

EDF's Nuclear Fleet in France



- Largest nuclear fleet, homogeneous and standardized

58 reactors in operation

- 19 sites,
- single technology : PWR Power : 63 GWe
- 3 series in operation; mean age :
 - 900 MW : 34 units, i.e 31 GWe; 32 years
 - 1300 MW : 20 units, i.e 26 GWe; 22 years
 - 1500 MW (N4) : 4 units, i.e 6GWe; 16 years
- First EPR Flamanville 3 (2018)
- 9 reactors in decommissioning

- EDF owns and operates the nuclear facilities

- EDF is the architect/engineer/assembler

Nombre par type	Réacteurs à Eau Pressurisée					UNGG	EL	RNR
	300 M'06	900 M'06	1300 M'06	1450 M'06	1600 M'06			
Construction ou Projet					2			
Exploitation		34	20	4				
Déconstruction	1					6	1	1

EDF's Nuclear Fleet in UK

Operating Fleet

EDF Energy UK	<ul style="list-style-type: none"> • 1 PWR • 14 AGR • 8 sites 	<ul style="list-style-type: none"> • 8880 MWe
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New Build

- EPR UK (up to 4 units):
 - Decision made in 2016 for 2 units at Hinkley Point C
 - Decision under way for Sizewell C



Nombre par type	AGR	REP	EPR	Ingénierie
Exploitation	14	1		
Construction ou Projet			4	
Unités d'appui aux centrales				2



Flamanville 3 France
100% EDF



Taishan China
30% EDF

EDF
New Builds (EPR)
in progress



Hinkley Point C
United Kingdom
70% EDF



Foreword

EDF Group's objectives are to operate its NPPs under the **highest international standards and to strive to excellence**

Some of the **key fundamentals** implemented by EDF Group to operate its NPPs:

- **A demanding Nuclear Safety Policy**
- **An Independent Oversight**
- **An overall Safety Assessment Organization**
- **An experienced Design Authority**
- **A robust Emergency Preparedness**

Agenda

Some EDF Group's Nuclear Safety Fundamentals

- **A demanding Nuclear Safety Policy**
- An Independent Oversight
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EDF Group's Nuclear Safety Policy

We all, within EDF Group, share the same vision that

- **Nuclear Safety is the overriding priority** in the sustainable use of nuclear energy,
- Recognising that nuclear energy needs also to be
 - **efficient,**
 - **affordable**
 - **environmentally friendly**

→ It is an indispensable precondition when providing energy to humanity



EDF Group's Nuclear Safety Policy

Internal Commitments

An overriding priority is placed on nuclear safety at every stage of the plant lifecycle: design, construction, operation and decommissioning

Excellence in everything we do is underpinned by **equipment reliability, human performance and efficient organization**, as these are the main drivers of nuclear safety

Importance of establishing **a good nuclear safety culture** among staff and contractors

The concept of defense in depth, which concerns the protection of both the public and workers, is fundamental to the safety of EDF's NPP"

EDF Group maintains a **comprehensive emergency plan** at a high state of readiness,

Continuous improvement is promoted and organized.

Operational Experience is collected, analyzed, reported and acted on



EDF Group's Nuclear Safety Policy

External Commitments

International experience enriches continuous improvement and drives for excellence

EDF receives regular international peer reviews and provide suitable peers for such reviews in other companies

Openness and transparency are promoted anywhere

We strive for a constructive, open and trusting **relationship with our stakeholders**

EDF wants to be acknowledged as a Responsible Operator?

A Responsible **Industrial Firm**

- **Maintaining the highest levels of safety** in our installations
- Remaining the best major energy provider in the development of low carbon energy
- Investing in renewable and increasing their competitiveness
- Significantly contributing to the improvement of energy efficiency within households

A Responsible **Employer**

- Resolutely **reducing workplace accidents** among our employees and our contractors
- Preserving the professional excellence and performance of our employees through training
- Refusing to tolerate any violation of human rights, fraud and corruption in any of our companies or among our suppliers

A Responsible **Partner**

- Promoting **transparency and dialogue** on sensitive issues
- Contributing to the development of territories through employment
- Proactively fighting fuel poverty and promoting access to electricity
- Preserving water resources in all activities

