Plant Lifecycle Management

Fortum Thermal Production and Power Solutions

Panndagarna 2016, Ulla McNiven
12 April 2016, Karlstad

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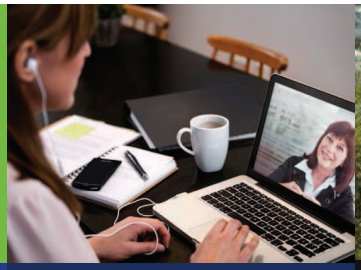
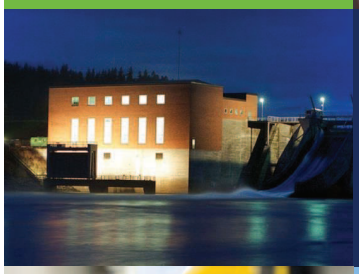
Fortum in brief

Forerunner in clean energy



Some 8,000 energy professionals

Nordic and Baltic countries, Russia, Poland



64% of power generation CO_2-free - in EU 97%

Core competences in hydro and nuclear power, combined heat and power production and in operating on energy markets

Energy-related products and expert services

1.3 million electricity sales customers

Figures: 2015

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Fortum – Forerunner in clean energy

MEGATRENDS

Climate change
Urbanisation
Active customers
Digitalisation, new technologies

MISSION

We provide customers with energy solutions that improve present and future life, and we deliver excellent shareholder value.

STRATEGY

- Drive productivity and industry transformation
- Create solutions for sustainable cities
- Grow in solar and wind
- Build new energy ventures

MUST-WIN-BATTLES

Put the customer in the centre | Establish a culture of speed and agility | Digitalise our business for maximum scalability | Create value from market volatility | Drive competitive markets and fair regulation

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Success through a shared perspective in thermal solutions: Power Solutions/Fortum's expert services in brief

- Fortum has extensive references in commissioning, operating, maintaining and upgrading thermal power plants in European and Asian energy markets
- Core competence in thermal, hydro and nuclear power
  - Built on Fortum's knowledge and history as an energy producer
  - Over 300 employees delivering high quality expert services
  - Experience from projects in over 20 different countries
- Services to improve technical and economic performance of new and existing production capacity in
  - Bio-energy
  - Energy from waste
  - Combined cycle
  - Gas, coal and peat fired power plants
- Expert references cover hundreds of customers globally
- Co-operation with various partners and networks
- Combining our top technical know-how with an economic view enables us to identify opportunities and turn them into measurable results
- Independence of equipment suppliers

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Value Creation with Plant Lifecycle Management

Maximum productivity during the lifecycle

- Benefit 1: Safety – managed risks Environment
- Benefit 2: Better availability – lower unavailability costs
- Benefit 3: Savings – optimised action plans
- Benefit 4: Knowing the life of the main components allows scheduling of refurbishments and investments to be optimised, improving safety and productivity
- Benefit 5: Predictability – possibility to better utilise condition data

Potential for value added to be assessed taking into account:

- Unexpected failures
- Unplanned corrective maintenance
- Availability degradation
- Investment costs
- Long-term planning
- Systematic approach
- Energy efficiency
- Risks

The purpose of asset lifecycle management:
To optimise the resources invested in assets to maximise the revenues during the asset lifetime

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Lifecycle Management built on expertise

Boiler	Combustion, burners	Turbine	Generator	Other rotating machinery	Transformers	Automation, control and safety devices

Setting of objectives, collection of initial information and data

Analysis of component criticality and planning of inspections and maintenance actions

Inspections and measurements, analysis of the results, correct timing for action and investment plans, also follow-up and necessary updates

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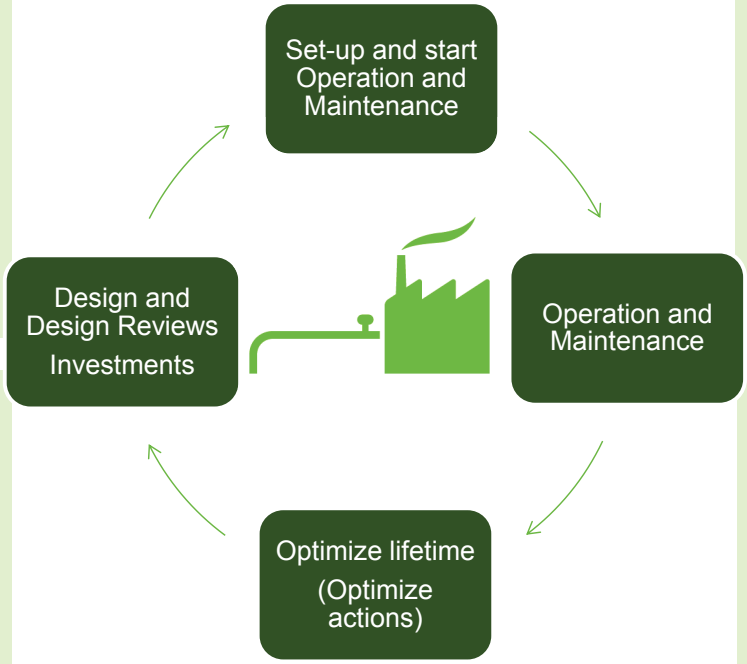
Asset Lifecycle Management, Fortum practices

Set-up Integrated Management System
Set-up Maintenance Management (Maximo®)
Set-up other ICT: TOPI®, etc.
Design Reviews
Document management

Set-up risk management
Feasibility studies
Criticality analysis
Lifetime analysis and long-term planning

