ETN October Workshop 2024

GT Lifetime Assessment & Extension WG Meeting, Luc Gooren, Engie

Agenda of the Meeting

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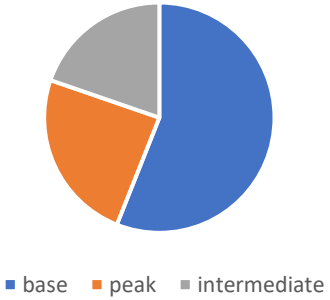
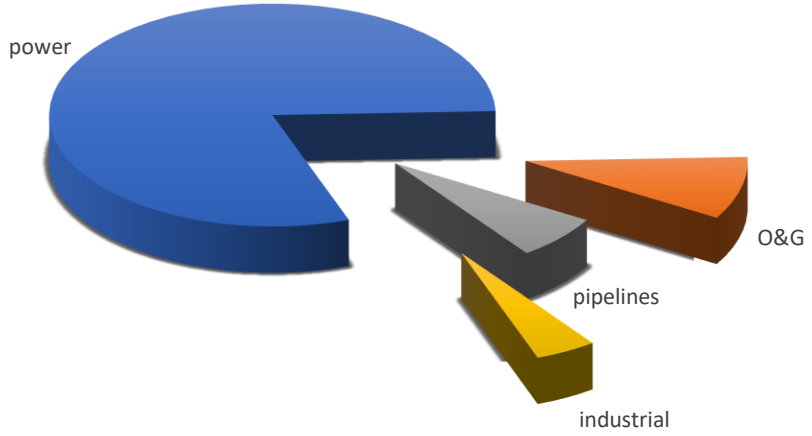
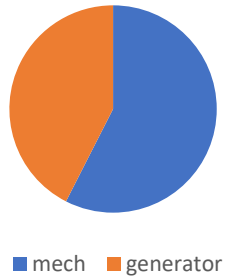
1. Results of 2024 & Learnings from Day 1
2. Activities for 2025 (What, How, Why)
3. Thematic Presentation – Ansaldo Energia
4. Q&A