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EDF's Independent Oversight Principles

- The existence of an **independent safety oversight function is required**
 - on every nuclear power plant,
 - as well as within the corporate nuclear generation division (DPN)
 - and within the EDF Group,
- Each level of the I.O. line (Independent Oversight Line) **challenges** the same level of the management line, combined with its ability
 - to review and provide critical analysis
 - to promote safety culture
- The independent oversight function is **separate from line management**
- The IO function oversees **performance and compliance with policies, procedures and standards.**
- EDF's CEO mandates a General Inspector (IGSNR) to confirm that
 - the EDF Group Nuclear Safety policy is implemented within the Group
 - skills & competences of the Independent Oversight Line are the right

ones



Independent Nuclear Safety Line (EDF France)

Management Line

Committees

Independent Oversight Line

Company level

CEO
Exécutives
& COMEX

NUCLEAR SAFETY
COUNCIL (CSN)

GENERAL INSPECTORATE
OF NUCLEAR SAFETY &
RADIOPROTECTION
(IGSNR)

Nuclear
Generation
Division
level

NUCLEAR GENERATION
DIVISION DIRECTOR

OPERATIONAL SAFETY
REVIEW COMMITTEE
(CSNE)

NUCLEAR INSPECTORATE

Station
level

NUCLEAR POWER PLANT
SITE DIRECTOR

SAFETY TECHNICAL
COMMITTEE
(GTS)

SENIOR ADVISOR,
SITE IO TEAM,
SAFETY & QUALITY

SHIFT MANAGER

DAILY CHALLENGE
(MEETING)

SAFETY ENGINEER

The Independent Oversight Function delivers a day to day contribution to Nuclear Safety

- Nuclear safety engineers of each nuclear facility perform:
 - **A daily assessment of the safety status** of each nuclear plant
 - **A daily challenge of the line management** analysis
- While maintaining the **whole responsibility of the management line** on nuclear safety, the independent oversight function contributes to the effectiveness of the line management
- It is a human and organizational way of the **“in depth defense”**
- The independent oversight function contributes **to consolidate the nuclear operational focus of the line management**
 - Self assessments of line management are promoted
 - This contributes to develop prevention, capacity of analysis and management of the risks by the line management
 - The capacity of the line management to take into account the recommendations and suggestions of the independent oversight function is closely monitored

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Overall Safety Assessment

Importance of the international cooperation

- EDF's Nuclear Fleet is periodically reviewed by **external organizations**: the **Regulator (ASN), WANO, IAEA**. This enable to :
 - ✓ Challenge the EDF's standards
 - ✓ Benchmark with WANO indicators & identify Areas For Improvement (AFI)
 - ✓ Challenge the scope of the verification line (Independent Oversight)
 - ✓ Challenge the adequacy of methods of the line verification
 - ✓ Share the international experience on common issues
 - ✓ Promote Significant Operating Experience Reports (SOER)
 - ✓ Welcome Technical Support Missions (TSM) of WANO

- EDF's Nuclear Inspectorate also benchmarks with INPO, WANO, REA, CGN...

Overall French NPPs evaluation program

- **EDF Nuclear Inspectorate** performs an Overall Excellence Assessment **every 4 years** for each NPP.
- **WANO** performs a Peer Review every **4 years** on each EDF NPP
- **WANO** performs a Corporate Peer Review every **6 years** on EDF
- On the request of the French Government **IAEA** performs each year an **OSART** at one of the 19 EDF's NPP

Osart inspection at the Chooz NPP in 2013.



Overall Safety Assessment

EDF OPERATOR

FRENCH SAFETY AUTHORITY

EDF - NUCLEAR
INSPECTORATE
**OVERALL
EXCELLENCE
ASSESSMENT**

EDF - GENERAL
INSPECTORATE FOR
NUCLEAR SAFETY
SURVEY VISIT

SAFETY AUTHORITY
INSPECTION

WANO

PEER REVIEW

NPP

A photograph of a nuclear power plant with several cooling towers emitting steam, set against a clear sky.

