to start, compared with the optimum possible result.

There are also 15-minute information reviews every morning, which go over the work and schedules. The duty officer gives a status report, while the outage planner describes the work that has to be carried out during the next 24–48 hours, focusing on the critical path.

The outage duty officer will be the first contacted by foremen if something should happen in the outage outside normal hours. During the week, he or she remains at the plant until at least until 11 p.m. If a problem arises, the duty officer will contact the appropriate managers and specialists to arrange a meeting for first thing in the morning. A duty officer, said Vonka, would be an experienced engineer, typically from the maintenance or technical group. There are about 25 at the plant who will fill that post. Over the weekend, there will be a single duty officer.

When a problem occurs that could threaten the outage or is so significant that it cannot be solved by the line organization, the Outage Support Group will be called. This group is chaired by the head of the Technology Unit, with the Outages and Projects group manager as its secretary, and includes the outage manager, group managers, unit mangers, and foremen. It is able to evaluate the situation and implement necessary measures to repair or otherwise resolve the problem and, it is hoped, keep the outage on the critical path.

When all the work orders in a package have been finished, they must be signed off by the shift supervisor before the systems can be put back into operation. During the outage, the shift supervisor or reactor operator must be in the control room area, and one licensed operator must be in the control room. Operator trainees are used in the control room for various jobs.

Maintenance and outage information is recorded in the CMMS. The present system, called LOTI, was developed by Fortum and has been in use now for 17 years. LOTI is soon to be replaced by a new system, called MAXIMO CMM, developed in the United States.

Planning the next outage

With an annual outage strategy, there is little time at Loviisa between finishing an outage and beginning to plan for the next one. Immediately after an outage, the experience and lessons learned by staff and contractors are collected and a report prepared to provide feedback and information needed to update the data in the CMMS. A technical report is also produced for the regulatory body, and a meeting is held to evaluate safety performance. NN