Decommisioning
Mothballing
Demolition



Training
Fuels, combustion
Fingerprint measurement
O&M Contract
O&M Support Contract
Remote monitoring
Emission control
Overhaul planning

Performance monitoring
Maintenance and condition monitoring for main components
Audits, reviews, cPIP®
Refurbishment
Upgrading
Reinvestments

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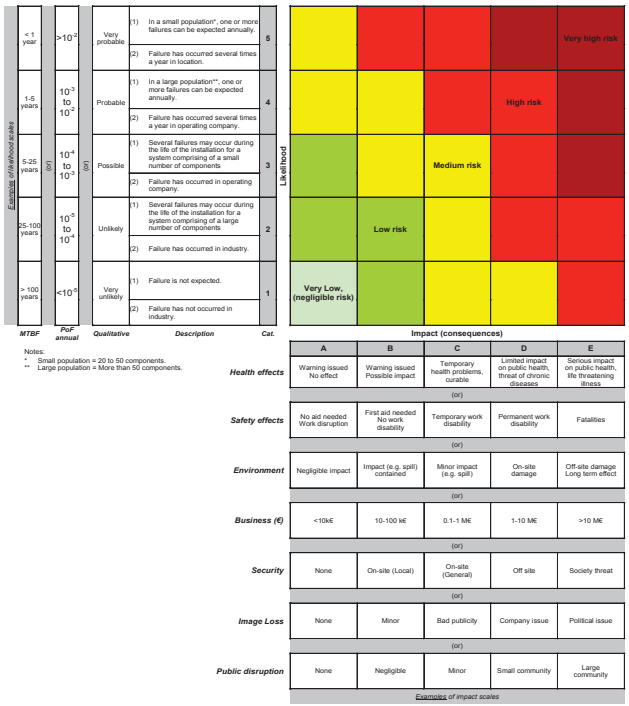
Risk-based Asset Lifecycle Management Implementing RBIM and RBLM

- Optimisation of O&M and Asset Management
- Defined and acceptable risk levels in relation to:
  - Safety, Health, Environment
  - Business/production/operation/availability
- Integrity related RBI:
  - Scenarios (structural damage)
  - Failure probability & consequences
    → Assessed risk
- Risk-based ranking of criticality and planning for cost-effective inspections and maintenance
- Planning for sustainability



RBI – risk-based inspections
RBIM – risk-based inspections and management
RBLM – risk-based life management

Source: "Risk Based Inspection Framework" (RBIF)

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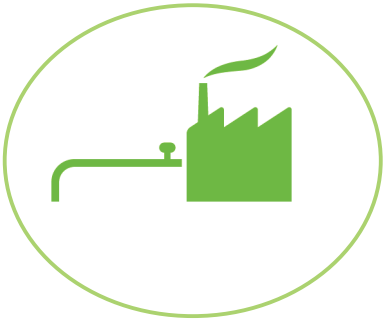
Availability & Reliability Management

Combined package including separate module services such as:

ReMaint®: Criticality Analysis, Maintenance and Spare parts Optimisation, FMEA/RCM Analysis

RAM Analysis and investment decision support

CMMS Audit and Population



KPI's monitoring and reporting: Feedback Analysis

Disturbance reporting
Problem Solving

Support: Training

- Continuously improve your plant's performance

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Joensuu Power Plant, Finland, an example

Ownership and personnel

Ownership	100 % Fortum
Operation by	Fortum
Maintenance by	Fortum
Staff	54
○ Operation	29
○ Maintenance	22
○ Asset Management etc.	3

Production

Heat production capacity	130 MW
Net electricity production capacity	
○ At CHP operation mode	50 MW
○ At Condensing operation mode	70 MW

Production units at the plant	**Power plant**	**HOB**
Start-up year	1986	2009
Fuel capacity (MW)	200	35
Main fuel(s)	Peat/ Wood	Peat/ Wood
Yearly operation hours (h)	7600	~4000
Boiler manufacturer	Ahlström	MW Power
Boiler type	BFB	BFB

Pyrolysis Oil Production started 2013

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Joensuu Investment planning & Lifetime Management project

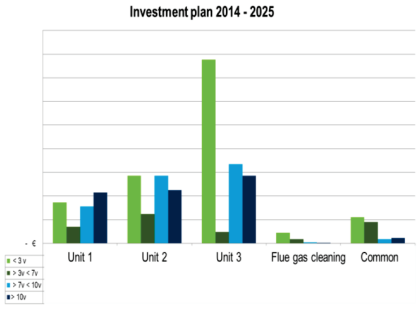
Technology and process	Investments and return	Efficiency and availability	Human factors	Safety and risks	Legislations and regulations	Environmental impacts
	€	%			§	CO_2

Planning

1. Select systems and scope for lifetime assessment
2. Collect initial data and interview, utilize annual overhauls (e.g. periodic inspections)
3. Prepare preliminary inspection plan and budget

Implementation

4. Plan detailed inspections and allocate resources
5. Prepare and carry out inspection
5. Analyze inspection results
6. Recommend immediate improvements
7. Establish lifetime assessment for critical parts, list of necessary long term actions and investment estimates



