FENNOVOIMA

Turbine Island

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Content

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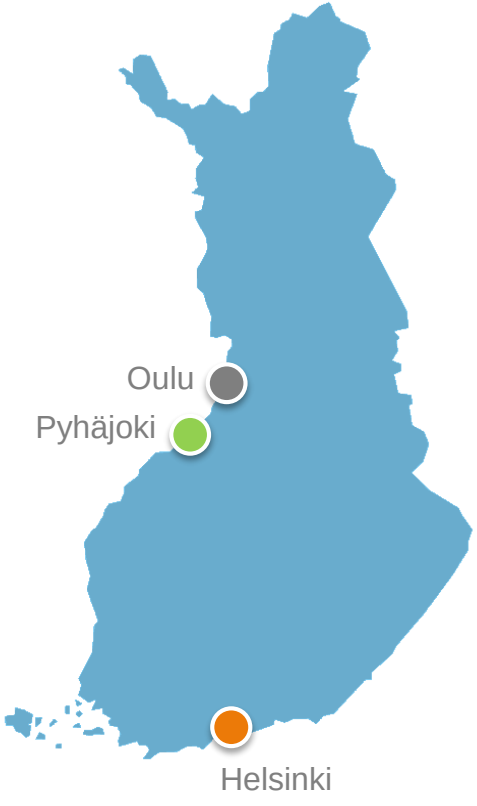
Fennovoima in brief

- Established in 2007
- Currently employs approximately 350 people, in operation phase approximately 500 people
- Head office in Helsinki, local office in Pyhäjoki
- Mankala company, produce electricity to shareholders on costs basis
- Builds and operates a nuclear power plant in Pyhäjoki
  - The total cost of the project € 6,5 – 7 billion
  - Equity 25%, debt 75%
  - Equity € 1,7 billion



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Project development roadmap

2016-2019

- Training building
- Main gate building
- Administration building
- Office building
- Fire station

2019-2022

- Reactor and turbine island buildings/ Auxiliary buildings for the power plant
- Equipment installation begins

2022-2024

- Commissioning of the power plant begins
- Fuel delivery to the plant

2024

Commercial electricity production begins

The plant will produce electricity for its owners for atl least 60 years

2016-2019

Infrastructure works and construction of auxiliary buildings

2019-2024

Construction of the nuclear power plant and installation works

2016-2019

Several municipal buildings, water and environmental permits

2019

Construction Licence for the the nuclear power plant

2019-2022

Up to 4000 people will be working at the site

2022

Operating Licence for the power plant

2024

During the operation phase, the plant will employ 450-500 people directly

Main sub-suppliers

- **Titan-2**, main building contractor, is in charge of the detail design, construction and installation works of the power plant
- **Atomenergomash*** supplies the long-lead items such as the reactor pressure vessel and steam generators
- **ALSTOM Power Systems**** delivers the turbine generator set together with Turbine Technology AAEM (joint venture between Atomenergomash JSC and ALSTOM Power Systems)
- **OKB Gidropress*** is responsible for the reactor building and primary circuit design
- **JSC Atomproekt*** is in charge of the basic design of the power plant

** Subsidiary of Rosatom*

*** A part of General Electric group*

Scope of supply

- Turbine-generator set is based on Alstom Arabelle™ technology.
- Turbine island consists of a turbine-generator unit, condenser(s), water pre-heaters, pumps and internal pipes.
- The scope of supply is divided into two lots: ALSTOM Power Systems (later called GE Power) and Turbine Technology AAEM

A large scale turbine equipped with HP/IP, 3 LPs and generator

Source: ALSTOM presentation material

HP = High pressure
IP = Intermediate pressure
LP = Low pressure

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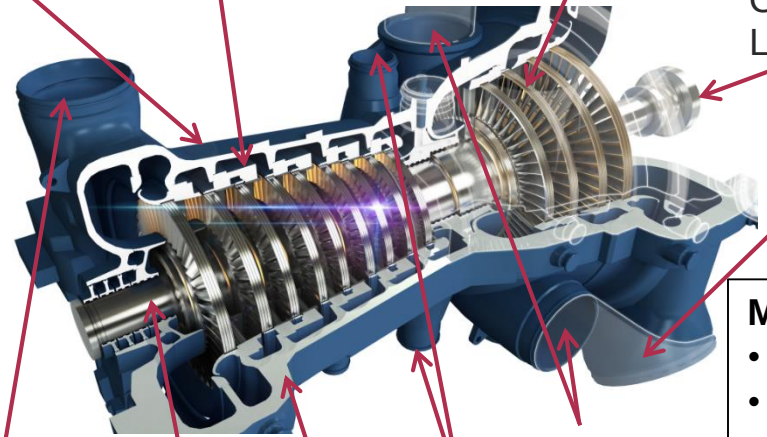
Arabelle turbine

