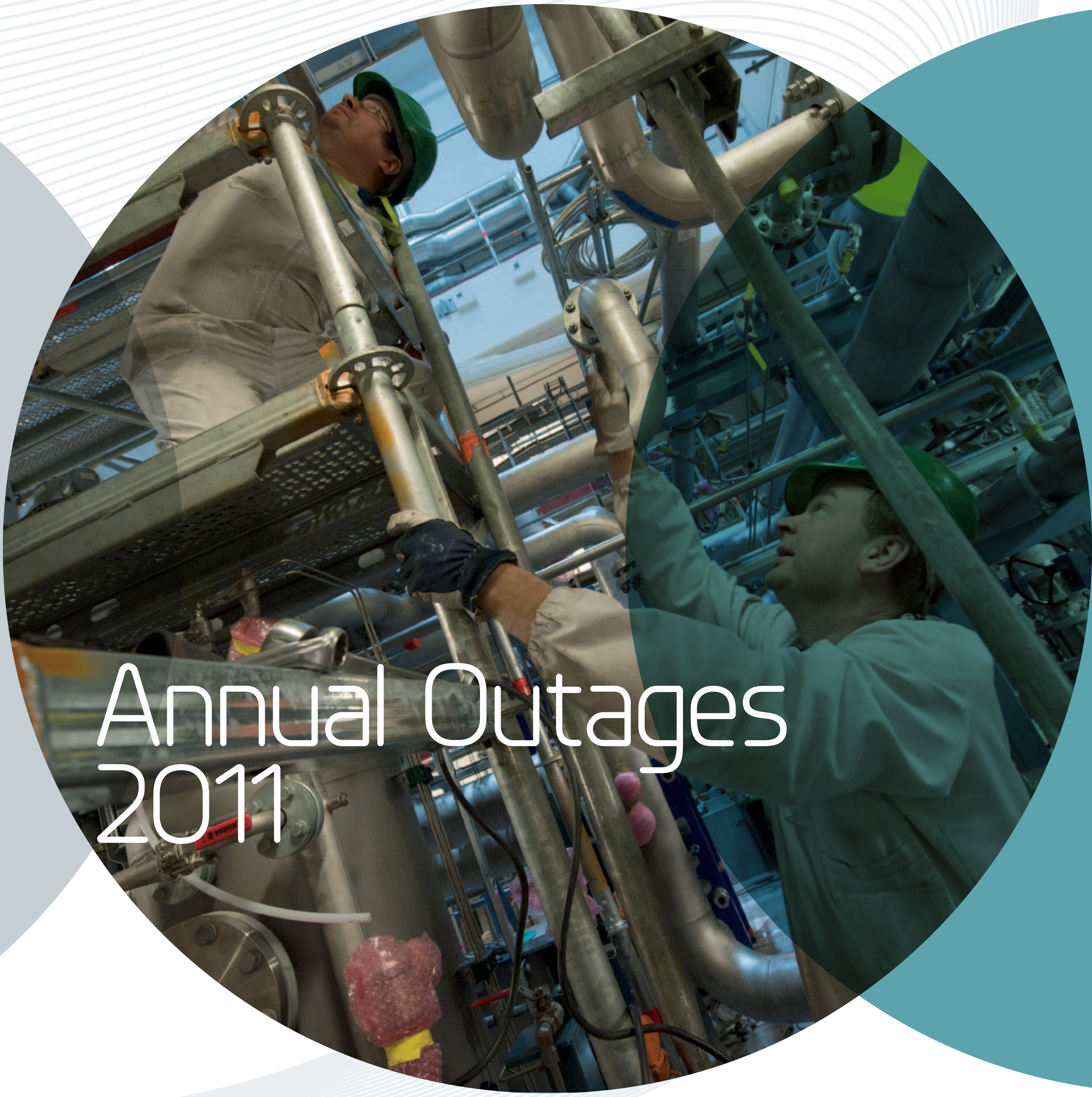
Annual Outages 2011



Teollisuuden Voima Oyj – Wellbeing with Nuclear Electricity

Publisher: Teollisuuden Voima Oyj
Domicile: Helsinki, Business ID 0196656-0
Layout and English translation: Alasin Media Oy
Graphic design: Mainostoimisto RED
Photos: Hannu Huovila
Printed by: Eura Print Oy, Eura

CONTENTS

04 Editorial

05 PELE went well

07 Risto Vähämäki –
Last spring at Olkiluoto

06 Professional, reliable energy

10 Charles Lindgren –
Suitcase full of experience

12 Startup schedules

13 Working like clockwork
Reactor work
Turbine work
Electrical and I&C work
Valve, pump, and pressure vessel work
Building services
Fuel work

16 Protection guarantees work safety
Radiation protection
Occupational safety
Fire protection
Waste management and decontamination

20 Olkiluoto 1 and 2 Annual Outages 2012

23 Companies in annual outages

37 days, 22 hours, and 44 minutes

Once again, the annual outages are successfully over. As can be seen from the title, their total length was rather long by current standards. When looking at the outage statistics, we need to go as far back as 1988 before the total length of the outages exceeds that of this year. Back then, the annual outages had a total length of 39 days. In going further back in time, the outage for Olkiluoto 1 alone in 1983 lasted 44 days.

The outage for Olkiluoto 1 was proceeding like clockwork and according to the planned schedule until we encountered what you always tend to expect, even though you wish that it would not occur: something new and surprising came up in the service and inspection work. This time, the problem occurred with a diesel generator that had a voltage regulation problem. Is the fault systematic and can it exist in more generators? According to a culture of good safety, questions such as these are the first to come to mind. Based on this discovery, we will need to adjust the scope of preventive maintenance that is planned for the generators.

The outage for OL2 was also proceeding nearly as planned until we discovered fractures and wear in the reactor blowoff system valve internals. Valves that had already been inspected and reinstalled had to be inspected again, which led to the discovery of new faults. The inspections performed on the equipment during preventive maintenance and the estimates concerning the need to replace components will need to be re-evaluated for the key components. We are considering increasing the amount of input into outage work from the original equipment suppliers. The valve spare parts received from Forsmark together with our own spare parts enabled us to restart Olkiluoto 2 only three days behind schedule. Thank you also goes to the hard-working TVO employees, material experts from VTT Technical Research Centre of Finland, experts from Sempell, and the authorities.

The availability of spare parts is essential for ensuring good operating results. Spare parts need to be maintained, and replacement spares need to be purchased on time. We also need to maintain good, functional contacts with both the equipment suppliers and other nuclear power plants to receive support when necessary.

The PELE project is now nearly complete; only the generator at Olkiluoto 1 is awaiting replacement, which is due next year. The turbine and generator replacement at Olkiluoto 2 went extremely well. The lower turbine case supports on the LP4 turbine that were removed in the search for additional power were also replaced and, at the time of this writing, the turbine is operating steadily without problems. Thanks also go to all the over 200 TVO employees who participated in the project and its execution.

The plant units have been in operation for a little over 30 years, and signs of ageing sometimes appear, even though preventive maintenance and modernisation are applied to manage ageing. In the near future, we will need to evaluate our methods for ageing management.

We still have a few leftover tasks to clean up from the annual outages in 2011. To inspect and possibly replace the reactor blow-off system valves, we need to shut down Olkiluoto 1 at the end of June and Olkiluoto 2 near the end of the summer for a brief service outage.

Thank you once again to all the participants in this year's annual outages. It is now time to enjoy the holidays and the warmth of the summer.

Mikko Kosonen
Production Manager, Senior Vice President

Story by Juhani Ikonen

PELE went well

TVO FOLLOWS THE PRINCIPLE OF CONTINUOUS IMPROVEMENT IN THE OPERATION AND MAINTENANCE OF THE OLKILUOTO PLANT UNITS. THE PELE PROJECT, MAINLY COMPLETED DURING THE ANNUAL OUTAGES IN 2010 AND 2011, FORMS ONE PART OF THE SYSTEMATIC DEVELOPMENT OF OLKILUOTO 1 AND OLKILUOTO 2.

