



ELECTRICAL PART OF EPR

*DESIGN, APPLIED STANDARDS AND POSSIBILITY OF
COOPERATION WITH POLISH INDUSTRY SUPPLIERS*

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Conference: Electrical part of a nuclear power plant in the light of international requirements – guidelines for Polish industry

AGENDA

- **About EDF**
- **The EPR Technology**
- **EPR electrical design and applicable standards**
- **EPR scope of supply and opportunities for Polish suppliers.**

EDF GROUP

KEY FIGURES OVERVIEW

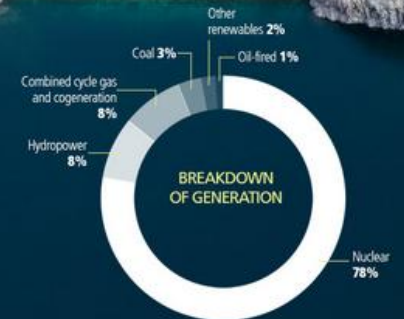
Efficient & responsible
electricity company, champion
of the low-carbon growth

71.2
billion euros
in annual revenue

154,845
employees worldwide

37.1
million clients
worldwide

584.7 TWh
EDF Group's
electricity generation



662
million euros
in R&D budget

88%
of electricity **CO₂ free** *

* Direct emissions, including the life cycle analysis of generating plant and fuel.

**EDF produces around 22% of the European Union's electricity,
primarily from nuclear power**

EDF, THE VENDOR OF THE FRENCH NUCLEAR TECHNOLOGY

6 EPR REACTORS UNDER CONSTRUCTION



Flamanville 3



Olkiluoto 3



Taishan 1&2



Hinkley Point 1&2



in
construction

THE EPR REACTOR

1,650 MWe PWR



- Generation III+ PWR
- High power output (1,650 MWe)
- Evolutionary design (Konvoi / N4)
- Low global power generation costs
 - Fuel consumption reduced by up to 15%
 - 60 years of operation
 - Improved flexibility to reduce OPEX
- Maximized benefit from size effect
- Minimal environmental impact
- MOX Fuel capability
- Reactor being designed in collaboration with utilities and safety authorities
- EUR criteria compliant
- An outstanding safety level...

... ACHIEVED TODAY THROUGH THE EPR REACTOR

Reduce the probability of a severe accident with core meltdown

Physical separation, diversity, and redundancy of critical components



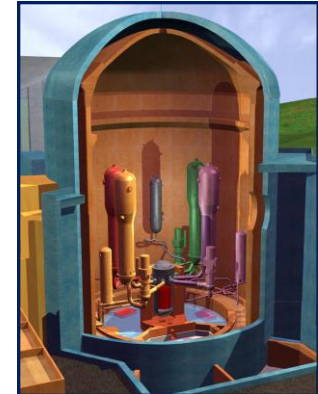
Protect population and environment in case of severe accident

Confined corium and radioactive products in the reactor ("core catcher")