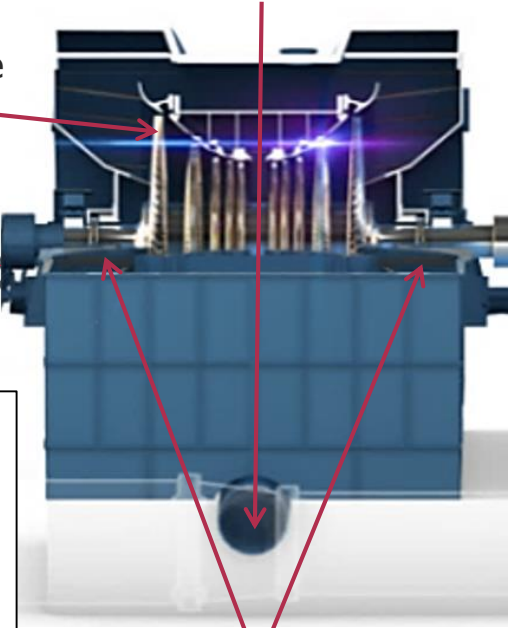
Source: GE www-page

Turbine and auxiliaries



Typical Arabelle HP/IP + LP turbines

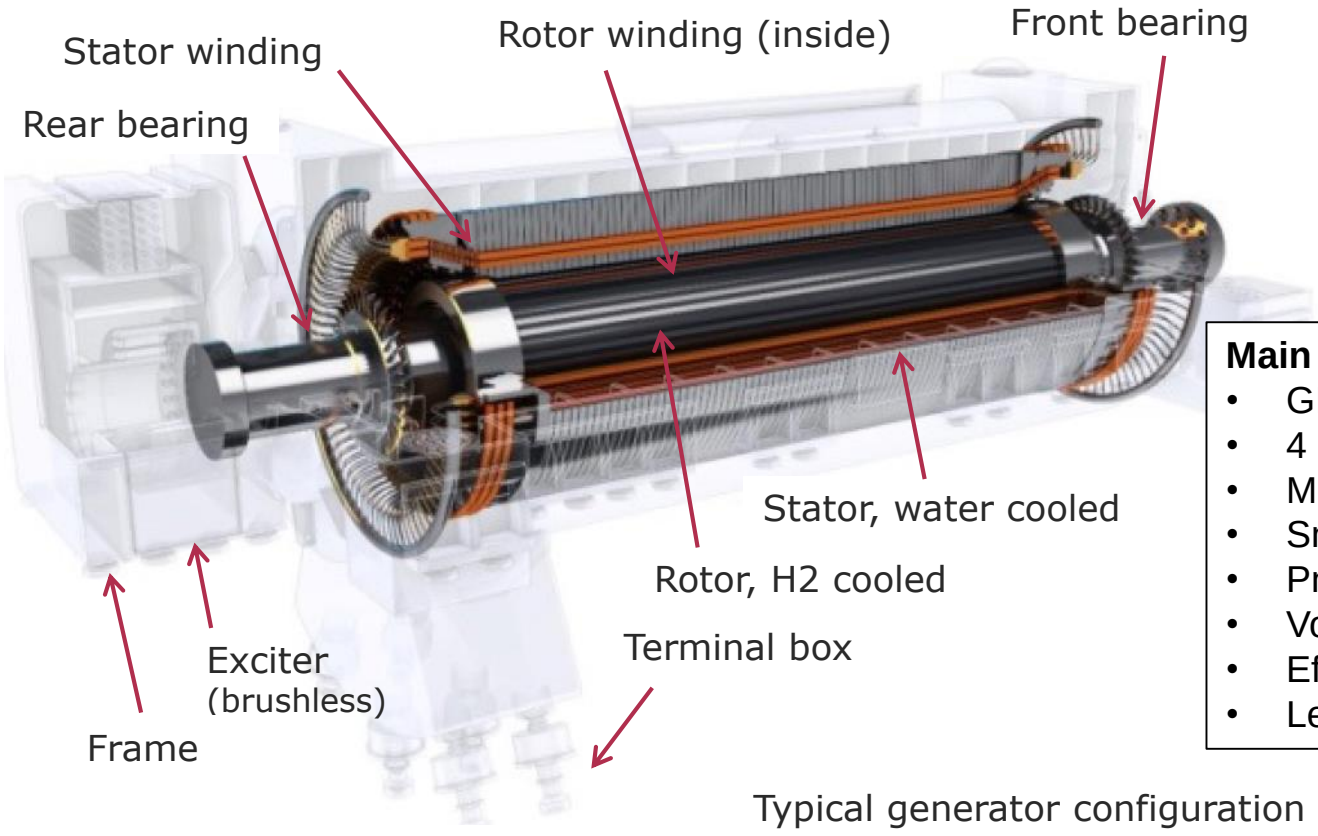
Source: ALSTOM presentation material.