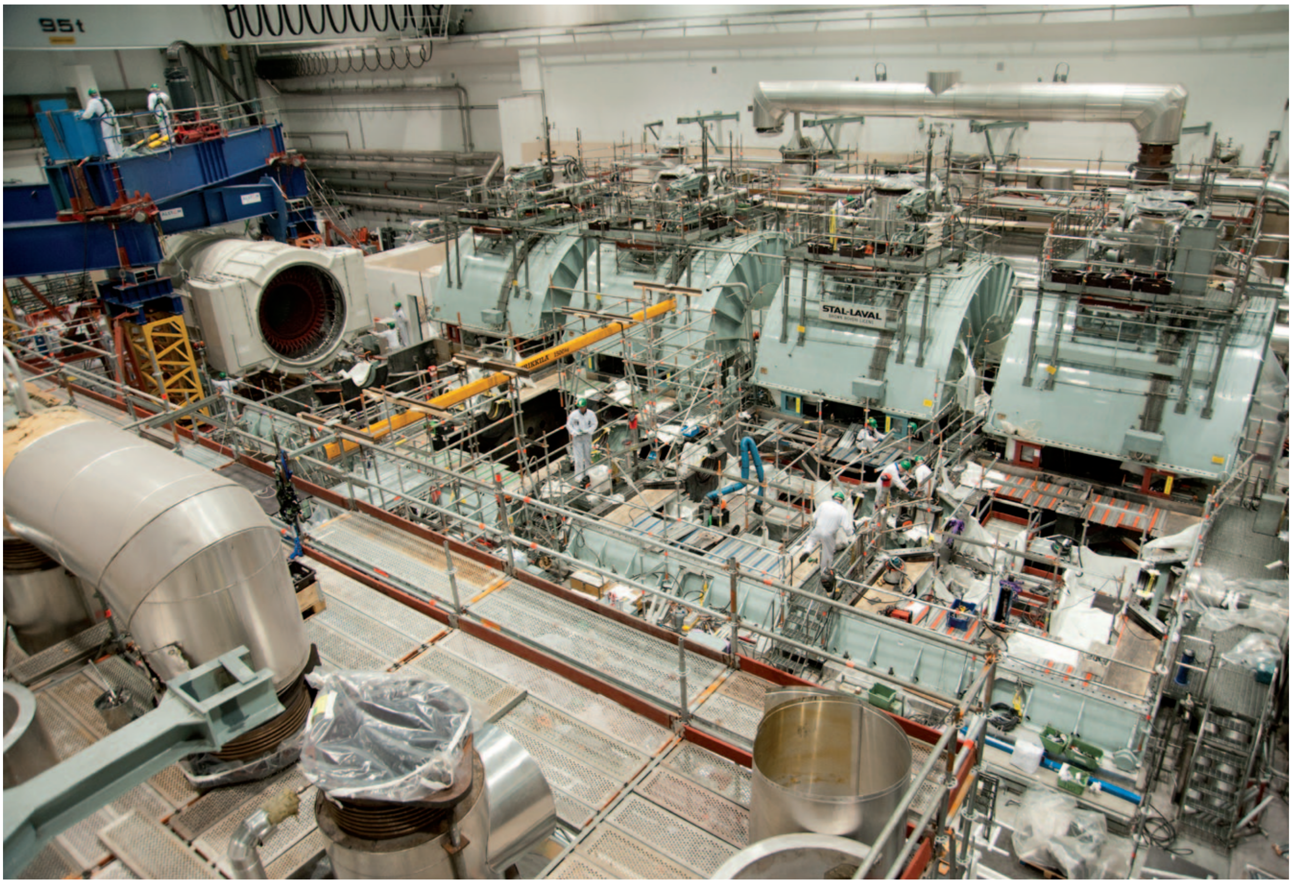
TVO maintains a long-term development programme that aims at systematically modernising the plant unit systems and equipment based on the latest technology. According to the programme, the Olkiluoto 1 and Olkiluoto 2 plant units are constantly renovated with the intention of keeping them safe and reliable, and of having 40 years of technical service life remaining at all times. - The aim of the modernisation projects is to improve the safety, reliability, and performance of the plant units. At the same time, we are ensuring product support from the equipment suppliers and the availability of spare parts, says Director **Janne Mokka** from the Technology Department.

The PELE project (Plant Efficiency Improvement and Lifetime Extension) consisted of several single projects collected into one for coordinated project management.

Powered by a new generation

- All in all, PELE was very successful, and we have the 100 TVO employees who participated in the project groups, and also the subcontractor employees, who amounted to a maximum of 1,500 persons during the outages to thank for this success. The execution of the PELE projects went extremely well during the outages. The replacement of the low pressure turbines and seawater pumps improved the efficiency of the plant units, and a power increase of nearly 20 MW was achieved at both plant units. The power increase was slightly below what was planned and, compared to the turbine replacement at OL1 last year, we performed some modifications on the new low pressure turbines at OL2. If these modifications improve efficiency, we will most likely perform them at OL1 next year, Mokka says.

- A significant feature of PELE is that the project was mainly performed by people from a new generation of TVO employees.



Low pressure turbines; on the left, a stator for the new generator.

Many of our senior experts have already retired, and they have been replaced by young professionals. PELE wonderfully manifests one of the strategic goals of our company; developing the competence of our in-house personnel by working in projects. PELE has taught us a lot, and many of my colleagues who started working during the past few years have obtained a substantial amount of valuable experience and expertise during the execution of the project, Mokka says.

In line with the systematic development of the power plant, the planning for the next large project is already underway. The focus areas of the TVO 2017 project are plant unit lifetime extension, improving operational reliability, and further development of the safety features. The main focus of the project is on the work that is carried out in preparation for the operating licence renovation in 2018. Like in PELE, the aim is to assemble all the subprojects into one larger project, and the work will be performed during the annual outages of 2014 to 2017.

The PELE works carried out during the annual outages 2010 to 2011

- Low pressure turbines: rotor, stator vane, casing and turbine instrumentation replacement.
- Seawater pumps: blade wheel, shaft, inner casing and switch replacement, and renovation of the shut-off valves, electric motors, and hydraulic actuators.
- Replacement of epoxy coated seawater pipes.
- Replacement of inner isolation valves on the main steam lines.
- Renovation of the extraction pipes inside the condenser.
- Generator replacement at OL2. The generator for OL1 will be replaced during the annual outage of 2012. The generator cooling system was replaced at both plant units.
- Low voltage switchgear equipment was replaced. This project will continue during future outages.
- The condensate cooling system I&C was modernised. This project will continue during future outages.

Story and image by Petra O'Rourke

Last spring at Olkiluoto

RISTO VÄHÄMÄKI, 70, FROM ALSTOM HAS BEEN INVOLVED IN 61 ANNUAL OUTAGES FOR TVO'S PLANT UNITS. NOW, HE HAS DECIDED TO FINALLY RETIRE FOR GOOD, AND HE WANTS TO FOCUS EVEN MORE ON QUALITY OF LIFE.

- The hardest part is losing your co-workers; they will be greatly missed, Risto says.

You would not believe Risto is his age. The active lifestyle that he leads is healthy both physically and mentally and enjoys working. From his long career, he cannot recall ever feeling bad about going to work on a single day. The last outage for Vähämäki is now complete: the work for the ALSTOM team was completed successfully and on schedule, a little over three hours before the penalty limit.

From sailor to landlubber

Risto Vähämäki graduated as a machine operator in 1965, and spent four years sailing the seas. It was his ambition to one day work on the large ocean ships. Vähämäki spent six months learning Swedish on a turbine ship owned by Salen Rederiet from Sweden; the aim was to transfer onto an ocean ship after this. That never came to pass, however. In 1970, Stal Laval Suomi (currently, ALSTOM) was seeking an engineer for turbine service, and Vähämäki was hired. He received two years of training in Finspång, Sweden, and has been working on turbines ever since. The ALSTOM employee came to Olkiluoto in 1976, when employees were sought for OL1 and OL2 to manage commissioning tasks until the start-up of the plant units.