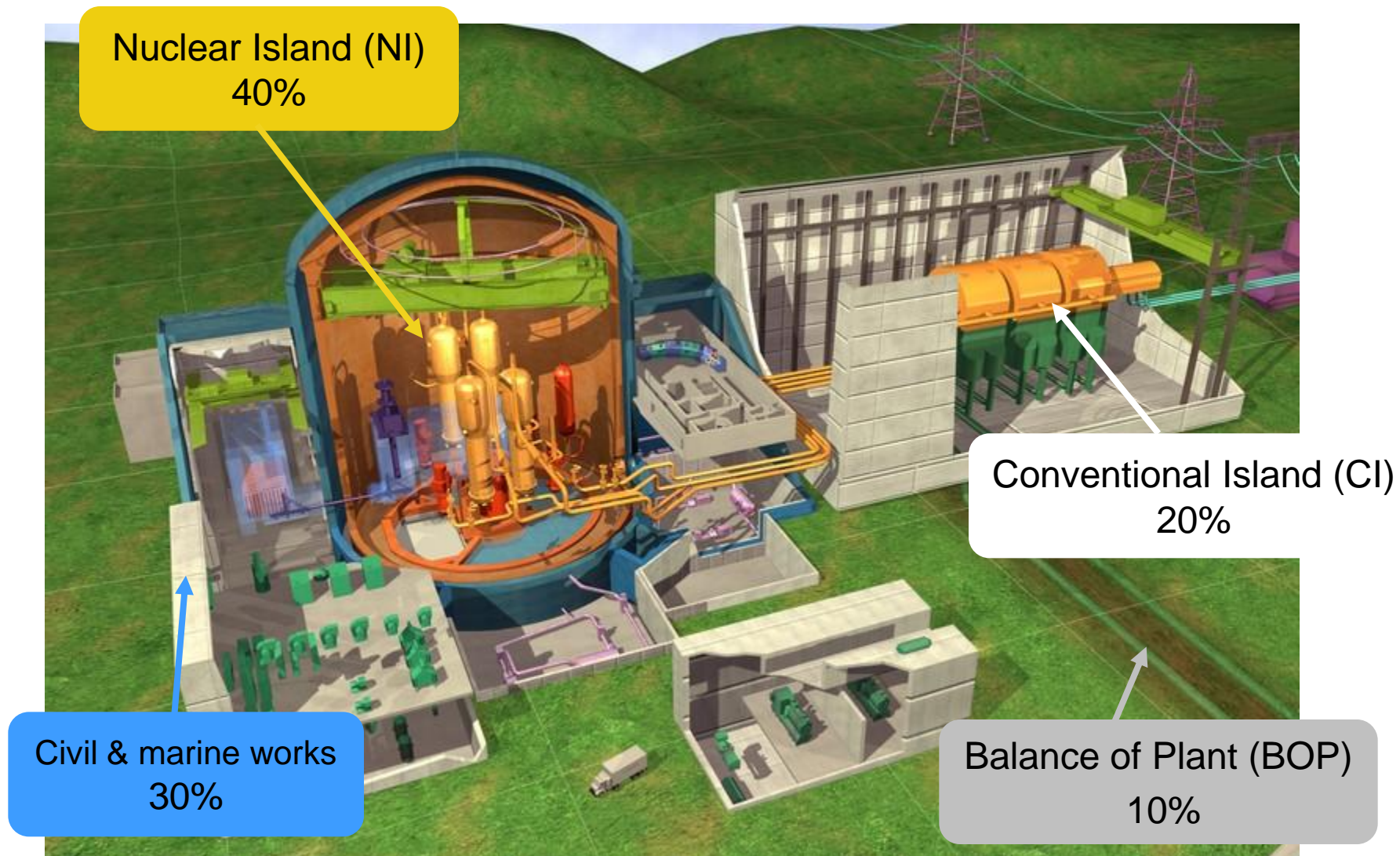


Protect against malevolent act (e.g. airplane crash)

High structural resistance



EPR REACTOR – MAIN BUILDINGS



EPR REACTOR - ELECTRICAL SYSTEMS - SLD

Main Supply / Power Evacuation

Auxiliary
Supply

NPP
Auxiliary
Systems

Conventional
Island (CI)

Nuclear
Island (NI)

Main EDG
(DBC)

SBO EDG
(DEC)

Main
control
sources
(DBC)

Severe
Accident
control
sources
(DEC)

TRAIN 1

TRAIN 2

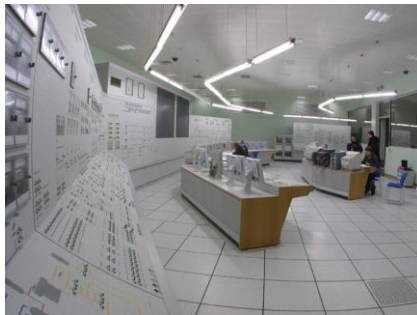
TRAIN 3

TRAIN 4

EPR REACTOR – ELECTRICAL SYSTEMS

Instrumentation & Control system

- Operational I&C
- Nuclear Safety I&C
- Control rooms operator equipment
-



Instrumentation equipment

- Sensors
- Transmitters
- Manometer
- Thermometer
- Limit switches
- ...



Distribution equipment & systems

- Switchboards
- Switch gears
- Transformers
- Cables
- Batteries
- Rectifiers (chargers)
- Inverters
- Converters
- Emergency diesel generators ...