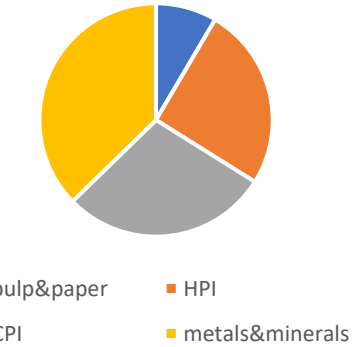
Results of 2024 & Learnings from Day 1

Market >2000 GW in operation

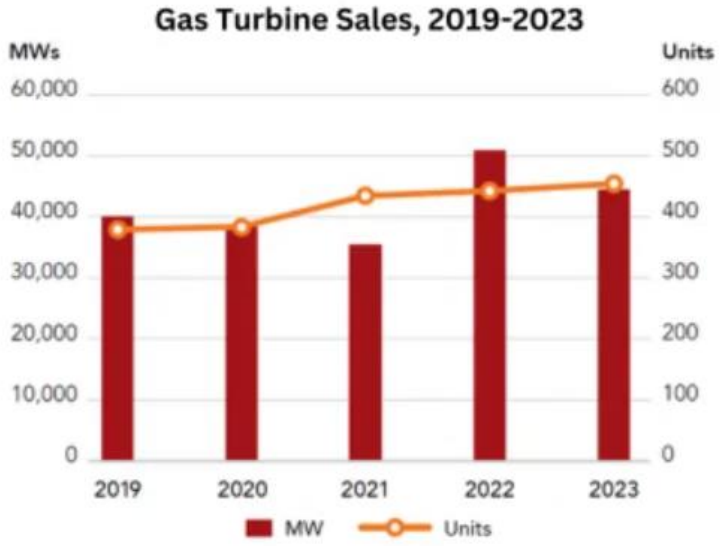


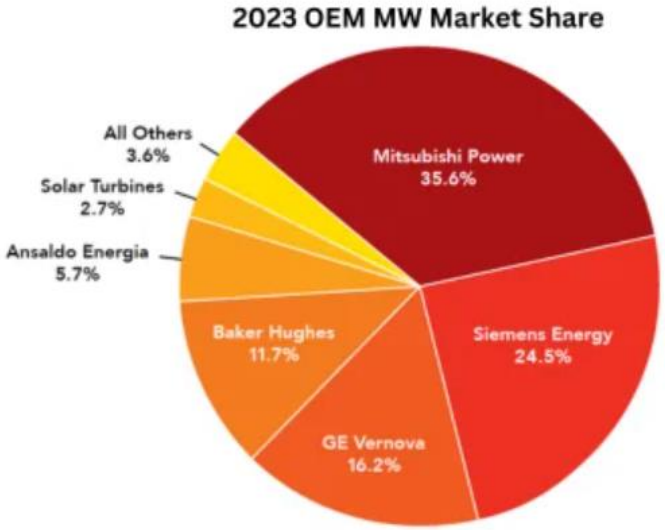






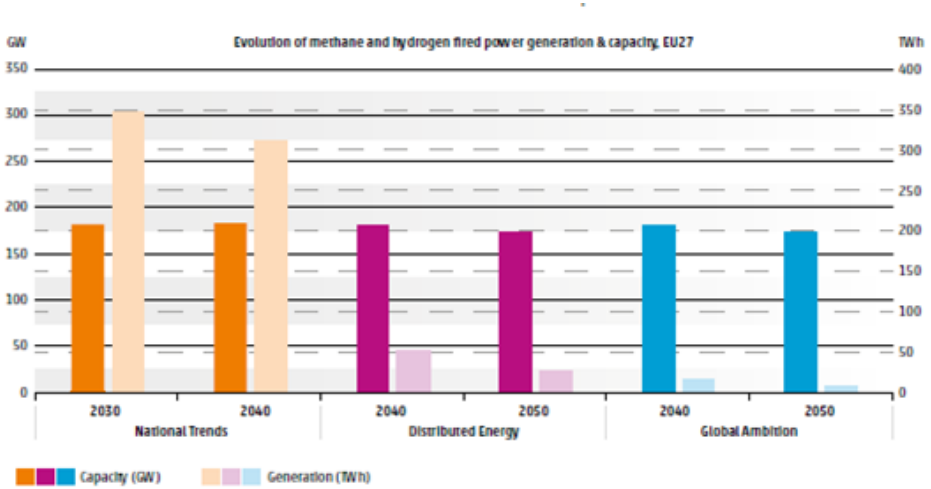
Market: new builds



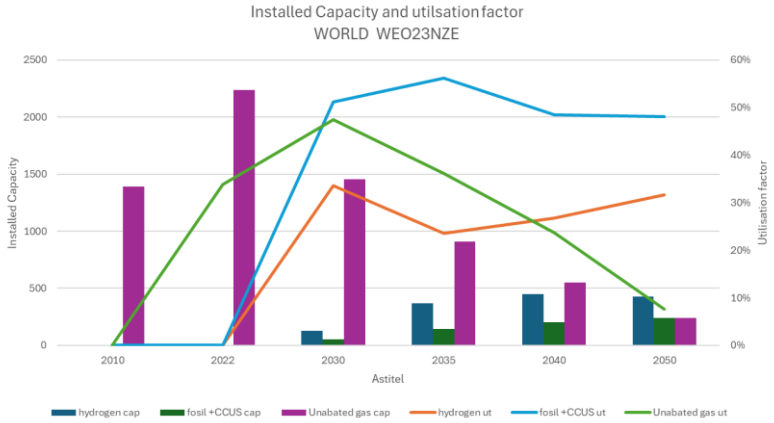


- Yearly addition of 40 GW/400 units is expected over the coming years
- GE, MHI and Siemens are leading (MW based)
- New build order books are full