Part of an expert group

Starting in 1980, Vähämäki worked at Olkiluoto as Site Manager for ALSTOM, with his main duties being outage planning and execution. He has been involved in 61 annual outages at the Olkiluoto plant units, and has also visited the Swedish power plants during their outage. He officially retired at age 68, but was unable to resist his true calling. For two years, he has worked as Vice Site Manager with **Juha Jalava** and **Jari Järvi** in the turbine outage planning group. – I work here despite being retired simply because it is so nice. This is a social event for me, Vähämäki says. However, the Rauma resident who has been working for 51 years has now decided that this will be the last spring with TVO's outages. According to the seasoned veteran, the best part about working at Olkiluoto has been the functional co-operation with TVO's personnel. He especially wishes to thank **Jukka Wallenius** for their work together.

Power through research

The long-term ALSTOM employee has witnessed the development of annual outages first-hand. – The first outages lasted two months. Currently, the schedules are as tight as can be achieved, and they really should not become stricter, he says. Computers and other technology introduced over the years assist in outage planning. – Even this large outage went exactly to plan, exactly like we thought last winter. The start is always the most critical, and no unplanned problems should occur at that time, Vähämäki says. The turbines themselves have also been improved over the years. – With the help of blade arrangement, the same amount of steam now generates 300 MW more power than in the original turbine, Risto reminds us.

Exercise and travel

Vähämäki is not changing his active way of life in retirement. He has played veteran ice hockey for 16 years, three times a week, and believes that is one of the contributors to his good health. – In the future, I intend to play even more ice hockey, spend time at my summer home, and travel a lot, he says. After 35 years at Olkiluoto, Risto is happy to leave his post. – The current ALSTOM Site Manager, Juha Jalava, is a competent fellow, and our work is in good hands. I would say character is the most important thing in this work: you need to get along with people and have a sense of humour, he says, summarising the good characteristics of his young colleague. Vähämäki will take his well-deserved summer vacation immediately after the outages. – I'll take my dog with me and spend three months at my summer home in Jämsä. Even my wife can come.

Professional, reliable energy

OLKILUOTO 1 AND OLKILUOTO 2 ARE STILL IN EXCELLENT TECHNICAL CONDITION. PROOF OF THIS ARE THE GREAT PRODUCTION RESULTS FROM THE OPERATING CYCLES BEFORE THIS YEAR'S ANNUAL OUTAGES. HOWEVER, A KEY FACTOR FOR GOOD RESULTS IS COMPETENT PERSONNEL IN THE OPERATION, MAINTENANCE, AND TECHNICAL SUPPORT DEPARTMENTS. THE PLANT UNITS ARE OPERATED ACCORDING TO THE PRINCIPLES OF A GOOD SAFETY CULTURE.

Both plant units experienced a couple of production interruptions and power limitations due to equipment failure during the operating cycle. Furthermore, periodic tests requiring power reductions were carried out approximately once every two months. At other times, the plant units operated at full power. Due to failures and disturbances, approx. 15 GWh (0.2%) of production was lost at Olkiluoto 1, and 107 GWh (1.4%) at Olkiluoto 2. Together, they correspond to approximately five and a half days of production from one plant unit operating at full power.

Olkiluoto 1

Plant unit operation during the operating cycle 2010 to 2011 was steady and no large disturbances occurred. The energy availability for the cycle was high at 99.1%.

The operating cycle started after the largest outage in TVO history on 12 June 2010, when the generator was synchronised to the national grid.

The modifications performed during the outage to improve plant efficiency increased the electricity output by approx. 20 MW, due to which the nominal power of the plant unit was increased to match the new power level starting from the beginning of July 2010. The new nominal electrical power is 880 MW (net) and 910 MW (gross).

There were two disturbances causing significant production losses during the operating cycle. During the post-outage power increase on 12 June 2010, the generator was disconnected from the grid due to a cooling system disturbance. The disturbance caused the loss of approx. five hours of production. The second significant disturbance occurred in December, as the plant unit had to be switched to dump operation due to a reheater adjustment valve fault. This disturbance also caused the loss of approx. five hours of production. During the operating cycle, about 17 hours worth of production was lost due to disturbances.

The plant unit started coast-down operation on 28 April 2011. Shutdown for the annual outage was started on 1 May 2011 at 14:50, and the grid disconnection occurred at 18:01.

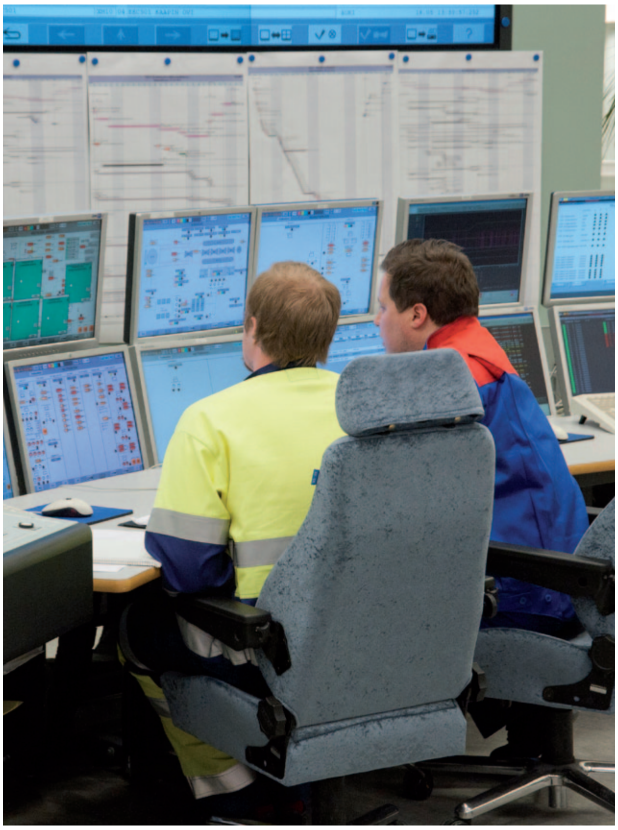
Olkiluoto 2

Aside from a few disturbances, plant unit operation during the operation cycle 2010 to 2011 was steady and free from incidents. The energy availability for the cycle was high at 98.4%.

The operating cycle started after the outage on 14 May 2010, when the generator was synchronised to the national grid.

There were three disturbances causing significant production losses during the operating cycle. During the post-outage power increase on 15 May 2010, with the plant unit at 90% reactor power, a reactor scram was tripped when the main steam valves closed due to a leak in the pressurised nitrogen system. After the scram, the plant unit was operated to cold shutdown to carry out leak rate testing and repairs on the main steam valves. The plant unit was resynchronised to the national grid on 18 May 2010. The disturbance caused the loss of approx. three and a half days of production. At Midsummer, on 25 June 2010, the plant unit was operated to cold shutdown for approx. one day due to blowoff system control valve replacement. The outage caused the loss of approx. 30 hours of production. The third notable disturbance occurred on 19 March 2011, when the plant unit's power was decreased to approx. 50% to locate and repair a seawater leak in the condenser. The disturbance caused the loss of nearly five hours of production. During the operating cycle, about five days' worth of production was lost due to disturbances.

Shutdown for the annual outage R211 was started on 10 May 2011 at 12:30, and the grid disconnection occurred at 18:25.



Contractor workers following the testing progress in the main control room.

