Civil Works — Full Raw Material + Energy + Carbon Exposure Table (per MW installed)

Function	Raw Material / Energy / Carbon	Quantity per MW	2025 Unit Price (€)	Euro Equivalent	Market Index / Hedging Proxy
Excavation & Earthworks	Crushed stone / aggregate	12 m^3	35 €/m^3	€420	CRU Global Aggregates Price (proxy)
Excavation & Earthworks	Sand	10 m^3	25 €/m^3	€250	Local Construction Material Index (proxy)
Structural Construction	Cement	1.2 t	110 €/t	€132	European Cement Index (ECI) (proxy)
Structural Construction	Ready-Mix Concrete	15 m^3	120 €/m^3	€1,800	Regional RMC Price Basket (proxy)
Reinforceme	Steel Rebar	0.1 t	900 €/t	€90	EUROFER Rebar Price
Heavy Infrastructure	Structural Steel	0.15 t	1,050 €/t	157.5 €	Steel Scrap / HRC Index (LME / Platts) (proxy)
Construction Machinery	Diesel	500–700 L	1.60 €/L	800–1,120 €	Brent Crude Futures / Diesel CIF Rotterdam (proxy)
Site	Electricity	1,200	0.15 €/	€180	EEX Baseload Futures
Carbon	EUA (EU	0.5 tCO_2-	80 €/tCO_2	€40	EUA Futures (ICE / EEX)

Detailed Function Explanations

1. **Excavation & Earthworks**
    - **Purpose:** Prepare the site for foundations, basements, and heavy structures. Includes leveling, trenching, soil compaction, and earth transport.
    - **Raw materials:** Crushed stone, sand. Needed for soil stabilization, drainage layers, and backfill.
    - **Energy impact:** Diesel used in excavators and transport vehicles.
2. **Structural Construction**
    - **Purpose:** Build foundations, walls, containment buildings. Supports the weight of the nuclear island and conventional island structures.
    - **Raw materials:** Cement, ready-mix concrete.
    - **Energy impact:** Electricity for mixing, pumps, and curing. Carbon exposure arises from CO_2 emissions in cement production.
3. **Reinforcement**
    - **Purpose:** Strengthen concrete structures, resist tensile stress, prevent cracking, and ensure seismic stability.

- **Raw materials:** Steel rebar. Steel production is carbon-intensive, so EUA exposure applies indirectly.

4. **Heavy Infrastructure**
   - **Purpose:** Structural steel for support frames, gantries, heavy civil components (bridges, cranes).
   - **Raw materials:** Structural steel.
   - **Energy & carbon:** Steel manufacturing is energy-intensive; carbon exposure is linked to EU ETS allowances.
5. **Construction Machinery / Site Operations**
   - **Diesel:** Powers heavy machinery, mobile generators, transport vehicles.
   - **Electricity:** Powers pumps, lighting, and small equipment.
   - **Carbon exposure:** Energy use leads to indirect CO_2 emissions; can be partially priced via EUA hedges if the site is in the EU and subject to carbon regulations.
6. **Carbon (EUA Exposure)**
   - **Function:** Hedging the cost of CO_2 emissions associated with material production (cement, steel) and energy use (diesel/electricity).
   - **Quantity estimate:** Approx. 0.5 tCO_2-eq per MW of civil works (typical nuclear construction intensity).
   - **Hedging:** ICE / EEX EUA futures or forwards. Direct hedge if the plant is liable under EU ETS.

Methodology Notes

1. **Quantity per MW**
   - From nuclear power plant construction benchmarks (ENR, RSMeans, EDF / AREVA nuclear EPC data).
   - Electricity and diesel estimated from **construction site energy models**.
2. **Unit Price (2025 Forecast)**
   - Materials: Europe market sources, CRU, Platts, Eurostat.
   - Energy: EEX forward curve (electricity), Brent crude futures (diesel).
   - EUA: ICE / EEX EUA futures.
3. **Euro Equivalent**
   - Simple multiplication: **Quantity × Unit Price**.

4. **Market Index / Hedging Proxy**
    - Perfect hedge exists only for EUA and electricity.
    - Other materials use **proxy indices** (aggregates, steel, cement).