Market : utilisation factor



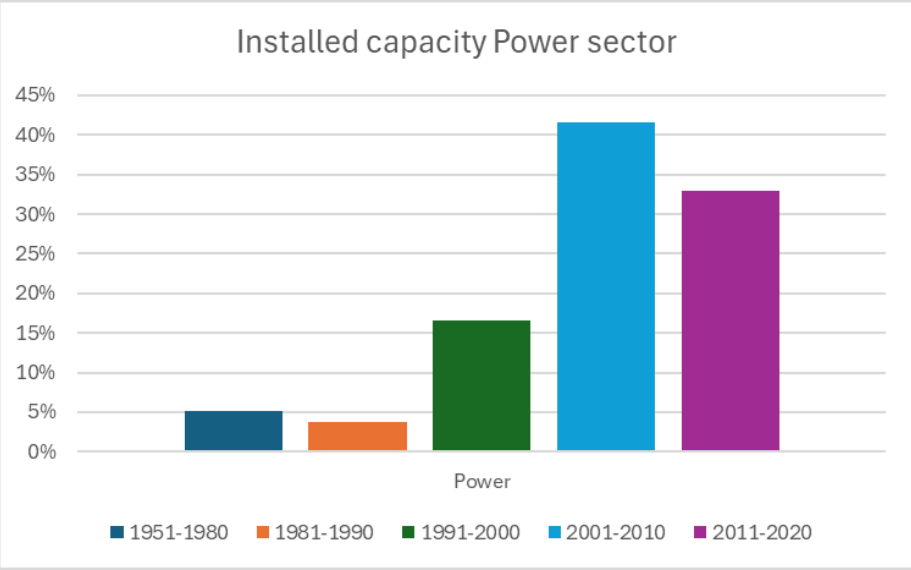
TYNDP 2024

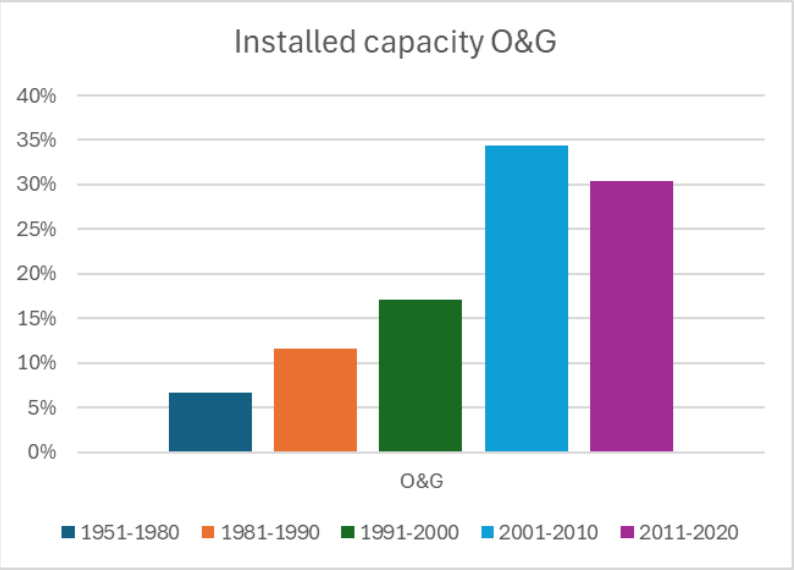


IEA 2023

- GT Capacity remains high (energy security)
- Utilisation factor is significantly reducing

Aging of the fleet





- A significant part of the fleet will reach end of life before 2035 (20 years criteria). This will be accelerated through cyclic operation.
- New build capacity OEMs is not sufficient to replace engines after 2035.
- There is a need for life extension to secure the energy system.

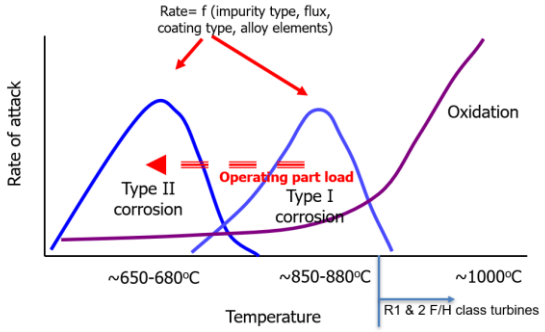
Results of 2024

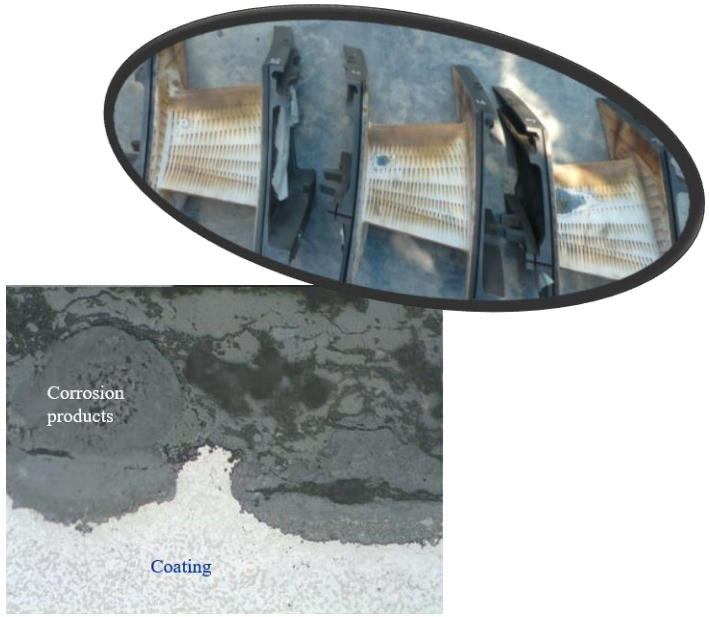
Summary

2024 Activity	Scope	Objectives	Timeline
Rotor life assessment and extension	Review of rotor lifing practices. Identification of gaps and recommendations.	Review report	Q2/2023 – Q1/2024
Hot section degradation and integrity	Understand the impact of turbine operation (cyclic regime) on the hot section part degradation and life extension	- To perform a review of the impact of GT operation on integrity of hot gas parts - Develop a guideline for the life extension of turbine blades with high cyclic loads	Chapters to be written end of Nov. 2024 Q2/2024 – Q1/2025