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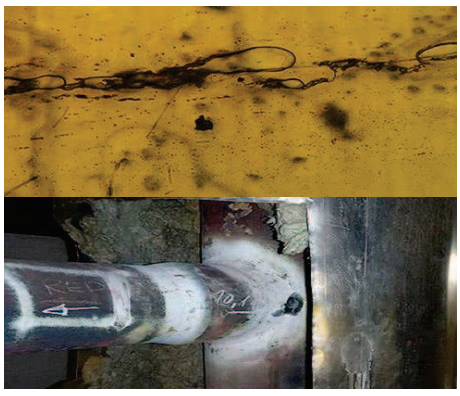
A practical example at Joensuu Power Plant, Finland 2014-2015 Life assessment

Project

- Collect existing data, inspection results, reports, experience, condition reports, maintenance and operational information
- Plan the needed inspections and measurements
- Implement inspections, measurements, assessments
- Analyze results
- Plan and schedule actions, update earlier plans and information in systems

What was found

- Creep damage in the main steam line (material X20CrMoV121)
- Hanger improvements needed
- Internal layer thicknesses affect life of a superheater
- RBI Risk assessment needed



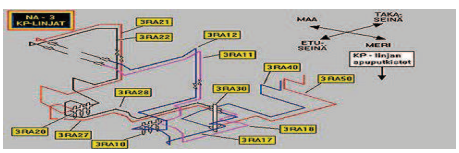
- Possible safety risk, significant unavailability risk eliminated

  (over 220 000 operation hours)

More results

Additional life for the main components assessed: 100 000 hours

- Timing of new investments taking into account the life of the existing equipment
- Continuous safety improvement
- Timing of the correct investments -> benefits already on the short-term
- Risk assessments utilized



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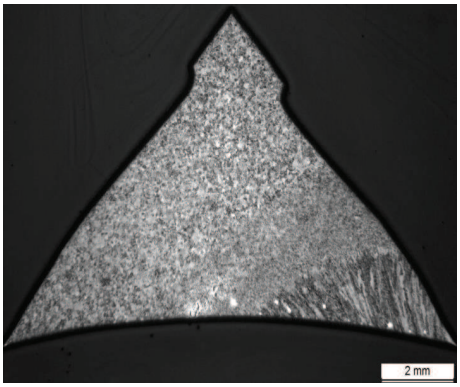
Some details in the Joensuu Lifetime Management project

Creep damage in the main steam pipeline found on time

- Repair planned and carried out during the outage

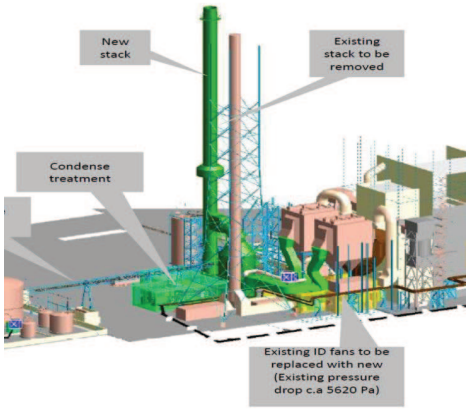
Samples examined to support decision making



- Work supported by laboratory studies
- Timing of superheater refurbishment supported by life assessment of tube samples
- Inside layer thickness, temperature follow-up etc.

Important results

- No safety hazards
- Unavailability costs avoided
- Optimum timing for investments



Flue gas cleaning and heat recovery / flue gas condenser plant

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Case 2: Eskilstuna Project, boiler plant refurbishment

Background

- Eskilstuna Energi och Miljö AB (EEM) aims to extend the lifetime of the CFB boiler
- Turn-key project
- Public procurement tendering process
- Time schedule
  - Site work 1 April – 1 July 2016
- Plant: 110 MW Biofuel CHP
  57_{dh} MW Biofuel CFB (in this project)

Scope

- Modernization of the boiler and auxiliary systems including

  renewal of
  - CFB boiler cyclones
  - Start-up/support burners (2 pcs) with an oil pumping unit; possibility to bio-diesel firing
  - Fuel day silo bottom and the hydraulic system
  - Flue gas recirculation fan and ducts (partly)
  - Bottom ash removal system incl. a new 'ash' building
  - Soot blowers (6 pcs) for district heating ECO
  - Extension of the SNCR -system
- All installation work is included

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Outcome of the Eskilstuna Project