EPR REACTOR - ELECTRICAL EQUIPMENT- SWITCHBOARDS

Main characteristics

■ HV SWITCHBOARDS

- ✓ **Rated voltage:** 10 kV
- ✓ **Rated current in continuous service (I_r):** 1250 A or 3150 A
- ✓ **Rated short-time withstand current (I_k):** 50 kA
- ✓ **Peak value of the rated withstand current (I_p):** 125 kA
- ✓ **Earthing arrangements:** IT
- ✓ **IAC (internal arc class) classification:** Type A ; F/L
- ✓ **Technology:** vacuum



*HV switchboard with deflector
(internal arc)*

■ LV SWITCHBOARDS

- ✓ **Rated voltage:** 400V or 690V
 - Rated current in continuous service (I_r): 800 A or 3500A
 - Rated short-time withstand current (I_{cw}): 65 kA
 - Peak value of the rated withstand current (I_{pk}): 80kA to 160kA
- ✓ **Earthing arrangements:** TN-S



HV cell



LV cell | 10

EPR REACTOR - ELECTRICAL EQUIPMENT- TRANSFORMERS

Main characteristics

■ HV/LV TRANSFORMERS

- ✓ Rated power : 1600kVA to 5000kVA
- ✓ Rated voltage: 10kV /720V or 10kV/420V
- ✓ Connection symbol: Dyn11
- ✓ Short-circuit impedance: 10%(+/-10%)
- ✓ Type of tap changer : off-circuit
- ✓ Technology: Dry type



HV/LV transformers



HV/LV transformers

■ LV/LV REGULATED TRANSFORMERS

- ✓ Rated power: 500 kVA
- ✓ Rated voltage: 400V /400V-230V
- ✓ Accuracy : +/- 1%
- ✓ Technology: Dry type



LV/LV regulated transformers



Regulator

EPR REACTOR - ELECTRICAL EQUIPMENT- CABLES

Main characteristics

■ HV CABLES

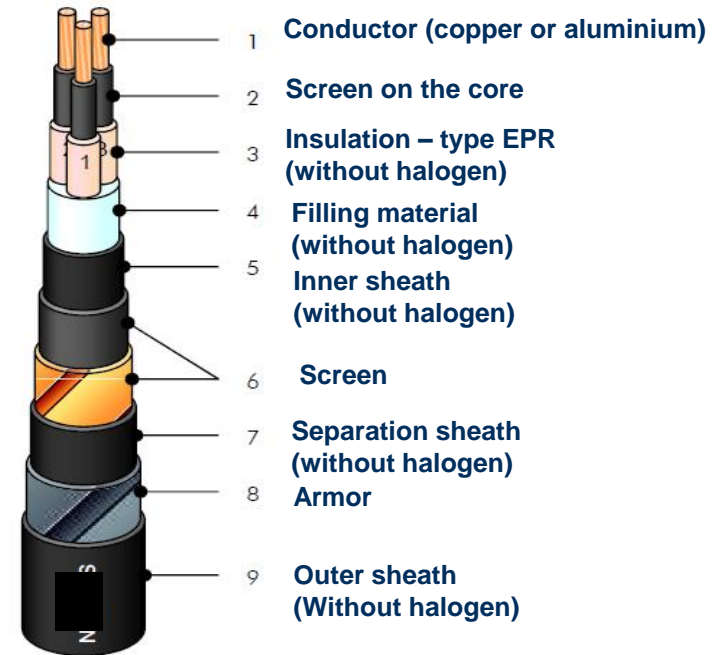
- ✓ **Rated voltage:** 10kV
- ✓ **Characteristics of the materials used for insulating coatings, sheaths, fillers and tapes**

■ LV CABLES

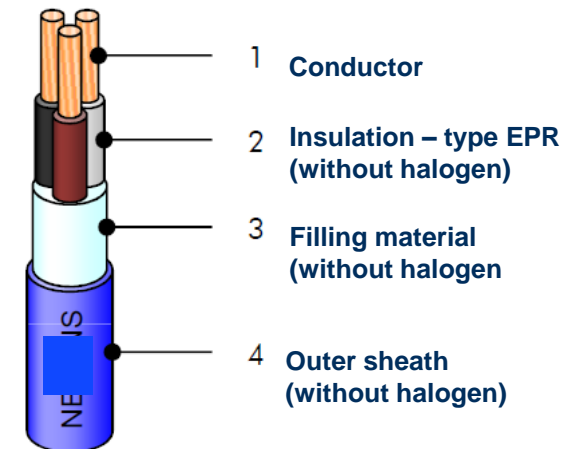
- ✓ **Rated voltage:** 690 V or 400 V
- ✓ **Characteristics of the materials used for insulating coatings, sheaths, fillers and tapes**

■ For both :

- ✓ **Fire behavior:** the cables shall not propagate fire, according to the provisions of IEC 60332-3-23
- ✓ **Fire reaction:** the use of halogen-free cables is recommended. The density and corrosiveness of the smoke produced in the event of a fire shall comply with IEC 61034-2 (opacity), IEC 60754-1 and IEC 60754-2.