Main characteristics

- Arabelle
- 1500 rpm
- 25NHIP10.041 + 3*LT69A
- HP 9 stages, IP 4 stages, LP 2 x 5 stages (3 LPs)
- Impulse type
- Power 1265 MW
- Last stage blade 69”
- Length of shaft ~53m (excluding generator)

Generator, exciter and auxiliaries



Main characteristics

- GIGATOP
- 4 poles 1500 rpm
- Model TA1200 – 78
- Sn 1411 MVA
- Pn 1270 MW (cosφ=0,9)
- Voltage 24 kV
- Efficiency 98.99%
- Length of shaft ~16m

Typical generator configuration

Source: ALSTOM presentation material.

Condenser

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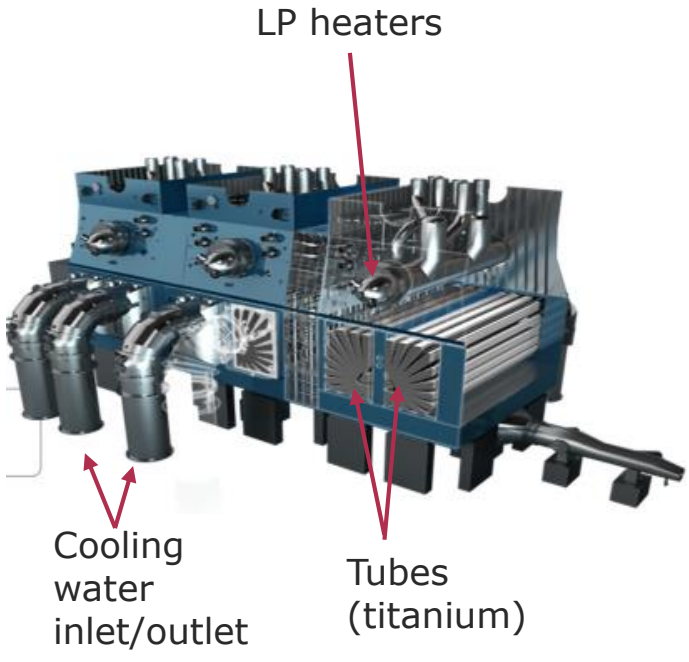
- After low pressure turbine (LP) steam is led downwards to condenser.
- In condenser, two-phase steam (at 0,025 bar ~ 20°C) is condensed by cold cooling water (direct sea water cooling)
- Transfer heat to the sea
  - 3200 MW reactor
    - 1200 MW electricity
    - 1700 MW to sea
  - Sea water flows titanium tubes, amount approx 40 m³/s
  - Heat transfer surface approx 90 000 m²