LTA hot section parts- A Reference Paper

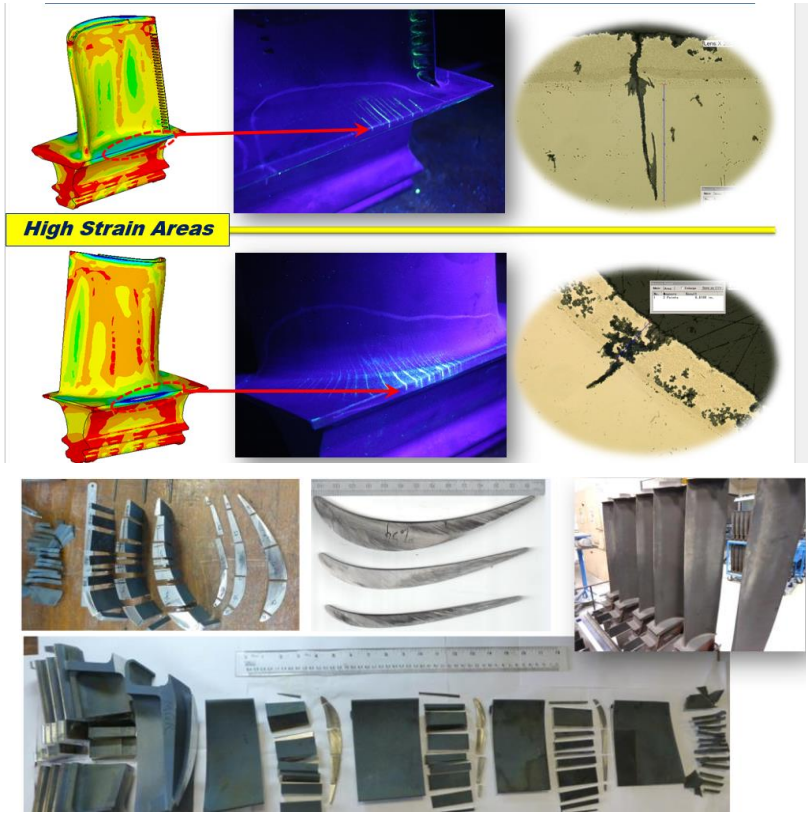
- **Chapter 1: introduction**
  - Background on the E, F, G, H class turbines (examples of the nominal TITs from main manufacturers)
  - Operational flexibility and life limiting factors
  - Marginality in design (increasing the TIT)
  - Future
- **Chapter 2: Life limiting damage mechanisms for F-H class gas turbines blades**
  - A review of various damage mechanisms such as creep, fatigue, hot corrosion etc (as of slides 2 and 3) affecting the turbine hot components, by considering:
    - Creep
    - Fatigue (HCF, LCF, TMF)
    - Creep/fatigue interaction
    - Oxidation, hot corrosion; Intake air and combustion fuel impact
    - Impact of the environmental attack on the mechanical property loss
    - Structural design; DS/SX alloy, poly crystalline parts
    - Coating damage
      - Metallic coating:
        - Internal Aluminised
        - External MCrAlY
      - TBC coating
        - Standard TBCs
        - Advanced TBCs
      - Abradable and other coatings
      - Future development

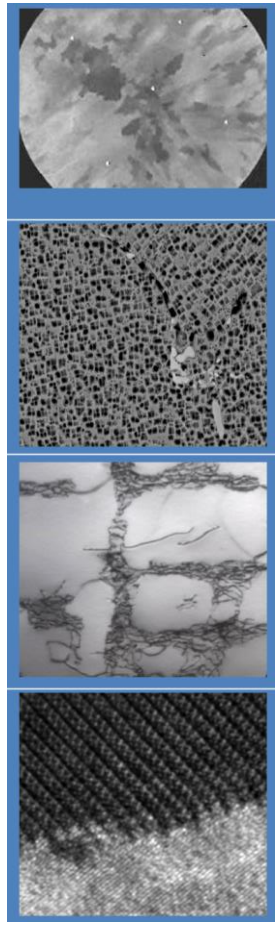




LTA hot section parts- A Reference Paper (cont.)