PRODUCTION STATISTICS

OL1

Operating cycle 12 June 2010 to 1 May 2011

Gross electrical energy	6,991 GWh
Net electrical energy	6,742 GWh
Production losses	
- due to failure	15 GWh 0.2%
- due to power situation	0 GWh 0.0%
- due to seawater temperature	52 GWh 0.7%
Reactor critical	7,852 h
Generator synchronised	7,759 h
Energy availability	99.1%

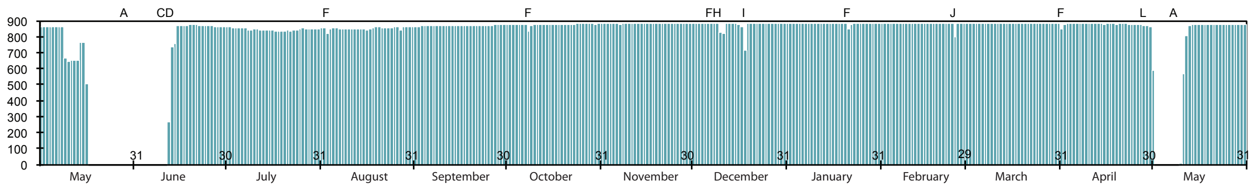
OL2

Operating cycle 14 May 2010 to 10 May 2011

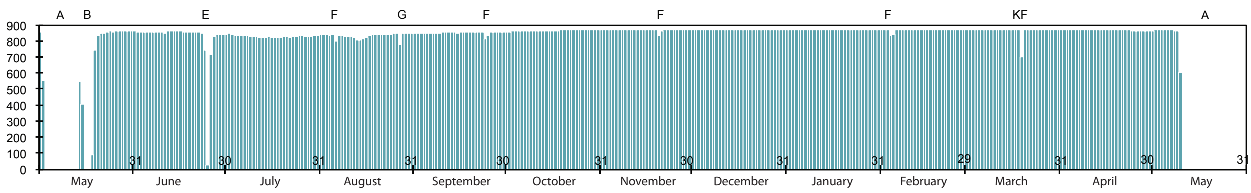
Gross electrical energy	7,600 GWh
Net electrical energy	7,336 GWh
Production losses	
- due to failure	107 GWh 1.4%
- due to power situation	0 GWh 0.0%
- due to seawater temperature	61 GWh 0.8%
Reactor critical	8,618 h
Generator synchronised	8,579 h
Energy availability	98.4%

OPERATION DIAGRAMS

OL1 OPERATION 12 JUNE 2010 TO 1 MAY 2011



OL2 OPERATION 14 MAY 2010 TO 10 MAY 2011



A = annual outage

B = reactor scram after the main steam valves closed

C = load decrease after a generator cooling system disturbance

D = feedwater system valve leak repair

E = blowoff system control valve replacement

F = periodic test

G = main steam line watering valve leak repair

H = reheater maintenance hatch seal leak repair

I = reheater adjustment valve repair

J = feedwater pump repair

K = condenser leak repair

L = coast-down

Story by Petra O'Rourke

Suitcase full of experience

CHARLES LINDGREN, 57, AN OUTAGE LEGEND WORKING FOR WESTINGHOUSE ELECTRIC SWEDEN AB (WSE), IS KNOWN TO MANY. GOOD TEAM SPIRIT, FAMILIAR FACES, AND MEANINGFUL WORK BRING THE TRAVELLING WORKER TO OLKILUOTO YEAR AFTER YEAR.

When Lindgren was younger, he could spend all year working at nuclear power plants around the world. Now, he says he's kicking back: only 4 to 5 months are spent each year at international nuclear power plants, such as in the U.S., Mexico, Spain, and here at Olkiluoto.

Cosmopolitan by nature

Lindgren, born in Karlskrona, Sweden, took after his father in the mobile way of life. When he was about five, the family moved from one town to another in Sweden, where his father worked for the railroads. Today, his home is in Västerås. Having completed a three-year technician's training, the young Lindgren started his career in a factory that also manufactured the rotors used at TVO and the Barsebäck plant units in Sweden. From there, he was recruited by Asea-Atom, currently WSE, and has stayed with the company for over 25 years. Lindgren has over 20 years of experience in annual outages at Olkiluoto.

Mentoring and practical work

During the annual outages at Olkiluoto, WSE performs service, inspection, and maintenance for the reactor pressure vessel inside the reactor hall. Work tasks include opening the RPV, lifting the internals, and closing the vessel. A second team from the company manages the recirculation pump service in the lower drywell; for example, they replace the pump motors according to the preventive maintenance schedule.

Charles works as a team supervisor at the plant, and he enjoys being in the thick of the practical work. – I want to do and see things myself. I try to act as a mentor for the younger employees, and the best part of the work is actually distributing your own life experience from dozens of years, Lindgren explains. The crew at WSE has changed over the years; some have retired and they have been replaced by new talent. Some workers return to Olkiluoto each year, while others remain in Sweden for the annual outages at the local nuclear power plants, such as Forsmark and Oskarshamn.

Work at the plant unit has not changed significantly, but the Swede is confused by the substantially increased paperwork. – Paperwork is good when there is a suitable amount of it. I would not want it to take priority over work at the plant, Lindgren says. It is his opinion that too much paperwork may extinguish the inherent thinking and creativity of the individual employees.

The workaholic does intend on having a holiday; a three-week getaway from the working life is planned.

Jussi Juntunen, Sami Mäkinen, and Vesa Laakso from ALSTOM Finland servicing control rod drives in the service facilities.

Finland is convenient for working

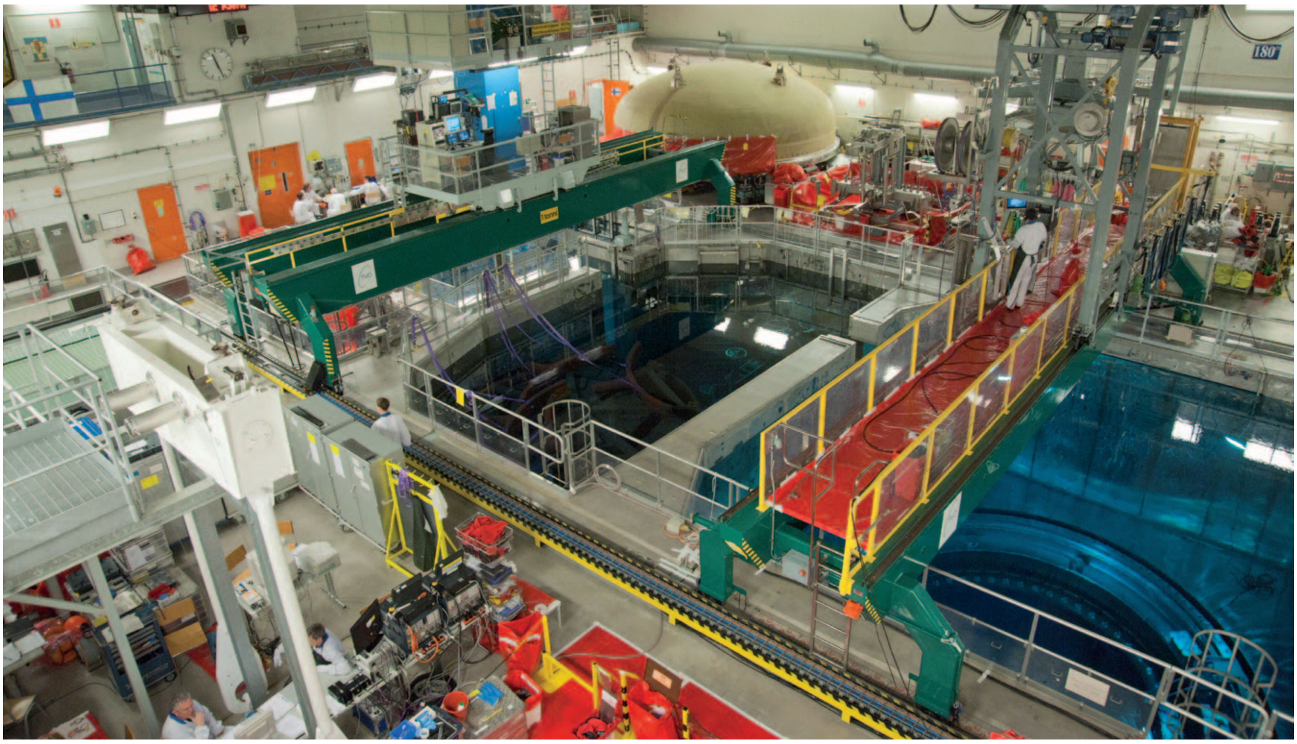
According to Lindgren, the plant units at Olkiluoto compare favourably to other countries: TVO is at the top of the industry in outage planning, and the plant units are in good condition compared to their age. Despite this, he sees room for improvement. - The schedules are tight, and on many occasions no reservations have been made for pre-job briefing, for example. Sometimes, however, the pressure may also be a positive factor, Lindgren summarises.

For the travelling worker, Finland is an easy country for working. - In Sweden, we are nearing the US model where the power plant area is more like an airport, with guards carrying weapons. Working is more difficult when you need to strip naked and go through an X-ray machine. Finland is safe, and there is no need to overreact, Charles says.