HV cable



LV cable

APPLICABLE CODES & STANDARDS FOR ELECTRICAL EQUIPMENT

Safety class	RCC-E	Qualification under ambient conditions	Periodic tests	Quality management	Seismic qualification
C1	yes	yes	yes	yes	yes
C2	yes	yes	yes	yes	yes
C3	yes	yes	yes	yes	Case by case
NON SAFETY (but important for availability)	Harmonized Standards: EN - National Industrial Standards				
NON SAFETY (and not important for availability)	ISO 9001 or equivalent				

RCC-E complies with IAEA Safety guides and with International nuclear & industrial standards (IEC, ISO, IEEE)

RCC- E

DECEMBER 2016 EDITION

DESIGN AND CONSTRUCTION RULES FOR ELECTRICAL AND I&C SYSTEMS AND EQUIPMENT FOR NUCLEAR POWER PLANTS

- **Volume I** : General and quality management
- **Volume II** : Specification of needs
- **Volume III** : Automation and control systems
- **Volume IV** : Electrical system
- **Volume V** : Electrical Engineering
- **Volume VI** : Layout of electrical and instrumentation and control systems
- **Volume VII** : Inspection and test methods



Règles de Conception et de Construction des systèmes
et matériels Électriques et de contrôle commande

afcen

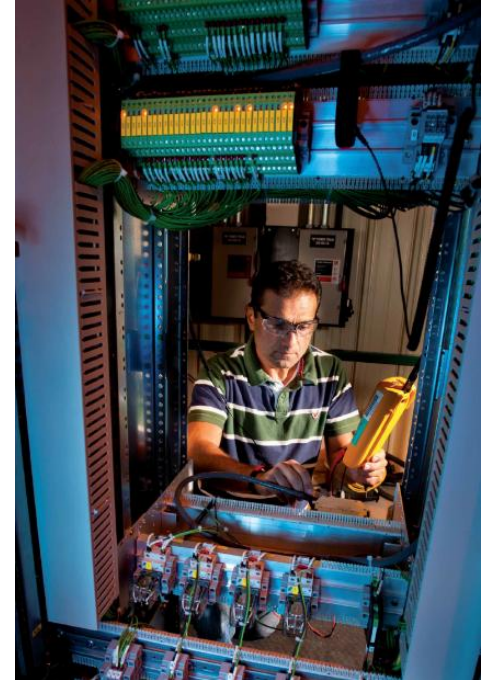
QUALIFICATION OF ELECTRICAL EQUIPMENT

Equipment qualification methods:

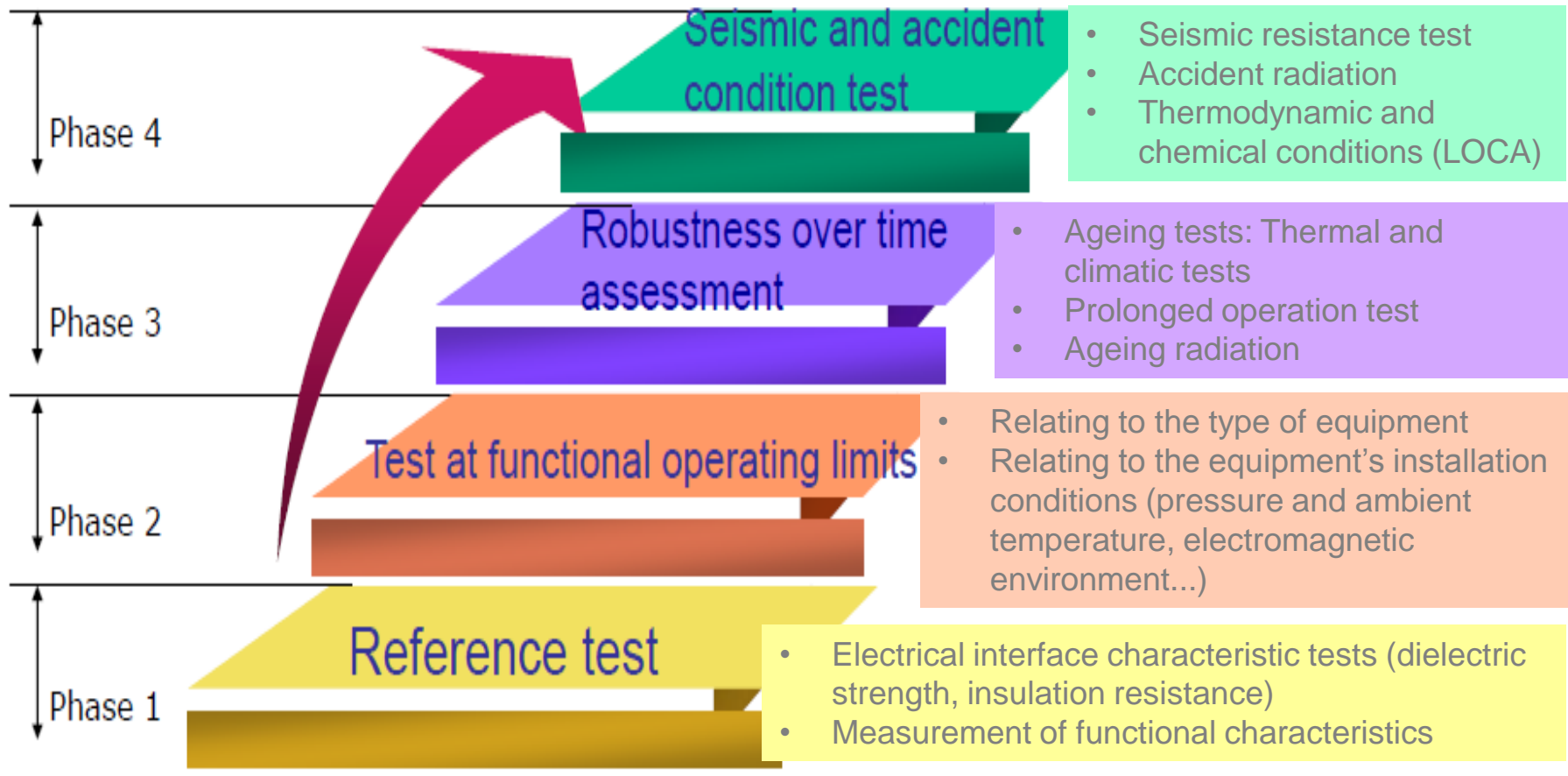
- **TESTING:** For the « First Of A Kind »
- **ANALYSIS:**
 - ✓ by analogy
 - ✓ by design (computation)
 - ✓ from operating experience (under conditions)
- **COMBINED METHODS**

Software qualifications:

Qualification of computer-based systems or digital devices shall be also compliance with the IEC appropriate standards depending on the Safety class (e.g. : IEC 60880, IEC 62138, IEC 62566, IEC 62671, IEC 60987...)



ELECTRICAL EQUIPMENT QUALIFICATION TEST SEQUENCE ACCORDING TO RCC-E (IEC/IEEE 60780-323)



A WIDE SCOPE OF OPPORTUNITIES ... EQUIPMENT

NUCLEAR ISLAND

- Over thousand km of cables
- Almost a hundred LV/HV switchboards
- More than 20 HV/LV & LV/LV transformers
- Almost a hundred km of cable trays
- 6 Emergency Diesels



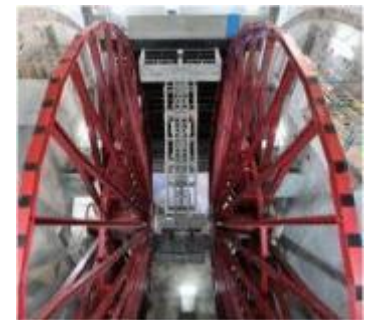
CONVENTIONAL ISLAND

- About 200 km of cables
- Over 6000 sensors
- Almost 50 LV/HV switchboards
- More than 20 HV/LV & LV/LV transformers



BALANCE OF PLANT

- About 13km of cables
- A thousands sensors
- Hundreds km of cables for marine works and galleries



A WIDE SCOPE OF OPPORTUNITIES ...