- **Chapter 3: Life time assessment techniques for F-H class gas turbines blades**
  - Appreciation of the design and operation of the advanced turbines
  - Numerical simulations: FEM+CFD
    - Thermal boundary assessment
      - Steady state
      - Transient operation
    - Stress analysis
    - Life analysis
    - Risk and uncertainty analysis (probabilistic analysis)
  - Non destructive or destructive assessments:
    - Non-destructive
    - Destructive testing (from ex-service components)
      - Sampling plan
      - Microscopic examination
        - Coating life evaluation
        - Microstructural evolutions (CC, DS, SX structures)
        - Kinetic of damage (estimating the metal temperature?)
        - Creep or fatigue testing?





LTA hot section parts- A Reference Paper (cont.)

- **Chapter 4: Life time extension techniques for F-H class gas turbines blades**
  - Component repair:
    - **Front engine parts:**
      - Advanced SX-blade repair, DS-blade repair, Parts with extended cooling (i.e. row 1 vanes)
    - **Last stage parts**
      - Blade and vanes, Issues, Can be assessed on site
  - Repair methods and integrity
    - Inspections
      - Conventional (UT, FPI etc), X-ray, Thermography, Other developments
    - Weld repair
      - TIG welding, Laser welding, Other methods
    - Brazing
      - Cleaning prior to the repair (FCC is the only answer?)
      - Narrow and wide gap brazing
    - Repair integrity
      - Risks and rewards (front engine parts, rear parts)
  - Coatings issues:
    - Internal coating, MCrAlY, TBCs
    - Coating development
  - Heat treatments and rejuvenation of the microstructures
    - Alloy and design type

LTA hot section parts- A Reference Paper (cont.)

- Chapter 5: In situ inspection techniques
  - Initial assessment from an in situ visual inspection (direct or by a borescope)
  - Further extended site based non-destructive assessments
  - Risks and rewards
- Chapter 6: Conclusions and recommendations

Learnings from Day 1

Key take-aways

- Sharing knowledge
- Users are somewhat reluctant to use third-parties
- “E-bay” for spare parts

Learnings from Day 1

Key take-aways

Challenge: (3) Are existing power plants capable to provide the flexibility needed to ensure grid resilience and supply security?

Challenge: (4) How can asset owners ensure long-term operational capacity for aging power plants when critical parts, spare parts availability, and legacy system support remain uncertain?

(3) Are existing power plants capable to provide the flexibility needed to ensure grid resilience and supply security?

3. How can ETN Global Network bring these solutions to life?

- Help promote awareness out with the ETN Community regarding capabilities within the turbomachinery industry. Key to get to policymakers.
- R&D activities on emission control on the combustion system at low loads and with alternative fuels.
- Investigate CCGT with flexibility with CCS.
- Forecast report on grid evolution over the next 30 years (scenario-based).

(4) How can asset owners ensure long-term operational capacity for aging power plants when critical parts, spare parts availability, and legacy system support are uncertain?

3. How can ETN Global Network bring these solutions to life?

- Facilitate set-up/validation of the **“e-Bay” of spare parts**
- **Information sharing**
  - Life-time extension
  - Non-OEM use-cases

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Activities for 2025

What, How, Why

Activities for 2025

Problem statement	Proposed activities
Rotor Lifing continuation • Material lifing and test program (IN706/IN718/ other…, 7/9F, LM2500, …) • Base load vs cyclic operation life	Industrial project Proceed to (A4 Objective paper)
Understanding of TMF life of advanced turbine blades (SX/DS): • Impact to part life and financials • Literature review with focus on metallurgical fundamentals • Possible rejuvenation process of operated parts • NDT inspection techniques	Report (which may generate interest to follow up with an industrial project) Proceed to (A4 Objective paper)
TBC life: • Life determining mechanisms literature review • Quality aspects (materials application technologies, chemistries, application quality assurance and control) • Damage tolerances: considerations • Inspection techniques	Report Proceed to (A4 Objective paper)
Interpretation of parts inspections: • Borescope and visual inspections • Dimensional measurements • Metallurgical inspections • NDT crack inspections (FPI and Red Dye, ultrasonics, eddy current, X-rays, others)	Seminars Proceed to (A4 Objective paper)
Hydrogen induced degradation • Stainless (fuel supply etc) • Degradation of hot section parts (combustion, blading, TBC coating etc)	Review, highlighting the gaps for further research To be talked with the H2 WG