Emission reduction

- Extension of the existing SNCR system to fulfill the required emission limits

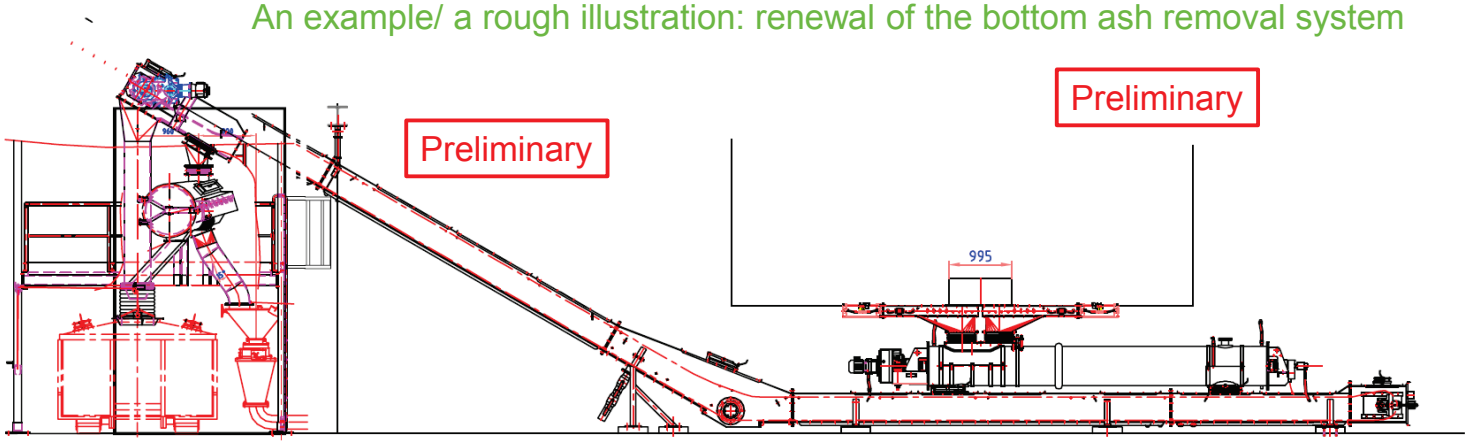
Production secured

- Safe and reliable production secured
- Availability improvements

Life extension

- The goal: life of the 30 years old boiler plant could be extended by 20 years

An example/ a rough illustration: renewal of the bottom ash removal system



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Asset Management Strategy

- Management system includes policies
  - Safety
  - Environment
  - Legislation and regulations
  - Resources
  - Organisation
  - Decision making criteria
  - Long-term objectives, sustainable outcomes, stakeholder requirements
- Continuous improvement
  - Development of assets, upgrading
  - Development of the management system

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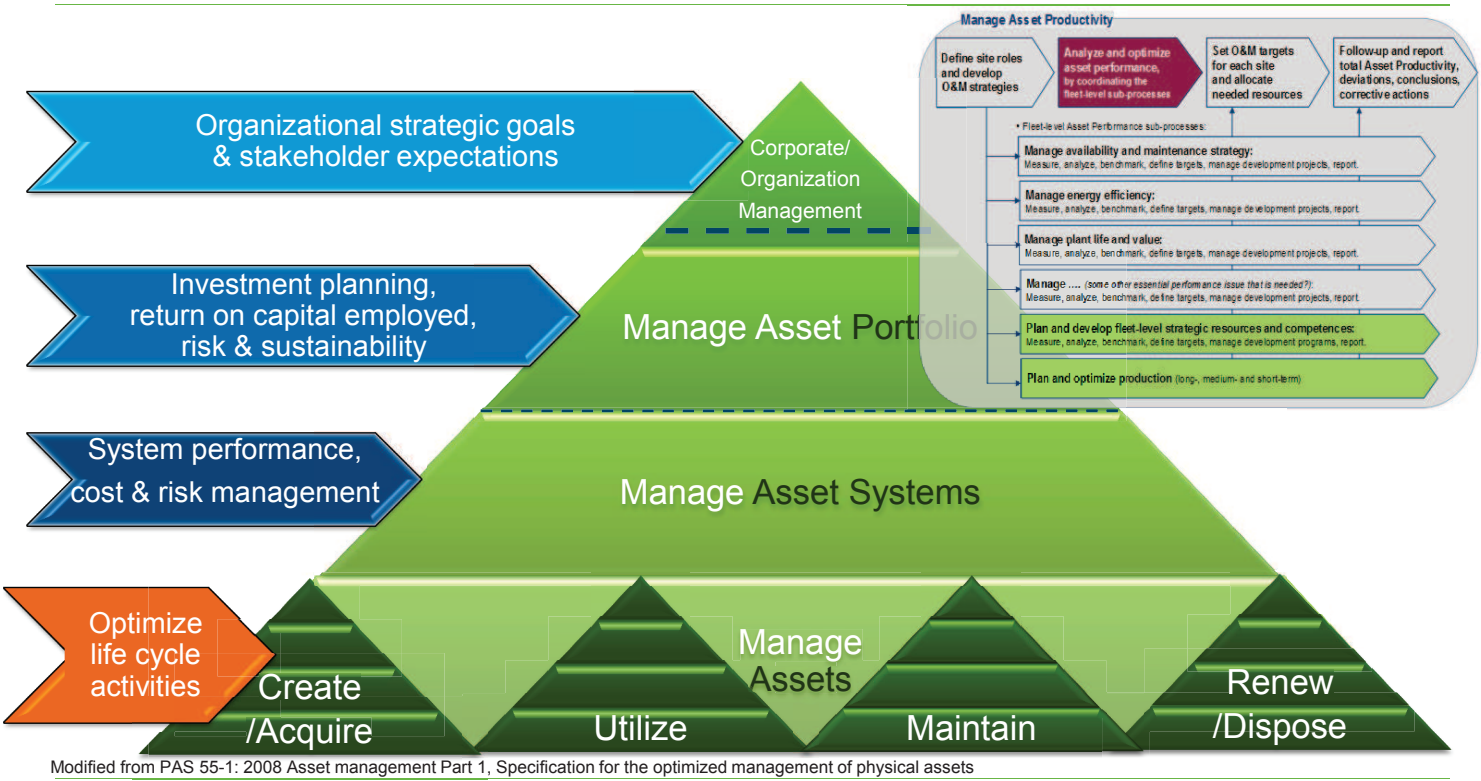
Asset Lifecycle Management -- Asset Integrity



Modified from PAS 55-1: 2008 Asset management Part 1, Specification for the optimized management of physical assets