IAEA

OSART

Overall Assessment Long Term Schedule

Programme	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
BLAYAIS		EGS		ECE/PR		EGE/FU		PR		EGE/FU	
BUGEY		ECS	EGE		ECE/PR		EGE/FU	OSART	PR		
BELLEVILLE			EGE		ECE/PR		EGE/FU		PR		EGE/FU
CATTENOM		OSART		EGE		ECE/PR		EGE/FU		ECE/PR	
CHINON		ECSR	PR		EGE/FU		PR		EGE/FU		ECE/PR
CHOOZ	ECS	PR	EGE	OSART	ECE/PR		EGE/FU		PR		EGE/FU
CIVAUX	ECS	EGS/PR		ECE/PR		EGE/FU		PR			EGE/FU
CRUAS	EGS	ECS	PR		EGE/FU		PR		EGE/FU		ECE/PR
DAMPIERRE	EGS/PR			EGE/FU	ECE/PR	OSART		EGE/FU		ECE/PR	
FESSENHEIM	EGS		ECE/PR			EGE/FU		PR		EGE/FU	
FLAMANVILLE			EGE/PR	FU	OSART		EGE*/PR*			EGE/FU	
FLAMANVILLE 3								PSU PR	OSART		EGE/FU
GOLFECH	EGS/PR		ECS/FU	EGE		ECE/PR	OSART	EGE/FU		ECE/PR	
GRAVELINES	EGS/PR		OSART		EGE		PR		EGE/FU		ECE/PR
NOGENT	ECS		PR	EGE/FU		ECE/PR			EGE/FU		ECE/PR
PALUEL		EGS/JPR		ECE/PR			PR			ECE/PR	
PENLY	EGS		ECE/PR	EGE/FU		ECE/PR		EGE/FU			ECE/PR
St ALBAN	OSART	ECSR	PR		EGE/FU		ECE/PR			EGE/FU	
St LAURENT	ECS	EGE/PR		ECE	FU		PR	EGE/FU		ECE/PR	
TRICASTIN	ECS	EGS/PR			ECE/FU	EGE	PR		EGE/FU		ECE/PR

EGE=OEA (OVERALL EXCELLENCE ASSESSMENT)

EGS=OSA (OVERALL SAFETY ASSESSMENT)

PR=PEER REVIEW (WANO)

FU=FOLLOW UP PEER REVIEW (WANO)

ECE=FOLLOW UP OEA (NI EDF)

EVP=SPECIFIC ASSESSMENT



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An experienced Design Authority is set up 1/2

Maintaining the design integrity of nuclear installations throughout their operating life is of the utmost importance in order to achieve a continuous high level of safety

Consistency needs to be maintained among

- ✓ the physical plant configuration,
- ✓ the design
- ✓ the documentation and drawings
- ✓ the licensing requirements

Design changes must be made with a full understanding of all the design information for the plant and the specifications for each system and component

An experienced Design Authority is set up 2/2

Failure to ensure full knowledge of how plant design is maintained and to manage design changes adequately will, over the lifetime of the plant, result in

- ✓ the lost of the plant configuration control
- ✓ the inconsistency in operating procedures
- ✓ the inadequate specifications for spares parts
- ✓ the difficulties to justify life duration extension

As an operating company, EDF has the overall responsibility for the safe operation and maintenance of the design integrity of a plant.