SCOPE OF SUPPLY

NUCLEAR ISLAND



- Project Management
- Engineering
- Equipments supply
- Installation
- Civil works
- Commissioning



CONVENTIONAL ISLAND



BALANCE OF PLANT



- Site preparation & infrastructure
(Clearance / leveling & roads, drainage, water...)
- Site camp
- Marine works / Cooling Towers
- Buildings

POLISH SUPPLIERS HAVE WORKED FOR THE EPR TECHNOLOGY

- 25 Polish suppliers have worked on the EPRs under construction.
- Huge involvement of Polish personnel in Olkiluoto 3 and Flamanville 3 projects.

ELEKTROBUDOWA SA:

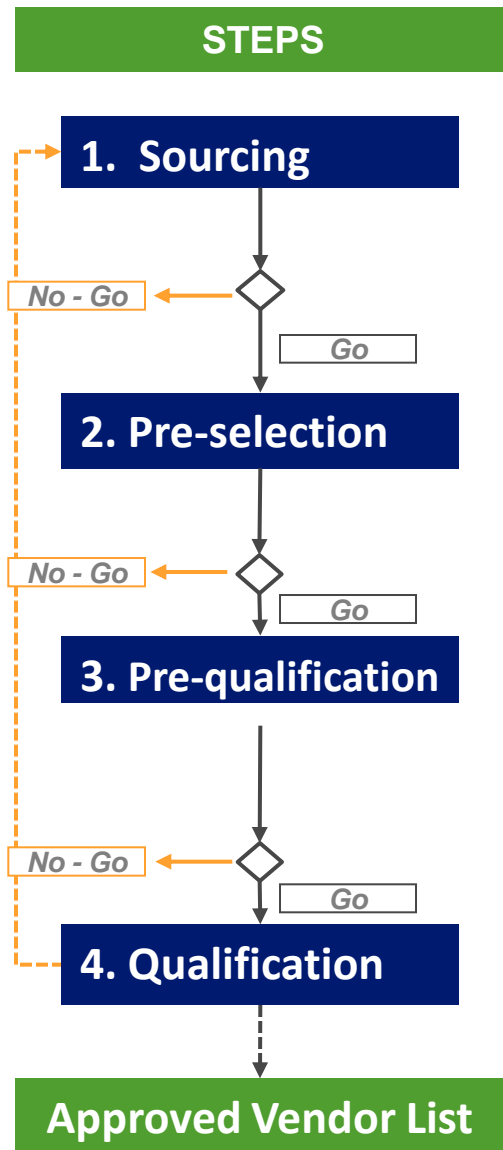
Installation of all electrical and I&C equipment at OL3

- All electrical and I&C Equipment at OL3 EPR™ project
- Nuclear Installation Contracts from AREVA for other Projects
- Several subcontractors, mainly for cable pulling



Polish industry has gained significant competences in the nuclear sector with the EPR projects

NEW COMERS PROCESS



1. Sourcing

- Establish the master supplier list
- Initiate first contact visits
- Send Request For Interest (RFI)

2. Pre-selection

- Preselect suppliers according to RFI feedback analysis
- Visit Suppliers for pre-assessment (quality management, design, manufacturing, etc.)

3. Pre-qualification

- Define development plan and follow-up
- Carry out product or process qualification tests as necessary
- Send a blank RFQ for detailed technical assessment

4. Qualification

- Approve supplier once qualification is satisfactory before the contract is signed (Approved Vendor List)

EDF IS INVOLVED IN THE POLISH NUCLEAR PROJECT

- Since 2010, EDF and AREVA have sponsored and performed several initiatives to prepare the local supply chain:
 - ✓ More than a hundred Polish suppliers have been identified with a potential industrial scope for the EPR.
 - ✓ 7 Suppliers Days have been organized.
 - ✓ 5 AFCEN seminars have been performed for nuclear training.
2 of them for the electrical codes -> RCC-E



For a successful nuclear project, the local industry should be developed.

CARE ABOUT SAFETY?

CHOOSE



**EPR KEEPS YOU ON THE
SAFE SIDE!**

DZIĘKUJĘ