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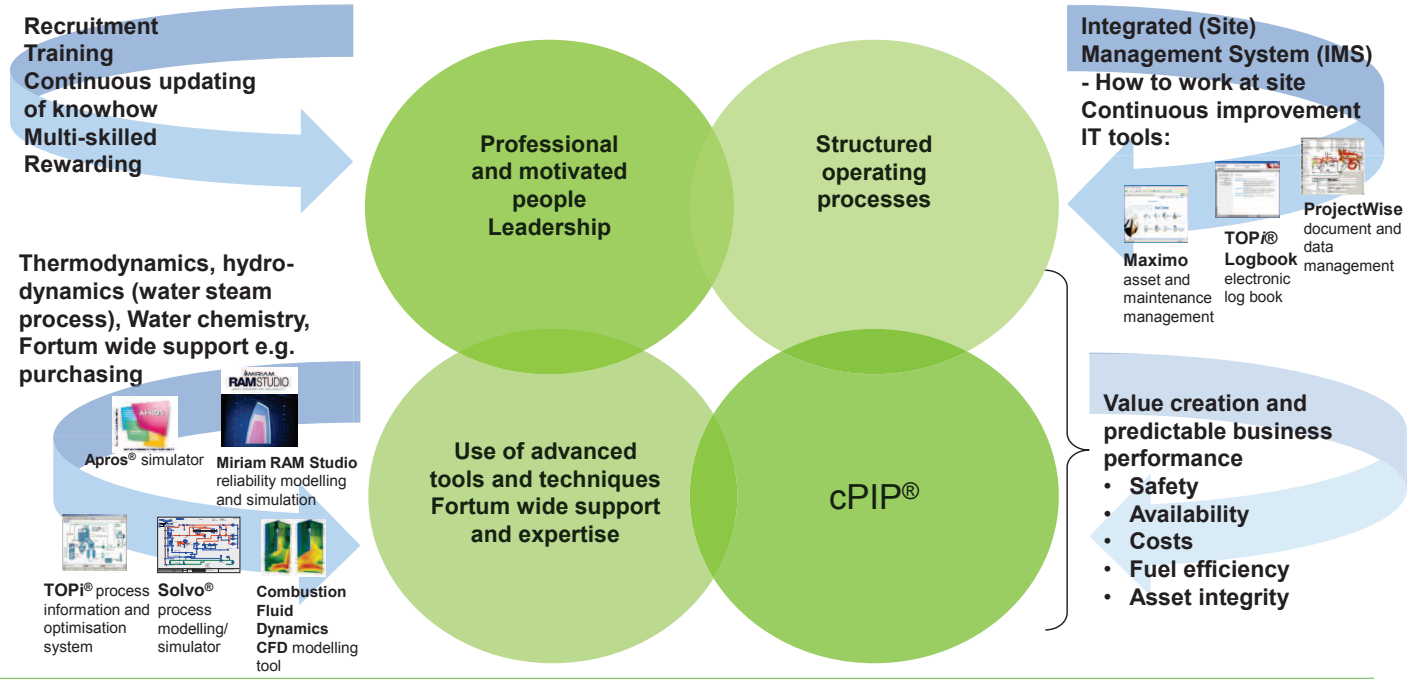
TOP*Gen*®

Fortum TOP*Gen*® O&M concept is *a company specific way to set up O&M organization, management systems and selected IT tools at power plants and to operate and maintain power plants*



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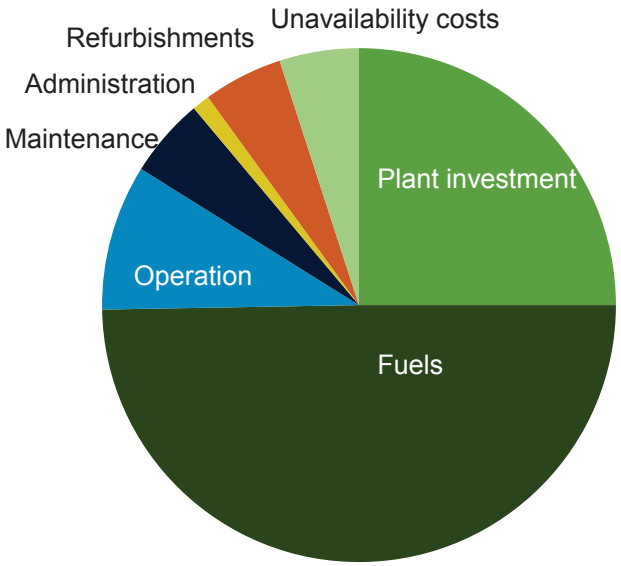
Make your power plant efficient!

- Optimise refurbishment costs
- Optimise operation & maintenance and management costs
- Minimise unavailability costs
- Fuel and emissions cost savings through optimum efficiencies



Case
CHP-plant
60 MWe
90 MWth
6000 h/a
=>1060 GWh_{fuel}
20 €/MWh_{fuel}

1 %- Fuel saving
10600 MWh_{fuel}
=> 212 000 €/a
2 %- Fuel saving
21200 MWh_{fuel}
=> 424 000 €/a

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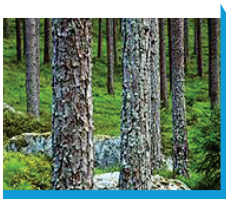
Basis for successful Plant Lifecycle Management, Fortum



Preplanning and requirements

- Documents
- Meta-data
- Coding system
- Formats
- Archive and method of delivery
- Coding of the systems and equipments

1 - 2 years

Planning

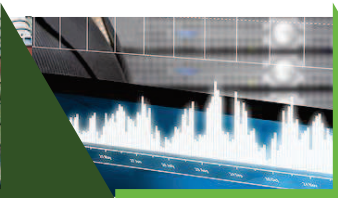
- Main level hierarchy
- Purchasing
- Acceptance
- Cost control
- Project documentation
- Criticality classification for main components
- O&M strategy