According to Lindgren, the Finnish working culture is very much like that in Sweden, but he appreciates the fact that people are allowed to think for themselves. In his view, it is important to follow the procedures, but it is equally important to let people share their ideas. - People who have held the same position for too long may be semi-blind in their work. Young people, looking at things with new eyes, may see things differently and help develop the activities of the company, Lindgren reminds us.

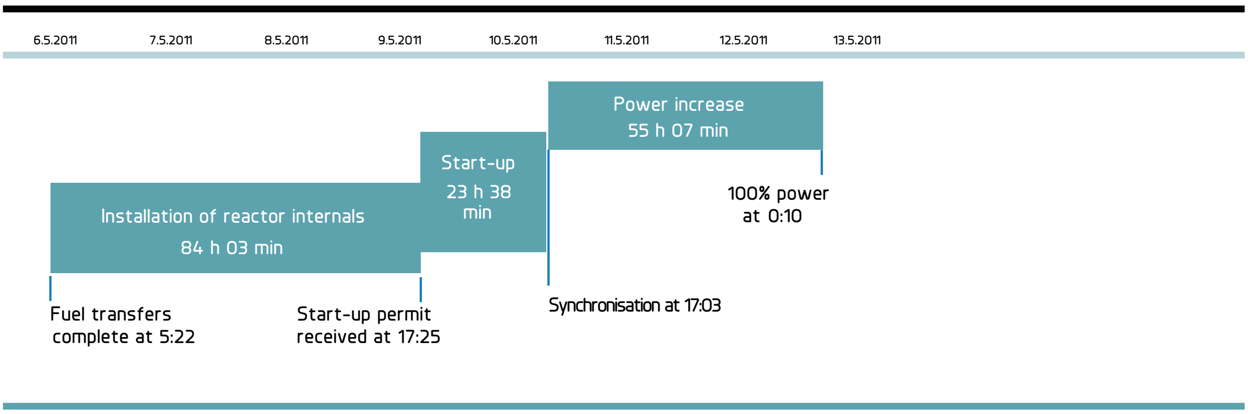
Sense of humour required

According to Lindgren, this spring's outages at Olkiluoto have proceeded as planned. The schedules have been kept and no mistakes have occurred. Olkiluoto is a nice place to work, as working with TVO's Maintenance department is easy, and the working atmosphere is very good. Ice hockey is a popular topic among the men, who have become friends during their years working together, and playful, mutual commentary on the sport can often be heard. Unforgettable moments at Olkiluoto have been the Sweden vs. Olkiluoto football matches and get-togethers with good food and drink, jokes, and the sauna. This is an annual tradition that has continued to this day. - We no longer play football, however, Charles says jokingly.

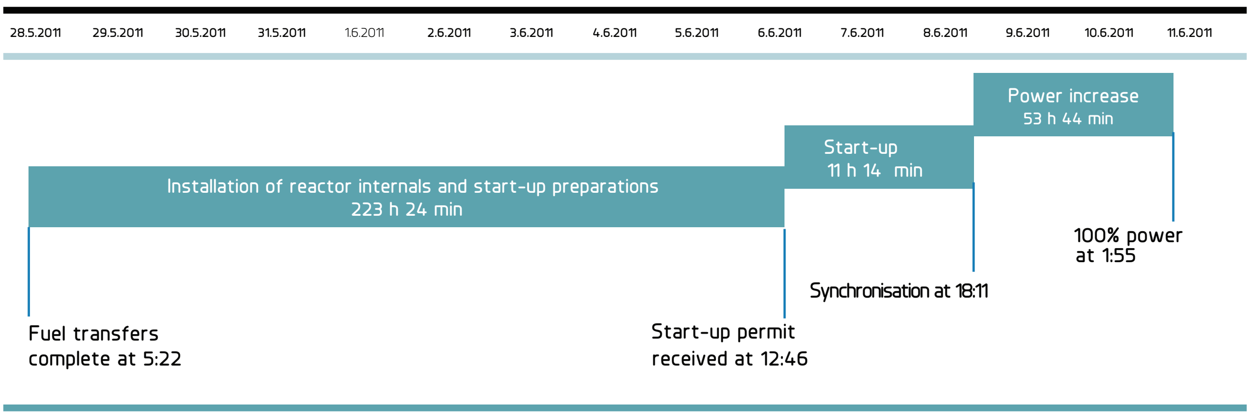


Many different types of outage work were performed in the reactor hall.

OL1 PLANT UNIT STARTUP



OL2 PLANT UNIT STARTUP



Working like clockwork

Reactor work

Normal reactor service work was carried out during the refuelling outage at OL1. The feedwater distributors were inspected without removing them. No control rod drives were serviced, as the services are scheduled for the service outages. No deviations were discovered in the general inspection of the drives under the reactor pressure vessel. Insulation resistance and axial clearance measurements were performed on the recirculation pumps.

During the long service outage of OL2, reactor nozzle inspections were performed as planned. For the inspections, the feedwater distributors and the core spray and boron system insticks tubes were removed. The surface measurement nozzles were also inspected. A total of 8 neutron flux measurement system probes (PRM) were replaced. According to the preventive maintenance schedule, a total of 24 control rod drives were serviced. No deviations were discovered in the serviced drives. All the electric motors and torque switches for the serviced control rod drives were inspected.

The motor and shaft for recirculation pump 5 were replaced according to the preventive maintenance programme. The newly installed motor had been serviced during the winter. The shaft had also been inspected and balanced. The insulation resistance and axial clearance measurements for five other pumps were performed normally.

Turbine work

In the refuelling outage for OL1, the most important task that was planned in advance was opening turbine bearing number 4, after which the decision was taken to open bearings 3 and 5. In the bearing inspection, it was discovered that the bearing surface of the lower bearing segments had partially deteriorated to the trailing surface, and it was decided that all lower bearing segments in bearings 3 to 5 will be replaced with new spare segments. In addition, one dump valve was serviced, and other service and inspection tasks were carried out according to the preventive maintenance programmes.

In the OL2 service outage, new low pressure turbines were installed (RETU project). The project replaced the inner casings, blade supports, and rotors of all the low pressure turbines. Other work performed in the project included the following: replacement of steam pipes in low pressure turbine extraction pipe 1, replacement of old three-segment bearings 3, 4, and 5 with new four-segment bearings, modification of the lower bearing segments in bearing 6, replacement of one oil pressure pump with two new pumps, replacement of auxiliary bearing pump with a new, more efficient model, installation of additional instrumentation on the LP4 turbine and steam extraction pipe to collect process data, lubrication system modifications, replacement of a mechanical overspeed inhibitor with an electrical one, modifying vibration and temperature sensors to a 2/3 connection, and replacement of the balancing enclosures with a new type.

The service outage also contained normal preventive maintenance tasks, of which the most significant were seawater condenser washing and repairs, and the service and repair of the seawater condenser cleanup system (Taprogge).

Electrical and I&C work

The task of Electrical and I&C Maintenance during an outage is to manage the preventive maintenance, condition monitoring, and repairs for electrical, I&C, and process computer equipment and systems. Furthermore, we need to manage the execution of modifications, such as installations, cabling, and commissioning.

During the extensive service outage for OL2 there were several major modifications. The most significant modifications included work related to the replacement of the low pressure turbines and their auxiliary systems (RETU), modernisation of the generator (GENU), generator cooling system (GEWA), and the main seawater pumps (COWA), replacement of internal isolation valves (SIVA), low voltage switchgear replacement as part of the SIMO-project, and condensate cleaning I&C replacement (LPM). Furthermore, several minor modifications were performed, including protection modifications of two UPS devices to improve the overvoltage tolerance of the plant unit, radiation measurement system renovations, isolation amplifier installations, and actuator and battery replacements. Service and inspection tasks, according to the preventive maintenance schedules, were also performed during the outage.

In addition to the annual service and inspection work, according to the preventive maintenance schedules, the refuelling outage for OL1 contained a few modifications. The

Lifting the generator stator requires team effort.


The annual service for the feedwater pump included, among other things, the replacement of the slip ring seal and a complete condition inspection.


Welding was performed around the neck of the low pressure turbine case.

most significant finding was the failure of a diesel generator sequence test that resulted in a few devices being subjected to overvoltage.