→ The Design Authority is a key functional department of EDF's nuclear fleet

Agenda

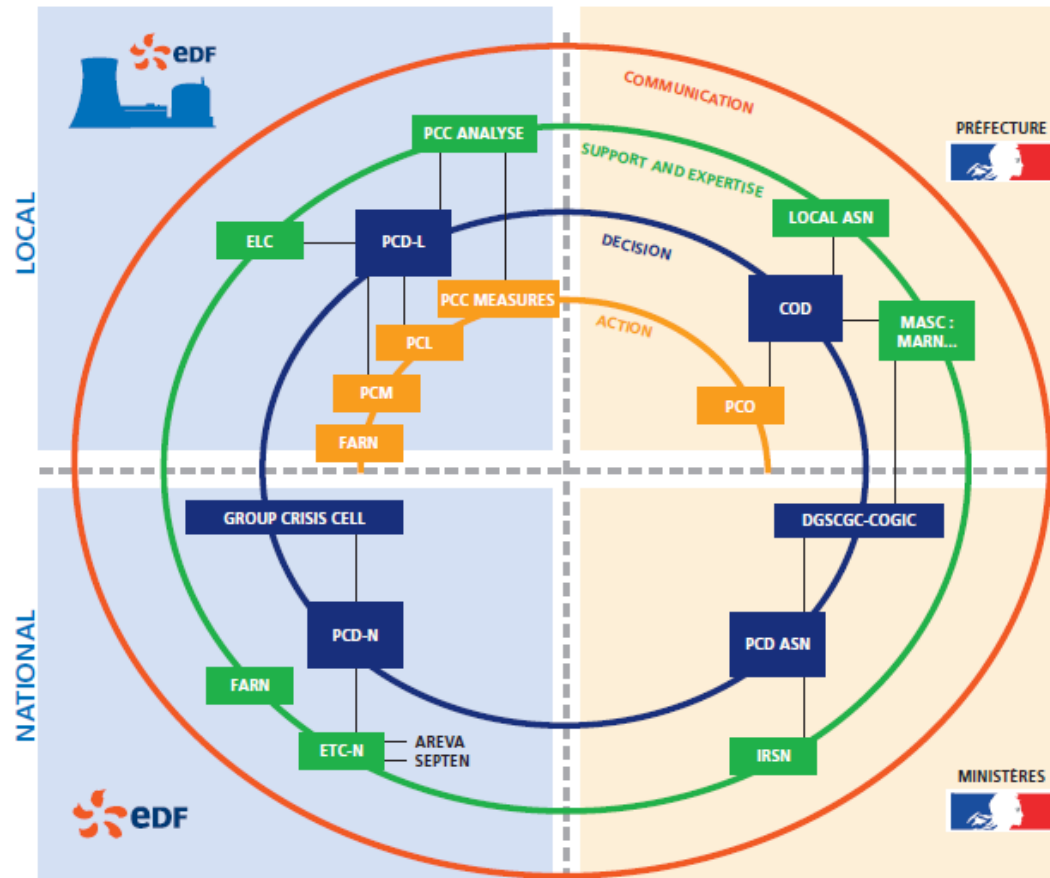
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A robust and periodically tested Emergency preparedness 1/2

- EDF has set up the **emergency response organization**, which fits in with that of the public authorities, around thirty years ago.
- **Designed to be robust and adaptable to any event, even unpredictable situations**, it defines the measures required
 - to manage accidents and their consequences
 - to protect site personnel, the local population and the environment.
- In operational terms, the emergency response organization is based on
 - the setting up of **coordinated emergency plans involving the operator and the public authorities**
 - the carrying out of **regular emergency drills** with local and national authorities

A robust and periodically tested Emergency preparedness 2/2



The following diagram represents the relations between the public authorities, the government, and the Nuclear Safety Authority, the operators and the technical supports



An emergency preparedness enhanced after Fukushima

1/4

Taking into account Fukushima event, EDF has set up a National Nuclear Rapid Response Taskforce (**FARN**)

The nuclear rapid response taskforce (FARN) can deploy human and equipment resources on a site in the event of a severe accident, **for support of the site shift crews and handover in less than 24 hours.**

The taskforce takes action **to restore water, power and compressed air** so as to limit worsening of the situation and prevent core meltdown.



An emergency preparedness enhanced after Fukushima 2/4

Scope of response of the nuclear rapid response taskforce **covers highly improbable situations** going far beyond the hypotheses previously considered:

- The nuclear power plant **is entirely affected** (all the site reactors are affected by total loss of power and heat sink);
- Extensive destruction of the surrounding infrastructures including **site access**
- **Impossibility** for the site teams on call **to go to the site** (their dwelling place and access have been destroyed);
- **Accumulated radiological and chemical risks** incurred by the surrounding industrial facilities.