1 - 2 years

Construction & Commissioning

- Equipment level hierarchy
- Commissioning logbook
  - Deviations
  - Failures
  - Preventive maintenance
- Acceptance of O&M documents
- Criticality classification for all components
- Preventive maintenance programmes
- Spare part management

1 - 2 years



Operational lifetime

- O&M budgeting (3 year interval)
- Strategy monitoring
- Long term planning (5 – 10 years)
- Preventive maintenance
  - Actions
  - Programmes
  - Analysis
  - Failure repairs
  - Yearly overhauls
- O&M data monitoring
- Benchmarking

30 - 50 years

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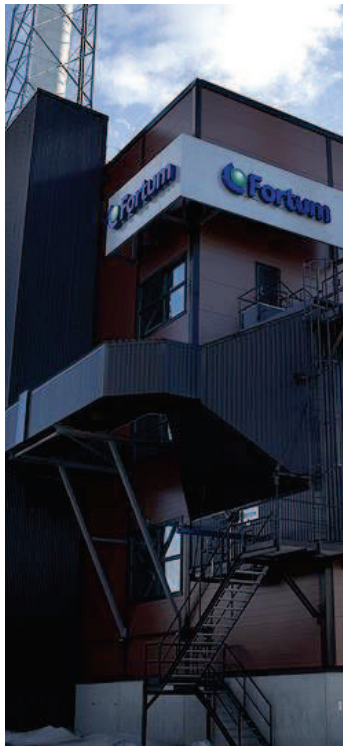
Fortum approaches for condition monitoring in lifetime management

General services for production plants / Continuous Condition management

- Process thermal performance and energy efficiency monitoring
  - IT-systems, process model, analysis and remote support
- Mechanical equipment condition management
  - Vibration monitoring for rotating machines
  - Structural mechanics analysis and studies
- Electrical equipment condition management
  - Generators, high voltage motors, transformers
- Water and environmental chemistry management

In addition for power plants / Overhaul and projects

- Combustion and boiler condition and lifetime management
  - Combustion modelling (CFD) for all boiler types and Low-NOx-burners
  - Combustion, fouling and corrosion monitoring including systems
  - Boiler and main steam line inspection planning and long-term plans
- Turbine and generator condition review, inspection, overhaul and modernisation
  - Including replacement of parts as well as control and protection systems



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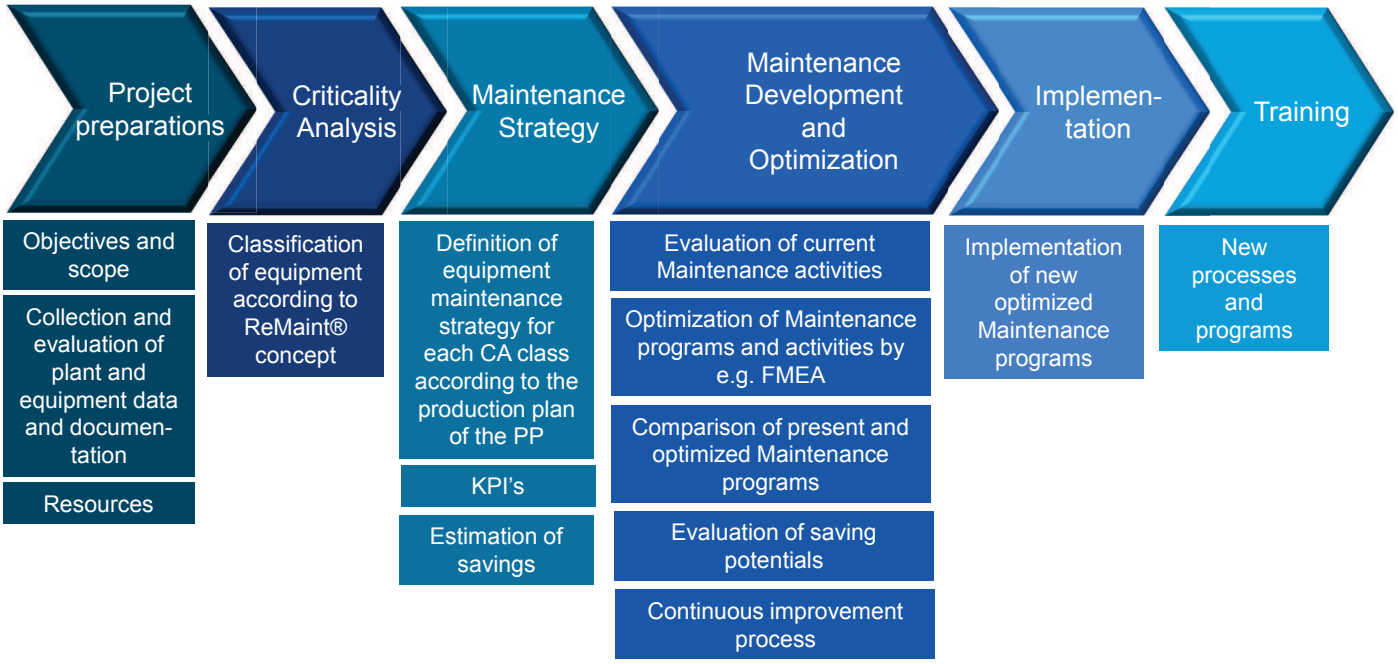
Maintenance development process, ReMaint®