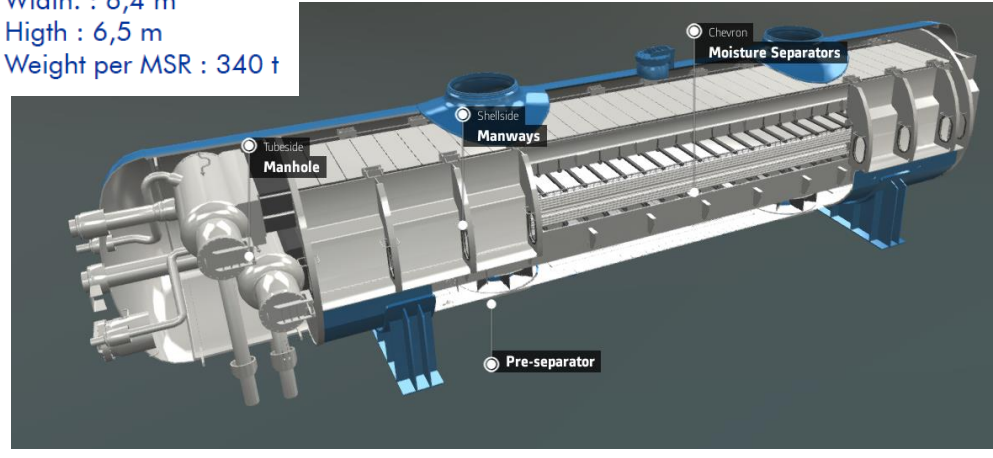
Configuration of three condenser

Source: ALSTOM presentation material.

Moisture separator reheaters (MSR)

- Moisture separator reheaters
  - In saturated condition steam includes always some moisture.
  - Moisture separators are used to remove moisture from steam and allow bigger power output.

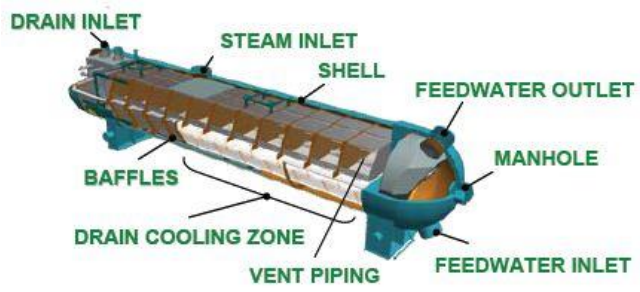
2 MSR per unit
Length : 24 m
Width. : 6,4 m
Higth : 6,5 m
Weight per MSR : 340 t



Typical moisture separator reheater
Source: ALSTOM presentation material.

Other components

- Heat exchangers and Feed water tank
  - Low and high pressure heaters are used to pre-heat condensate and feed water prior feeding to the steam generators.
  - Feed water tank equipped with a deaerator is used for removing of oxygen and other dissolved gases from the feed water.
- Pumps
  - Pumps are used for pumping water or condensate.
  - The feed water pumps and cooling water pumps are the most important pumps.