An emergency preparedness enhanced after Fukushima

3/4

FARN CONVOY PLAN DEPARTING FROM EVERY REGIONAL BASE

DETACHMENT 1



Advanced guard 4 x 4 pick-up with telecom trailer



Pilot 4 x 4 pick-up with FARN barge



Semi-trailer for heavy equipment transport



Flatbed lorry with crane



Flatbed lorry



Flatbed lorry

- WATER: pumps and pipes
- AIR: compressors
- ELECTRICITY: equipment
- Living base equipment
- Team member kitbags
- Other

DETACHMENT 2



Advanced guard 4 x 4 pick-up



Pilot 4 x 4 pick-up with tank trailer



Semi-trailer for heavy equipment transport



Flatbed lorry with crane

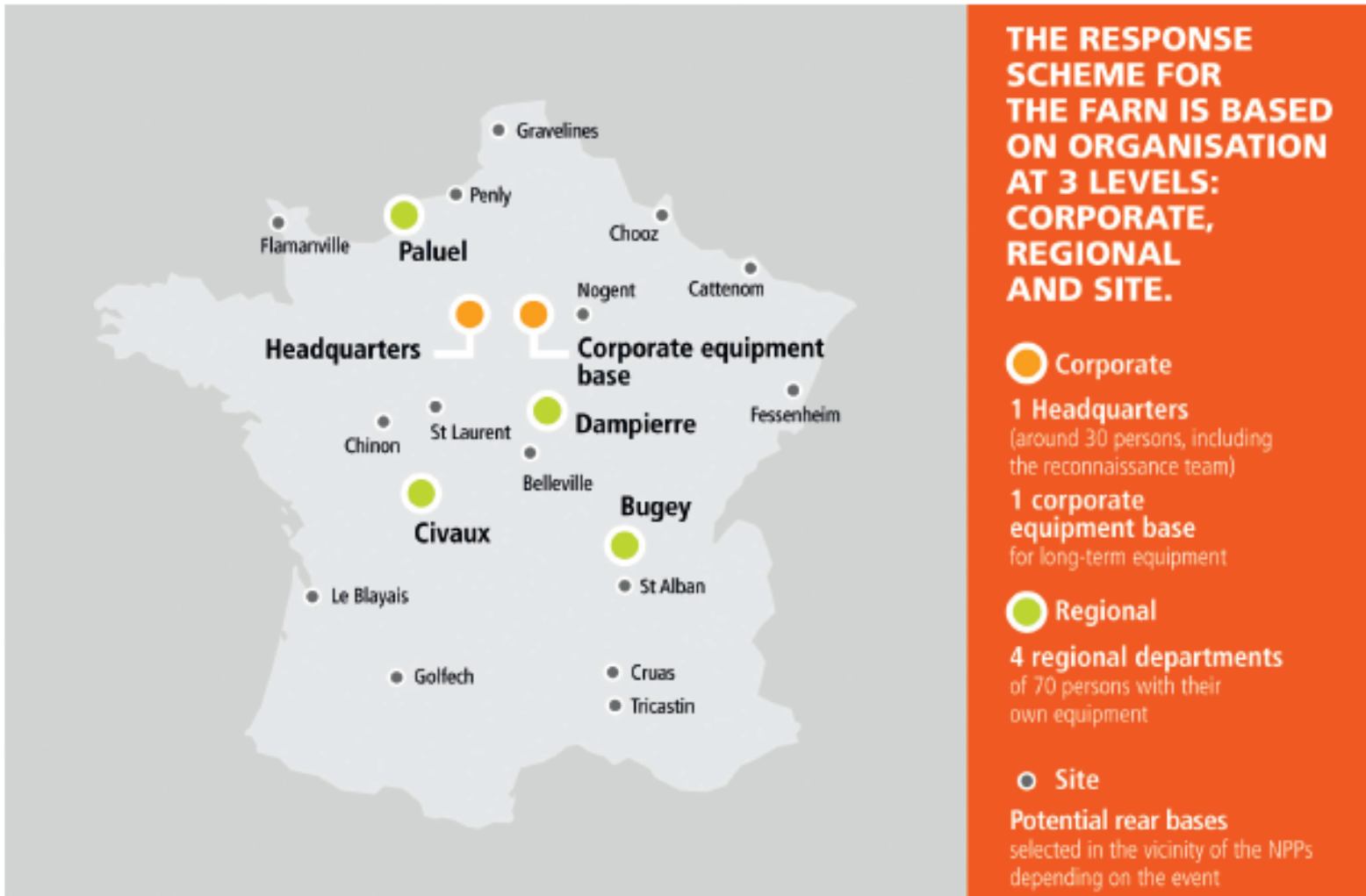


Flatbed lorry

52 VEHICLES
 COMPOSED OF 28 HEAVY GOODS VEHICLES,
 16 4X4 PICK-UPS,
 4 BARGES AND 4 FORKLIFT TRUCKS

An emergency preparedness enhanced after Fukushima

4/4





EDF and Rosenergoatom Cooperation

EDF and Rosenergoatom Cooperation

- Set up en **1994**
- To share experience in a **large scope:**
 - Operation & Maintenance
 - Engineering Support
 - R&D
 - New Projects (ie Fast Reactors BN)
 - Waste Management and Decommissioning
 - Overall Nuclear Safety Assessment
 - Supply Chain
 - Human Resources
- Through the **framework** of
 - an agreement periodically reviewed & renewed
 - on both company a senior executive responsible person
 - each domain is led by 2 peers (Russia / French)

Each year a cooperation program is validated
by the top management

This program includes:

- Seminars (Nuclear Safety Culture, HR, Equipment Reliability,...)
- Operating Experience Exchanges
- Knowledge Exchanges (Ageing, New Gen, ...)
- Exchanges about the development and efficiency of new Engineering and Methodology Tools
- Visits of NPPs

Conclusion

This long term cooperation demonstrates :

- The willingness of the 2 biggest nuclear operators in the world (EDF & REA) to learn from each other :
 - To continuously improve the NS and the performance of their nuclear fleet
 - To make nuclear energy efficient, affordable & environmentally friendly