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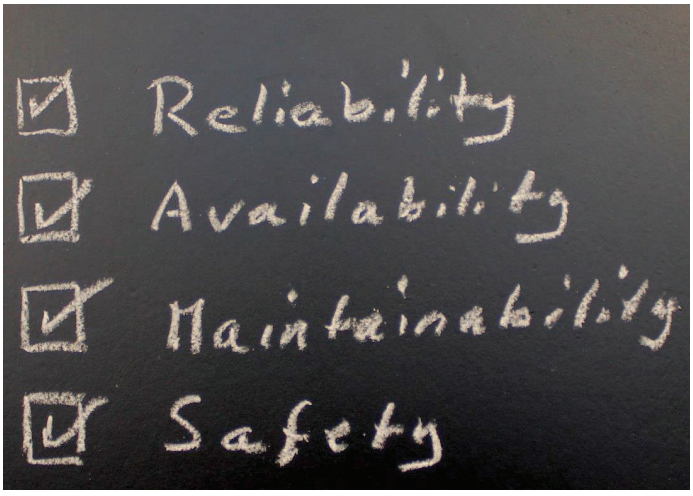
Case CHP plant – ReMaint®

Maintenance development

- Criticality Analysis based on risk assessments
  - Waste-to-Energy plant 160 MW_{TH}
- FMECA*) and RCM**) analysis for the most critical system(s)
  - Fuel handling system
- Optimization of Preventive Maintenance (PM) programs and critical spare parts



Benefits for the Power Plant business

- Not anymore disturbances and unplanned shutdowns due to critical components (before c.a. 190 h / 11 y)
- Systematic, comprehensive and well-timed PM programs for critical components
- Outsourcing of routine maintenance, for example bearings lubrication
- Easy mobilization of critical spare parts, placed in site storage or near in spare pool

*) FMECA = Failure Mode, Effect and Criticality Analysis
**) RCM = Reliability Centered Maintenance

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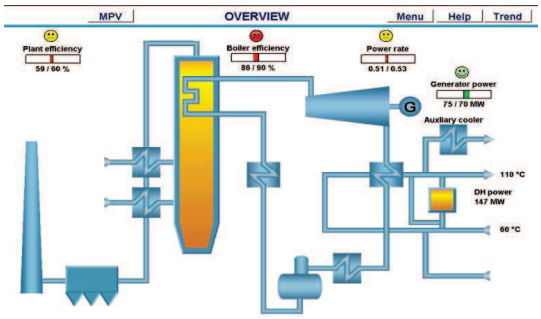
Systematic follow-up, performance indicators

- Performance: Performance indicators (KPIs), TOP*i*® (process performance), CMMS
- Management system: cPIP® auditing, reviews and internal audits at planned intervals
- Predetermined condition reports at planned intervals, scheduled long-term plans



Condition Indexes	Main unit			
	Turbine		Generator	
Power plant/unit	Runner	Distributor	Stator	Rotor
PL1 - G1	Very good	Very good	Very good	Very good
PL2 - G2	Good	Fair	Good	Fair
PL3 - G1	Poor	Poor	Very good	Good
PL4 - G1	Fair	Fair	Poor	Poor
PL5 - G2	Good	Good	Good	Good

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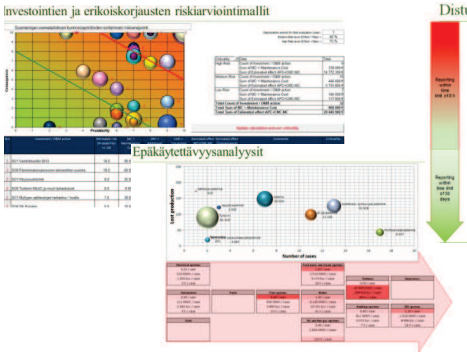
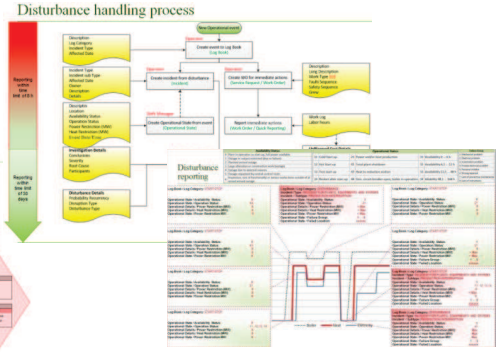
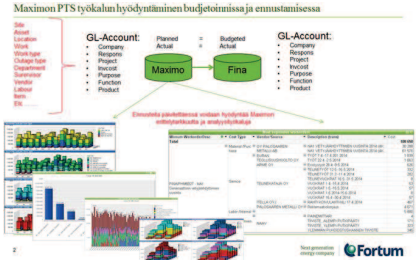
Audit, Analyse and Develop the use of CMMS

CMMS (computerized maintenance management) in the asset lifecycle management

- Long-term planning
- Investment projects
- Daily operation and maintenance management and reports
- Condition reports
- Analysis, planning and budgeting support







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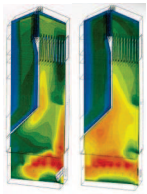
Tools and methods for development
Summary

Tools and methods
Case Fortum

- **Assessment and auditing processes,** Safari® and cPIP®
- **Prioritization methods** – Criticality analysis (CA), RBI, analysis of production failures, condition and life cycle assessment
- **Analysis methods** – Failure Mode and Effect Analysis (FMEA), Hazard and Operability Study (HAZOP), Cause & Effect Analysis and Root Cause Analysis, Problem Solving
- **Integrated Management Systems (IMS), TOP*Gen*®, Maintenance Handbook, ReMaint®**
- **Applications,** Miriam RAM Studio, Availability follow-up tool, Elmas