The generator was diagnosed with a faulty thyristor and diode in the exciter. The generator was replaced with a spare from storage.

Valve, pump, and pressure vessel work

Over 270 work phases were prepared in advance for valve and actuator service. During the service outage of OL2, the inner isolation valves were replaced, and all 10 main safety valves were opened and inspected. During the refuelling outage for OL1, 52 valves were serviced, and one main safety valve was also serviced due to a long closing time. Approx. 160 valves and actuators were serviced at the OL2 turbine plant. Hydraulic actuators were installed on seawater check valves to reduce pressure loss.

At OL2, all the seawater pumps in the condenser cooling system and the pumps in the generator cooling system were replaced. Two feedwater pumps and two auxiliary condensate pumps were also serviced.

At Olkiluoto 2, periodic pressure vessel inspections were performed on a total of 44 registered pressure vessels. The reactor pressure vessel system pressure test, which was part of the periodic inspections, could not be performed during the plant shutdown due to a pressure adjustment disturbance, and it was moved to next year. During the OL1 outage, the internal inspection of high pressure pre-heaters 445E303-E306, moved over from 2010, was also performed. During the start-up of OL1, one tube in the low pressure preheaters was leaking, and 20 tubes were plugged due to this.

Building services

The efforts of the Building Services group in the outages of 2011 were divided in two: work assisting other organisations, and the actual maintenance work for the power plant buildings. As the outage was extensive, the support services that were required, such as constructing scaffolding and performing hauling (transfer of items), were essential for the success of the entire project.

Due to a large need for scaffolding parts, a temporary storage area was constructed north of Olkiluoto 2 with a direct connection to the controlled area of the plant unit. About five lorry loads of scaffolding were delivered into the storage before the start of the outage. The coordination and execution of the scaffolding work were rather successful, and we can be happy with the results.

Preventive maintenance for the power plant units was performed as planned. The programme included inspections of rooms with orange or red radiation levels, and the painting of surfaces where required. The painting of the walls inside the containment was also resumed from last year.

During the annual outage for OL2, two significant construction projects were executed with respect to the turbine building. The most significant maintenance work was performed on the roof of the turbine building. The entire roof, totalling 3,300 square metres, was repaired by installing a new middle layer and a double felt on top of the old bitumen roof. All the roof drains and inclinations around them were repaired. It is expected that the roof will not require more repair for 15 to 20 years.

Another significant modification was the resurfacing of the ground-supported floors in the turbine building. The old floor surface had been damaged due to the cracking of concrete, and the old surface had to be removed before the floor was resurfaced. The floor had a surface of approx. 1,600 square metres, and a fracture-proof, self-levelling flooring agent with tested radiation tolerance and decontamination properties was used.

Fuel work

The refuelling of Olkiluoto 1 consisted of 580 steps. 130 fuel assemblies were taken out of the reactor, 4 of which were reinstalled. Internally, 311 fuel assemblies were transferred. 124 fresh fuel assemblies along with two that had been removed earlier were introduced into the reactor. 59 assemblies remained in place. After the refuelling, the core now has 492 GE14 assemblies and 8 Atrium 10 XM assemblies. The fuel transfers took approx. 63 hours in total. Five fuel assemblies were inspected during the outage. Other fuel work was not performed.

The roof of the OL2 turbine building was serviced during the outages in 2011.

During the service outage for Olkiluoto 2, a total of 731 fuel transfers were made with a total duration of 103 hours. 232 fuel assemblies were taken out of the reactor, 120 of which were later returned. One fuel assembly was located and removed due to damage inflicted immediately at the beginning of the annual outage.

Internally, 268 fuel assemblies were transferred. On the 31st operating cycle of the plant unit, the core of OL2 contains the following fuel elements: 104 pcs SVEA 96 Optima, 392 pcs SVEA 96 Optima 2, and 4 pcs GNF2.

During the outage, 19 control rods were inspected; three of which were found to have fractures. These three, along with 12 other rods that will be inspected during the operating cycle, were removed from the reactor and replaced with intact rods.

Protection guarantees work safety

Radiation measurement at the generator level is routine practice.

Radiation protection

Radiation Protection manages the radiation protection measures and radiation monitoring of the work carried out in the controlled area of the plant units, during outages as well as power operation. The aim is to keep personal and occupational doses as low as possible, and to prevent the contamination of personnel and the spreading of contamination.

In addition to TVO's in-house RP personnel, 40 persons participated in the radiation monitoring work during outages this year. Like last year, the amount was fairly large due to OL2's extensive annual outage. The group of outside workers consisted of the unit's own summer workers, employees of Alaratech Oy, RTK-Palvelu Oy, Fortum Power and Heat Oy, and Doseco Oy, and OL3's operators. Preparation for the outage included a training period of 2 to 3 weeks, and a study of the most important outage work tasks and their radiation protection plans. A fuel failure had been detected at OL2 during the previous operating cycle, but it did not require extensive radiation protection measures or delay the start of the outage work in practice.

From the start of 2011, the induction training has had two parts; a general part and a radiation protection part. Working in the controlled area requires an accepted performance for both parts, and the course is valid for three years. Induction training, especially for outage personnel, was arranged by TVO's in-house personnel a total of 23 times in April and May, of which 14 sessions were held in Finnish, and 9 in English or German. The general training was attended by approx. 550 persons, while the radiation protection training had approx. 450 attendants.

Preparations ensure results

Radiation Protection prepared for the annual outages by acquiring additional dose rate meters, a hand and foot monitor, two measurement cabinets for small items, and different types of protective equipment. In addition, the ELDOS dose information system and personnel monitor measurement data processing were developed further, and an improved digital log was taken into use.

The total dose for OL1's refuelling outage, which had a total duration of approx. nine days, was 122.95 man-mSv, and it matched the estimate of 125 man-mSv very closely. The radiation dose for the outage is the smallest ever outage dose for a single plant unit at Olkiluoto. The largest personal dose, 2.90 mSv, was received from valve installation work. The number of employees under dose monitoring during the refuelling outage was 1,838.

The extensive service outage of OL2, with a duration of nearly 29 days, had a total dose of 673.40 man-mSv, which was approx. 6% below the estimate of 720 man-mSv. There were several work tasks that were challenging in terms of radiation protection, such as the replacement of the inner main steam valves within the containment, the ASME inspections of the pipe seams, control rod drive service, work in the reactor hall, reactor valve inspections and service, and the replacement of four low pressure turbines. The largest personal dose, 6.20 mSv, was received from valve installation work. During the outage, a total of 2,636 persons were subjected to dose monitoring.

The total dose for the annual outages for both plant units was 796.35 manmSv, and the largest personal dose (taking into account both outages) was 7.50 mSv. This means that we were able to meet our goal of keeping personal doses below 10 mSv. The legal limit for the annual dose of a radiation worker is 50 mSv.

During the outage, the measurement vehicle from the Finnish Radiation and Nuclear Safety Authority performed internal contamination measurements for 70 radiation workers. Like last year, no cases of internal contamination exceeding the registration limit of 0.1 mSv were registered. This confirms that the employees were working and using protective equipment, especially respirators, according to the instructions.

The steam dryers installed in the reactors of OL1 (in 2006) and OL2 (in 2007) have kept fresh steam very dry, which has worked to lower the dose rate levels during annual outages each year. This year, the average radiation levels were established to have decreased by 16 to 20 per cent from last year. The lower dose rate and contamination levels have significantly reduced the radiation doses from the work carried out at the turbine plant, which has helped to keep the total radiation doses from annual outages at a relatively low level.

Occupational safety

Due to their large scale, the annual outages in 2011 were also a challenge in terms of occupational safety. The amount of person work-hours was high, and work was performed on

An electronic work dosimeter system is used to monitor personal radiation doses in real time.

Working in confined spaces is occasionally required.