- That both company promote Nuclear Energy as a solution to the Energy Transition

Thanks to this LT cooperation EDF & REA were together able to deliver support to a common partner for its life extension (Kozloduy NPP)



Digitalization to support performance

About Digitalization in EDF nuclear business



Mobility

Structured Documents



Data Analysis



*Connected
Objects*



Scan 3D



*Augmented
Reality*

Why the Digital Futures?

- Digital is a critical enabler to maintain or increase performance
- Some of our employees expects it. There is demand for better connection.
- There is an opportunity to accelerate knowledge capture and transfer.
- Digital is key for communication with stakeholders. We must be part of it.

However

- It must be affordable and create business value
- Pace of change shall be ambitious, but acceptable to people.
- Mobility and more connectivity shall not compromise Information Security.
- Investment in technology will be necessary, but within budget constrains.

Where the Digital Futures?

Everywhere, in every business sector, in every kind of structure, **digital radically**

- changes our working modes,
- makes our business models evolve,
- sometimes threatening long established positions,
- and brings meaningful changes in the industrial processes themselves.

Main uses of digitalization in EDF nuclear

- To simplify activities performed in the field
- To secure sensitive activities
- To develop processes efficiency
- To improve equipments and systems performance

Which technologies are rolled out?

On our NPPs, the potential fields for digital development are that of

- virtual and augmented reality
- massive data process (big data ...) for O/M,
- mobility (use of connected tabs instead of paper files),
- softwares (apps, collaborative spaces for engineering teams, PLM, ...),
- standardization and industrialization of the data processing and storage
- creating economy of scale (cloud ...)
- connected objects
- digital models / digital twin reactor, ...

Digitalization: Opportunity or Risk?