Integrated management system

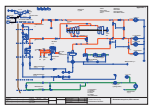
CFD modelling tools



Reliability modelling and simulation

Availability follow-up tool

Solvo® process modelling/simulator



ProjectWise document and data management

Elmas
Event Logic Modeling and Analysis Software

Maximo®
asset and maintenance management

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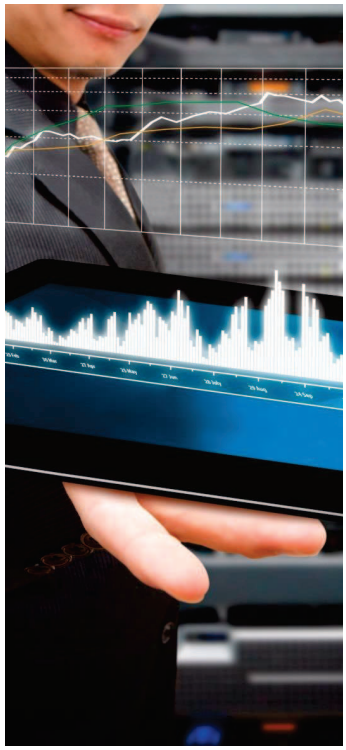
Creating measurable value

Asset productivity and lifecycle profits developed by:

- Improving the performance and productivity of existing power plants
  - Availability, energy efficiency, O & M costs development and the productivity of investments
- Managing risks and the condition of main components, such as turbine, generator, boiler, etc.
- Utilizing advanced analysis and management tools
- Performing successful O & M introductions and start of the commercial operation for new power plants
- Improving both site-level O & M and asset productivity processes



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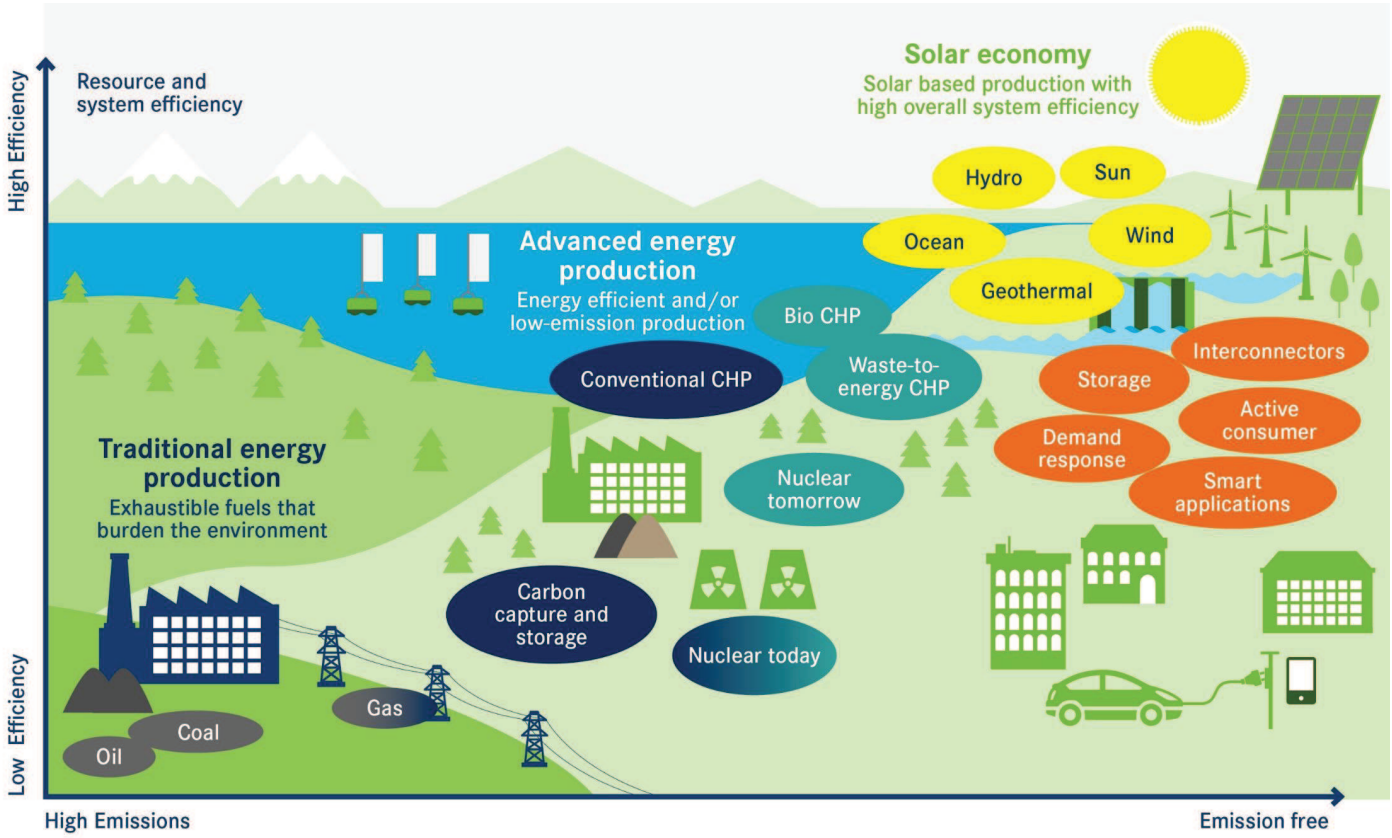
Transition towards Solar Economy is ongoing



Thank you!

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