Swipe samples of components are taken to determine surface contamination.

a constant, ongoing basis. Daily, regular occupational safety co-operation and supervision was maintained. Like last year, safety coordinators had been appointed for the largest work tasks; their job is to assist projects at the design stage to take into account the occupational safety issues. Co-operation with contractors was an important part of the occupational safety issues management in the field. This was supported by morning meetings every morning for each project, where work related tasks (including occupational safety) were reviewed. Separate EHS meetings were also held with Alstom each day. The occupational safety organisation was supplemented by OL3's operators (2 persons) and a summer trainee who started at the beginning of May. This also allowed for performing supervision during evenings and at weekends. Every day, inspection rounds were performed before noon and in the evening. Furthermore, three times a week a more extensive cleanliness and order walkdown was arranged, with the occupational safety representatives and their substitutes taking part. The safety observation mailboxes were emptied at least twice a day.

During the outage of OL1, one accident resulting in work absence was reported, along with two zero-level accidents that did not cause work absence. The accident leading to absence occurred when an employee was exiting the manhole

The generator and its entire cooling system were replaced.

on the condenser and twisted his/her knee. The accident caused an absence of 43 days in total. At OL1, the zero-level accidents were a metal fragment that entered a person's eye while opening a hatch, and a cut finger. During the outage for OL2, there were 4 reported accidents leading to work absence, and 12 zero-level accidents. The accidents causing absence during the outage were a sore knee, an open wound on the head caused by a measurement probe when exiting a process pipe, tripping on an obstacle on the passageway, and a finger cut with a utility knife while opening a cable tie.

Several incidents with hand injuries were reported as zero-level accidents. Cases included the worker's finger being squeezed by an object or door, fingers cut by sharp metal sheet edges, hammering a finger, and open cuts on the wrist and fingers from angle grinders. There were also zero-level accidents with the following descriptions: an employee hitting his/her head when turning in a confined space, an employee hitting his/her head on a scaffolding pipe, hitting a knee on a scaffolding pipe, hot water flowing on an employee's feet when opening a hatch, and cuts on the back.

Like last year, there were numerous safety observations. A total of 407 safety observations were made, which is 28% more than last year. The design of the safety observation card posters was renewed, and additional return points were added. Increasing the amount of return points made it easier to return the observation cards, and renovating the Kelpo system made them easier to process and classify. The occupational safety organisation reviewed each safety observation individually, and observations requiring action were processed immediately. In these cases, the occupational safety organisation did its best to carry out corrective actions immediately, or to contact the responsible individual from the target organisation. Other findings were either routed to the target organisations for information, or further actions and responsible employees were defined to carry out activities.

Fire protection

The outages for 2011 proceeded according to plan for the Fire Protection department. In addition to normal fire protection staff, 10 external fire guards were reserved for the outage at OL1, and 15 fire guards for OL2. The main task of the fire guards is to ensure sufficient spark protection, and to inspect the hot work site together with the person carrying out the work, in turn removing combustible material from the vicinity of the hot work, if necessary. During this year's outages, a total of 206 hot work permits were issued, of which 39 were at OL1 and 167 at OL2. In addition, the fire guards patrolled

Inspections are being performed in the fuel pool of the reactor hall.

the plant area, supervising the integrity of the fire sectioning and the type and amount of fire loads, for example. TVO's plant fire brigade and rescue authorities from the Satakunta Rescue Services performed fire inspections in the areas of both plant units.

During the outage, the Fire Protection department paid special attention to maintaining fire sectioning during repair and modification work. Whenever work was interrupted, such as for a coffee break or a lunch break, special attention was paid to temporarily blocking penetrations and keeping fire doors closed. A report was filed in TVO's deviation management system "Kelpo" for all open fire doors with no personnel around them. A fire is one of the worst accidents at a power plant and, for this reason, maintaining the integrity of the fire sectioning was emphasised during the training events held before the outages.

Fire detectors were replaced at both plant units in those rooms that are inaccessible during power operation. All the fire water lines, smoke vents, and fire dampers were inspected and tested to the extent not possible during power operation.

The inspection plant and an insurance company representative inspected the firefighting system. At the same time, a test triggering of the main transformer and own-use transformer extinguisher system was arranged. During the test triggering, the functionality of the system and the adequacy of the water screen were tested, and the water amounts were measured.

Waste management and decontamination

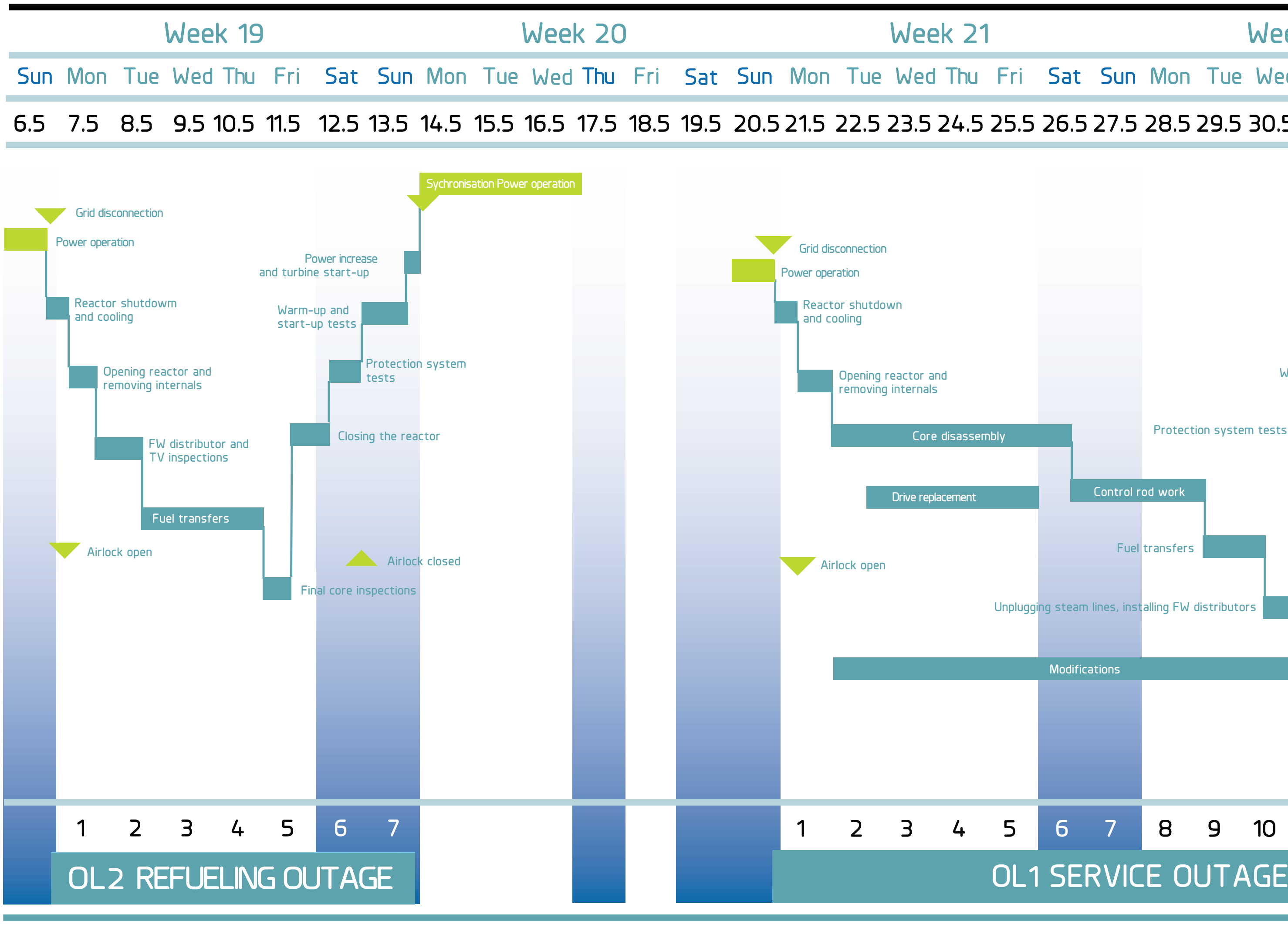
The annual outages for the plant units OL1 an OL2 generated a total of 20 tonnes of service waste and 42 tonnes of scrap metal from the controlled area. Approx. 4,100 cubic metres of purified water was pumped out from radioactive water processing. Decontamination was employed by the components taken out of the process for repair or overhaul, and the tools and scaffolding used during the service.

The water collected from the process purging, laundry activities, and housekeeping during the outage is processed by the liquid waste treatment system in order to allow it to be pumped out of the plant.