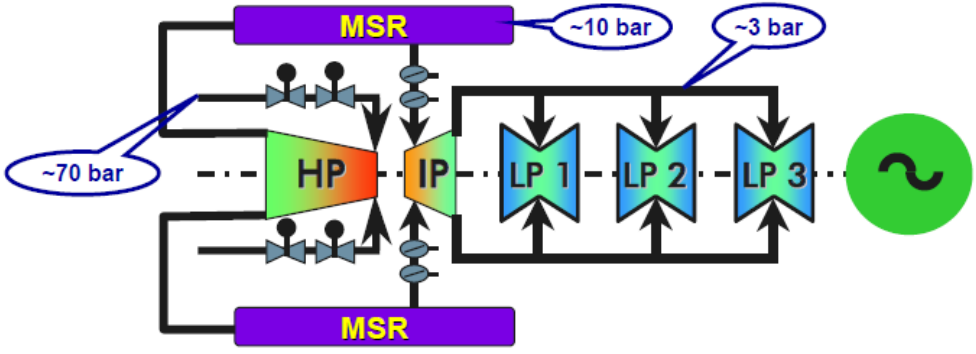
Typical HP heat exchanger

Feed water tank, 1 pc

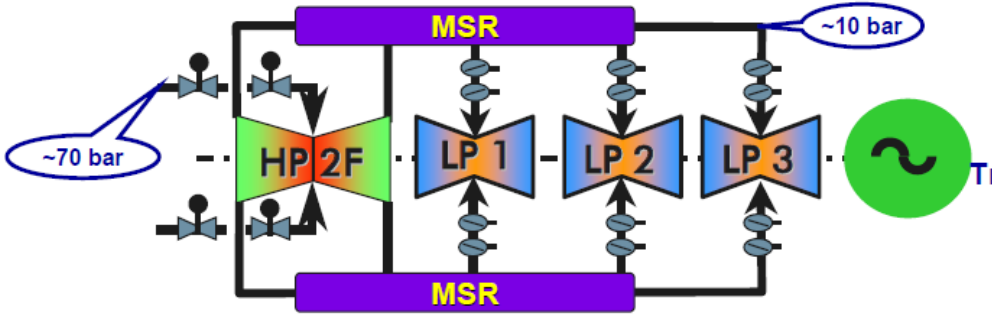
HP heat exchanger, 4 pcs

LP heat exchanger, 8 pcs

Arabelle with HP/IP and LP modules



ARABELLE
Unique configuration



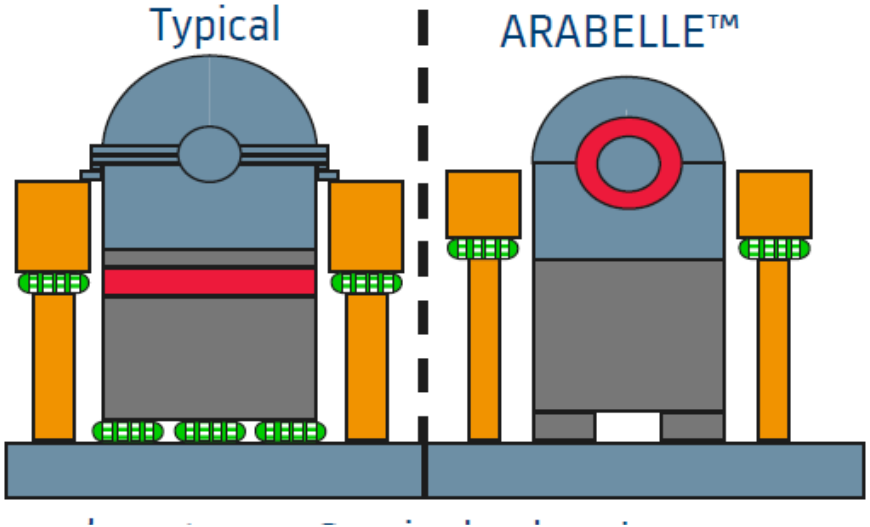
PREVIOUS
Traditional configuration

- 60% power generated in HP/IP turbine and 40% power in 3xLP turbines
- Lower temperature in LP turbine -> less axial movement
- Lower pressure to LP turbine, no intercept valves needed

Source: ALSTOM Arabelle turbine produce brochures material publically available before 2014

Independent LP structure

- Reduced turbine load on foundation
- No vibrations due to condenser level or backpressure variations



Source: Arabelle product brochure

- In other turbines, the LP inner casing is supported by the outer casing, which in turn is supported by the turbine table
  - Distortions of the outer casing or load variations on the table induced by vacuum or condenser weight variations during operation -> vibration
- Arabelle LP cylinders are designed with independent structures. The LP inner casing is connected at each end to an end-wall, which integrates the rotor bearing housings (exhaust structure fixed to concrete) .
- The LP outer casing (exhaust hood), which no longer acts as a support, simply becomes an envelope rigidly welded to the condenser, which is supported on the basement floor

Destia Oy began excavation and quarrying works in the nuclear plant area in February 2016.

