

Digitalization of Nuclear Power Plants at EDF

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About EDF nuclear fleet in France



Largest fleet in Europe, homogeneous and concentrated

- 63 GW, 400 TWh, 59 units, 19 sites,
- 3 PWR series in operation; more than 1600 year of Operating Experience :
 - 900 MW : 34 units, 31 GW, aver. age 34 years
 - 1300 MW : 20 units, 26 GW, aver. age 24 years
 - 1500 MW (N4) : 4 units, 6 GW, aver. age 19 years.
 - 1700 MW (EPR) : 1 unit (2019)
- 9 reactors in decommissioning



Nuclear Challenges require innovation

- improving the performance of the fleet of 58 Units in France and 15 in UK .
- achieving a fleet major overhaul to extend life over 40 to 60 years
- connecting to the grid the EPR at Flamanville and proceeding with HPC in UK
- preparing the nuclear renewal with new design of reactors (EPR2, SMR, ...)



Nuclear of the Future Initiative

Driving innovation towards existing plants and new built

A research and innovation program launched by EDF, CEA and Framatome in partnership with academics and industries aimed at :

- improving nuclear competitiveness
- attracting new talented people
- providing a long term vision to the nuclear industry : SMEs, academics
- being modular and applicable to new designs of reactors or as well as to the fleet in operation
- integrating recent technological breakthroughs of industry
- connecting to major people and society stakes



framatome





Nuclear of the Future Initiative A set of technological bricks

- Safety
- Digital Transition and Data
 Analysis for Operation
- New Material and Fabrication Modes
- Scenarios for flexibility needs beyond 2030





Nuclear R&D Top priorities for EDF

- Safety
- Plant Performance
- Long Term Operation
- Fuel Cycle
- New Reactor Designs
- Environment





Key performance improvement enablers In Nuclear Power Plants

Outage management

- Use of virtual reality for outage preparation
- 3D visualization for Plant Maintenance and Upgrade
- IT Interfaces for collaboration in outage between Outage Control Center, work sites, mobile workers

Human performance in operation

- Plant field workers mobile technologies
- Computer based procedures, Electronic Work Packages, App store
- Computerized operator support systems
- Augmented reality to improve situation awareness
- Cybersecurity control
- Advanced Training (video, knowledge capture)

Advanced plant control automation & digital architecture

- Integrated simulation platform for I&C functional engineering specification & validation
- Fab lab for design and fast checking of future concept of operations

On-line equipment & process monitoring



Improving outage preparation Virtual reality helps outage preparation and pre-job briefing



Hi Res 360° photos + laser scans +



360° photos : automated localisation of areas and equipments



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Virtual visit for outage preparation Capability to read a component tag at a distance of 5 m





Outage preparation The power of Machine Learning/Deep Learning



Where is the component tag ?



Outage preparation The power of Machine Learning/Deep Learning





Plant Maintenance & Upgrade Virtual simulation for laydown/package movements

Planche illustrant une simulation : distance maximale séparant le pont DRM d'un container 20pieds devant passer au-dessus de la DAM sur le GV1 (GRA tranche impaire)



Cas 1 : dépose rambarde ou passage du container au près de la

Il y a 4,55m entre le haut du container et le bas de la poutre du pont (la longueur du crochet et des élingues étant inconnues)

Version du Planning OPX utilisé Domaine d'exploitation Tâche de référence N° planche et indice Simulation 1 Date d'édition de la planche 21 février 2007 - 17h

Cas 2 : dépose rambarde ou passage du container au haut de la DAM(au plus près de ces rambardes)

Il y a 3,55m entre le haut du container et le bas de la poutre du pont (la longueur du crochet et des élingues étant inconnues)

> Attention, l'environnement a été créé à partir des données CAO de conception de la DIN, données Compatibles CPI/CP2 BR tranche impaire des différences géométriques existent nécessairement.

Test new scenarios in preparation

EDF CNP

2) Ramt

Rédact

Vérifica

Approba

Detection of inconsistant outage planning

Working rules (flying over reactor vessel, forbidden zones)

Updating handling charts inside the reactor building

Estimated time savings: about 20 hrs on the critical path by securing preparation activities



DAM

Performance in Operation

Improving collaboration between outage control center and work sites





Plant field workers

Computer based procedures and remote access for safety tags-outs, clearance, valve line-up





Performance in operation

Advanced video processing for fuel reloading surveillance





Plant control automation & digital I&C Rapid prototyping for I&C modification and qualification



functional specifications of I&C



Facilitate & optimize I&C equipments, according to performance targets and safety requirements



Improve Plant Productivity

Human factor assessement of operation procedures & technology



EPR control room



Advanced on-line monitoring No big data without data



WHAT IS BIG DATA ? Example for production maintenance

- 3Vs of big data:
 - Volume: Large data size (TBs to PBs)
 - Velocity: Data flows and fast data processing
 - Variety: Diverse data (structured/unstructured)
- At EDF, Predictive maintenance requires access to diverse data
 - Condition monitoring system data for each plant:
 - · DCS analog and digital data, Operator rounds
 - · Vibration: RCP, Turbine, Generator (RMS, harmonics)
 - · Balance of plant (MW Performance), Chemical analyses
 - O&M reports:
 - Maintenance / Inspection / Lubrication / Alarms
 - · Expertise, Technical monitoring updates, Design Reports





Virtual Power Plant

Developing digital twins for operation and maintenance

 Component

Process/multi-Systems

Local/building

Condition Monitoring and diagnostics : process & components

Condition Monitoring and diagnostics : process & components

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Condition Monitoring and diagnostics : process & components

Presentation Takeaway

- NPPs digitalization well on track at EDF
- Proven feedback of digital innovation implementation
- Costs and data governance
- System Engineering increases safety and reduces delivery time
- Data analytics are promising
- No big data without data
- Don't forget to embark people

www.sfen-index2018.org

25-26 June: a 2-day conference in Paris (Plenaries, keynotes, case studies and tech-demonstrations)

* +27 June: a 1 day-visit on WNE 2018 (WNE free exhibition access, WNE onsite guided tours and networking activities organized jointly by WNE and INDEX)