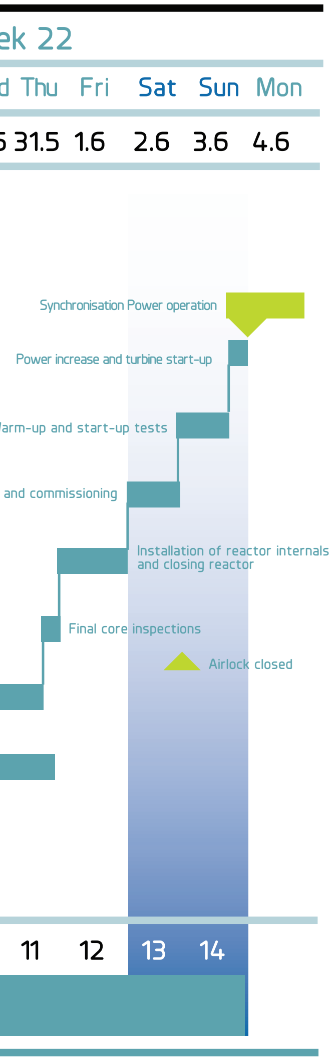
Waste management is also responsible for the storage and further processing of service waste, waste oil, scrap metal, and other waste generated in the controlled area. The purpose of decontamination is to reduce the radiation doses for equipment service and repair by removing the radioactive particles and other impurities from the surface of the component by using suitable washing equipment.

Preliminary; Olkiluoto 1 and 2 Annual O

R212 6 May 2012 to 14 May 2012, 7 days
R112 20 May 2012 to 03 June 2012, 14 days

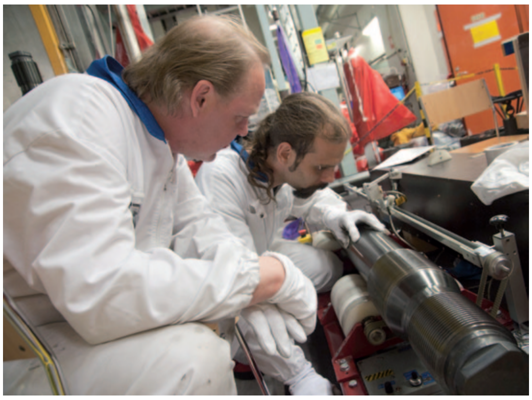


utages



A turbine bearing segment has been inspected and cleaned thoroughly before being transferred into place.

Lifting the new generator stator off the transport platform.

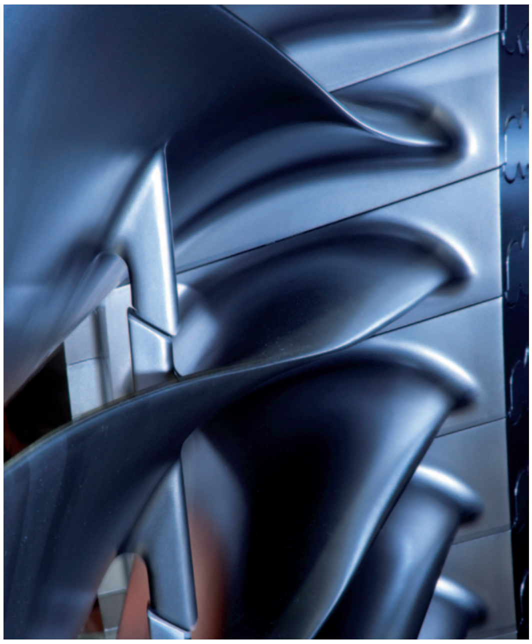


Reactor pressure vessel lid bolts are carefully inspected.

In the foreground, a low pressure turbine case; in the background, rotors.

Finland is the ice hockey World Champion in 2011.

TIG welder at work.



Reshaping the low pressure turbine rotor blades generates additional power.

Companies in annual outages

AB Truck & Krantjänst
ABB Alstom Power Finland oy
ABB Oy
ABB Oy Service
ABB Service Oy
Abori Montage AB
AIRIX Teollisuus Oy
Alaratech Oy
Alstom Finland Oy
Alstom Power Generation AB
ALSTOM Power Sweden AB
Alstom Power Turbomachines Gro
Amitec Oy
APP Start-up AB
ARE Oy
Arme Oy
Aro-Heinilä Lasse koneyrittäjä
Asennus N&H Service Oy
Best Partner Oy
CCI AG
CLS-Engineering Oy
CNC Maint-Tech Oy
Contec Byggprojektering i Västerås Ab
DEKRA Industrial Oy
Doseco Oy
Empower Suomi Oy
Etteplan Industry AB
Eupart Oy
Eurajoen Paloteam Oy
Euran teollisuushuolto Oy
Finnish Sea Service Oy
Finspect Oy
Flamsprutarna AB
Flamsprutarna Sverige AB
Fortiori Oy
Fortum Power and Heat Oy
HB Paloturva Oy
IKU-Tekniikka Oy
Ilmastointi Salminen Oy
Industrikompetens i Östergötland Ab
Infratek Finland Oy
Inspecta Oy
Inspecta Sertifiointi Oy
Inspecta Tarkastus Oy
Insta Automation Oy
Insta Group Oy
Is-Technics Oy
Jamtec Oy
Jergo AB
JJ-Rakennustyöt Oy
JMP-Asennus Oy
JR-Kiito Ky
Jukoi
Kil-Yhtiöt Oy
Kone Hissit Oy
Konecranes Service Oy
Koneistus J. Lähteenmäki
Kraftdragarna AB
KSB Finland Oy
L Blomberg Industriservice AB
Lapin Saumaus Veikko Peltomaa
Lassila & Tikanoja Oyj
Lemminkäinen Kiinteistötekniikka Oy
Lämpösulku Oy
Lännen Kaivuu ja Louhinta Oy
Länsi-Suomen Laatuasennus Oy
Maalausliike Heino Oy
Macor-Palvelut Oy
Maintpartner Oy
Masino Oy
Masor Works Oy
Metalock Sweden AB
MK-Vuokraus Oy
Nivico Oy
Noorfin Oy
Oy Ställverksprodukter Ab
Petteri Raak Oy
PG Solutions Oy
Power Instruments Oy
Proins Oy
Prosystem AB
Pöyry Finland Oy
Rakenne-Rinki Oy
Rakennus- ja konsultointi-
Rakennus Jalonen Oy
Rakennushuolto Kallio & Forss
Rauman Metallipaja Oy
Rauman Sähköpalvelu Oy
Rauman Tekniikkakeskus Oy
Rauvola & Simula Oy
ResRent Finland Oy
RTK-Palvelu Oy
SAG Netz-und Energietechnik Gm
Sammet Asennus Oy
Sata-Electro Oy
SAV Oy Länsi-Suomi
Securitas Oy
Sempell AG
Siemens Oy
Siemens Power Control GmbH
SK-Teline Ky
Sodexo Oy
SP-Suunnittelu Oy
Staffpoint Oy
Staffservice Finland Oy
Suomen Teollisuus-Sukellus Oy
Sweco Industry Oy
Swedewater AB
SVS Supervise Service Oy
Sähkö-Rauma Oy
Sähkö-Wire Oy
Säkylän Sähkö-Puisto Oy
Säserä Oy
Technology Design and Engineer
Teknikum Oy
Teline-Esu Oy
Telinekataja Oy
Teline-Rami Oy
Timanttityö Santala Oy
TL-Asennus Oy
Toiminimi H. Vainio
TÜV NORD Testing Oy
WesDyne TRC AB
Vesi-Vasa Oy
Westinghouse Electric SwedenAB
VTT
YIT Kiinteistötekniikka Oy
YIT Teollisuus Oy
YIT Teollisuus-ja Verkkopalvelut

Olkiluoto
FI-27160 EURAJOKI, Finland
Tel. +358-2-83 811
Fax +358-2-8381 2109

Helsinki
Töölönkatu 4
FI-00100 HELSINKI, Finland
Tel. +358-9-61 801
Fax +358-9-6180 2570

Brussels
4 rue de la Presse
1000 BRUSSELS, Belgium
Tel. +32-2-227 1122
Fax +358-2-218 3141