Main connection road network at site prepared in November 2016

The first concrete batching plant in operation in November 2016

The first building, training building was completed in December 2016

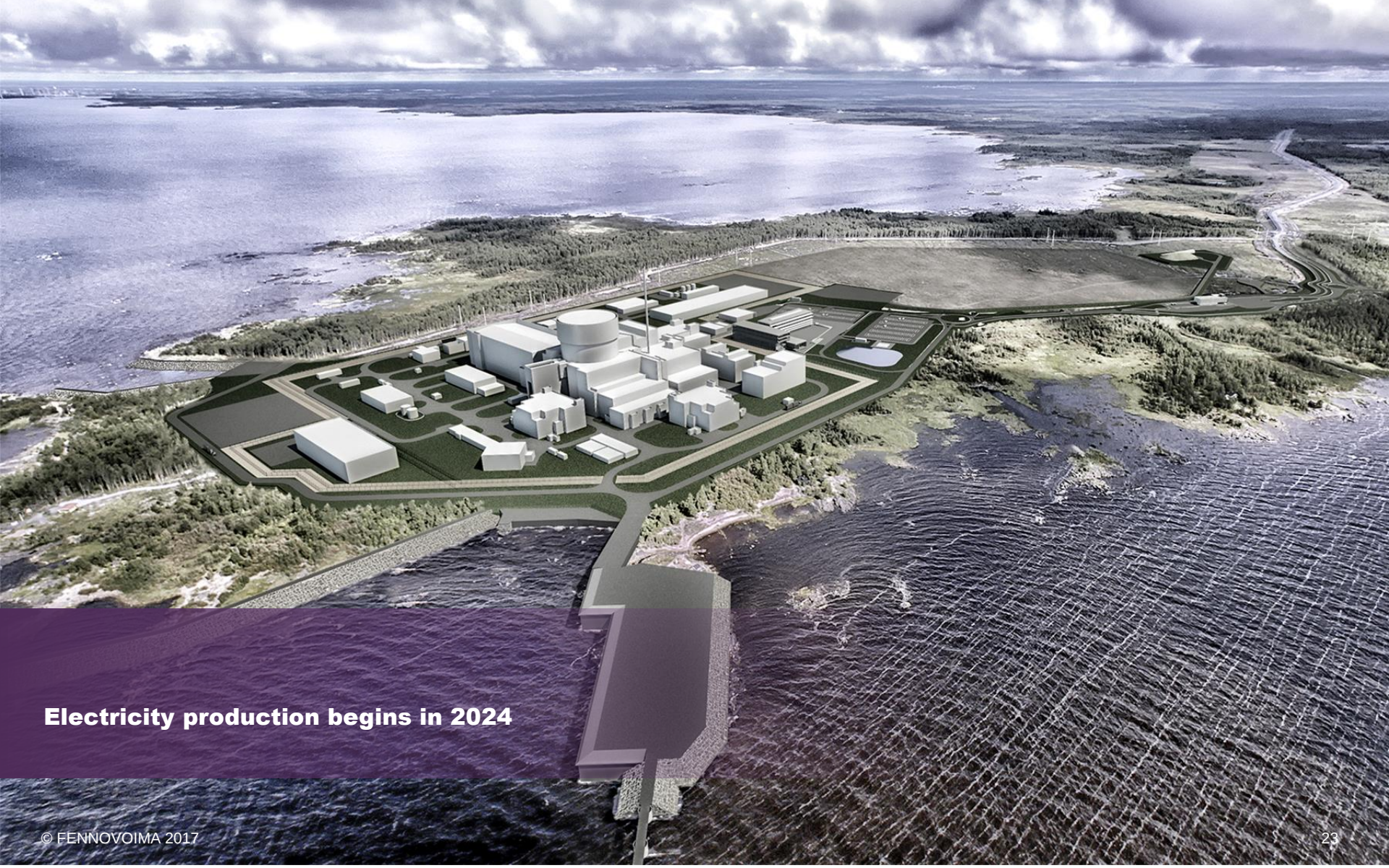
Dredging works began in 2016 and continues in year 2017.

Gate building was completed in July 2017

Accommodation village for 1000 persons is under construction in August 2017

Summary

- Fennovoima needs to support the supplier but also ensure that EPC Contract requirements will be fulfilled and good quality power plant is delivered by appointing local supervisors.
- Although several components are supplied by sub-suppliers from different locations/countries, but acc. EU standards, no comparison between Russian and EU standards needed.
- It is important to use proven technology also for auxiliary components to minimise unnecessary outages because of breakdowns.
- The turbine building is located so that there is no missile impact towards reactor building (nuclear safety issue).
- Spare parts (especially capital spare parts) play a significant role in the maintenance/overhaul strategy and allow possibility to achieve high availability for the power plant.



Electricity production begins in 2024