Digitalization can be seen as **an opportunities**

- to rethink our processes that have become obsolete and cumbersome for more direct , more flexible and more simple working modes.
- to experiment, to innovate and to encourage initiatives at all levels.
- to rethink the way we organize ourselves and the way we work, especially with the external.
- to make our nuclear business more attractive for younger generations

However digitalization requests **to keep under control new risks** that could be unacceptable for nuclear business

- adaptation of our actions regarding cyber security
- new skills need to be developed
- transition period to secure, change management (INSAG 18)

Conclusion

EDF's Digitalization Approach

Digitalization is recognized as an opportunity

- to improve the nuclear safety level of our NPPs
- to improve the performance of our NPPs
- to support nuclear sustainability
- to make nuclear more attractive for young generations

However to mitigate the risks that digitalization could introduce, the rolling out of these new technologies needs

- a progressive, cautious and safe approach
- a robust cyber security prevention program
- to make a demonstration through a POC (Proof of Concept)
- to test and experiment before rolling out

→ And a robust change management needs to be implemented

« Grand Carenage » Program
to support
Life Extension

3 MAIN OBJECTIVES OF THE « GRAND CARÉNAGE » PROGRAM

A major Renovation Program

1



Enable the operation
of the French Nuclear
Fleet beyond 40 years

2



Support a yearly
420TWh safe
generation

3



Secure and
optimize the
financial path of
investments

TEN-YEARLY OUTAGE

1

Full plant inspection

- Full post-maintenance testing of main reactor coolant system
 - RCS hydrotest
 - Non destructive examination of equipment (in-service inspection machine in reactor vessel)
- Re-testing of containment vessel

Plant compliant

2

Periodic safety review

Compliance review

- Compliance Review
- Additional Investigation Programme
- Aging control
- Continued post-maintenance testing

Safety Assessment

- Analysis of Operating Experience
- Update of safety assessments
- Inclusion of new techniques

Modifications programme

Grand Carénage Big Picture

- 10 years program from 2014 to 2025
- 3 different categories of activities
 - **Exceptional maintenance** activities
 - Steam Generators Replacements, Main Transformers Replacements, Condensers Replacements
 - Punctual Maintenance Activities (Hydraulic of Primary Pumps Renewal, ...)
 - **Modifications**
 - Fire Risk Prevention and Mitigation Upgrading
 - Regulatory Environment changes
 - Post Fukushima measures
 - Measures **to maintain the nuclear qualification** of the equipments after 40 years of operation
 - R&D programs, Tests programs,
- During these 10 years CAPEX are 30% higher

Cooperation reinforcement

- **Between Operator and Engineering**
 - To facilitate the integration of the modifications with a minimum of impact on generation implementation
- **Between EDF and its Industrial Partners**
 - Industrial Partners are involved during the conception and preparation phases
 - Industrial Partners and EDF teams work on the same “plateau”
 - Schedule is built taking into account Industrial Partners capabilities

EDF Group's Nuclear Safety Policy

1. Each EDF Group company operating in nuclear facilities acts in accordance to and in compliance with all **local statutory and regulatory requirements** specific to its country of operation.
2. While respecting national differences, EDF Group develops common guidelines intended to secure **the highest level of incident prevention and protection of workers, populations and the environment.**
3. Each company is **responsible for the proper operation** of its nuclear activities. Appropriate delegations of power are defined by each company at every level of decision and action.
4. **An independent in-house oversight entity** is established for each site and each company and at Group level.

Defense in Depth Concept is implemented

“The concept of defense in depth, which concerns the protection of both the public and workers, is fundamental to the safety of EDF’s NPP”

- We recognize the risk of **technical, human and organizational** failures
- We set up successive lines of defense for each failure considered
- These lines of defense are for each category
 - **Prevention** to avoid failures
 - **Monitoring** to anticipate failures (checks and tests)
 - **Action to mitigate** the consequences of failures

About the Nuclear Safety Governance

At EDF, the overall compliance with regulations and with the Group safety policy is assessed at each level of the organization (company, nuclear corporate, NPP).

At Group level, the **Nuclear Safety Council**, is composed of all corporate executives of the parent company and reports directly to the EDF Group CEO.

At Nuclear Division level, the **Operational Nuclear Safety Committee** (CSNE) reports to the directors of the Nuclear Generation Division (DPN).

At Power Plant level, a **Safety Technical Committee** (GTS) reports to the plant director (Site VP).

An **independent control line** of safety engineers and experts continuously assess the safety of facilities and organization, challenge the management line and reports to this GTS committee