Electrical Network & Piping — Full Exposure Table (per MW installed)

Function	Material / Energy /	Quantity per MW	2025 Unit Price (€)	Euro Equivalent	Market Index / Hedging Proxy
High-voltage	Copper Cable	0.05 t	9,000 €/t	€450	LME Copper Futures
Low-voltage Wiring &	Aluminum Cable	0.02 t	3,200 €/t	€64	LME Aluminum Futures (proxy)
Transformers &	Electrical Steel	0.01 t	1,200 €/t	€12	LME HRC / Electrical Steel
Insulation &	PVC / HDPE	0.15 t	1,500 €/t	€225	Plastics Market Index
Piping for Water	Stainless Steel	0.05 t	5,000 €/t	€250	LME Nickel / Stainless
Electrical	Connectors,	Lump	€50	€50	Electronics Components
Construction Machinery	Diesel	400–600 L	1.60 €/L	640–960 €	Brent Crude Futures / Diesel CIF Rotterdam (proxy)
Site Operations	Electricity	1,000	0.15 €/	€150	EEX Baseload Futures
Carbon	EUA	0.3 tCO_2-	80 €/tCO_2	€24	EUA Futures (ICE / EEX)

Detailed Function Explanations

1. **High-voltage Transmission (Copper Cable)**
    - **Purpose:** Transmit generated electricity from the plant to grid connection points.
    - Copper is the standard due to high conductivity and durability.
    - Hedging: LME Copper futures offer a near-perfect hedge.
2. **Low-voltage Wiring & Control (Aluminum Cable)**
    - **Purpose:** Internal distribution, lighting, instrumentation, and control circuits.
    - Aluminum used where weight saving is needed.
    - Hedging: LME Aluminum futures are a proxy.
3. **Transformers & Switchgear (Electrical Steel)**
    - **Purpose:** Core magnetic components for transformers and switchgear.
    - Provides high permeability and low loss.
    - Hedging: No perfect liquid market, use Electrical Steel or HRC as proxy.

4. **Insulation & Piping (PVC / HDPE Pipes)**
    - **Purpose:** Insulation conduits, cooling water, drainage, and cable protection.
    - Low cost, durable plastic piping.
    - Hedging: Plastics market indexes.
5. **Piping for Water / Cooling (Stainless Steel)**
    - **Purpose:** Safety-critical cooling circuits for reactor and conventional island.
    - Resistant to corrosion, high pressure, high temperature.
    - Hedging: Nickel / stainless steel proxies.
6. **Electrical Components (Connectors, Switches)**
    - **Purpose:** Operational safety, control, monitoring.
    - Lump sum because quantities vary; minor cost per MW.
    - Hedging: Electronics components price basket (proxy).
7. **Diesel & Electricity**
    - Diesel for cranes, excavators, welding units.
    - Electricity for pumps, small equipment, site offices, and lighting.
    - Hedging: Brent / EEX forward curves.
8. **Carbon (EUA Exposure)**
    - Function: Covers CO_2 emitted from energy use (diesel & electricity) and embedded carbon in materials (PVC, steel, copper).
    - Quantity: ~0.3 tCO_2-eq/MW (lower than civil works because less concrete).
    - Hedging: EUA futures.

Methodology Notes

1. **Quantity per MW**
    - Copper, aluminum, and steel quantities estimated from EPC material take-offs for power plant electrical and piping systems.
    - Diesel and electricity estimated from heavy equipment usage on electrical installation tasks.
2. **Unit Price (2025)**
    - Copper / aluminum / nickel / steel: LME forward prices + expected inflation.

- PVC / HDPE: Plastics market averages in Europe.
- Electricity: EEX forward curves.
- Diesel: Brent / CIF Rotterdam.

3. **Euro Equivalent**
   - Multiply quantity × 2025 price.
4. **Hedging**
   - Use futures for metals where available (Copper, Aluminum).
   - Proxy indices for plastics, stainless steel, and electronics components.
   - Energy and carbon hedges follow the same logic as civil works.

Nuclear Island & Conventional Island — Full Exposure Table (per MW installed)

Function	Material / Energy /	Quantity per	2025 Unit	Euro Equivale	Market Index / Hedging Proxy
Reactor Vessel & Pressure Components	Low-alloy steel / RPV	0.12 t	6,500 €/t	€780	LME HRC / Specialty Steel Index (proxy)
Steam Generators & Heat Exchangers	Stainless steel	0.08 t	5,000 €/t	€400	LME Nickel / Stainless Steel Index (proxy)
Turbines & Rotating Machinery	Alloy steel & copper	0.05 t	6,500 €/t	€325	LME Copper + Specialty Steel Index (proxy)
Piping Systems (primary & secondary	Stainless steel piping	0.06 t	5,000 €/t	€300	LME Nickel / Stainless Steel Index (proxy)
Instrumentation & Control	Specialized alloys /	Lump sum	€100	€100	Electronics Components Price Basket (proxy)
Insulation & Protective Systems	Refractory / concrete lining	5 m^3	200 €/m^3	€1,000	Regional RMC / Refractory Index (proxy)
Construction Machinery	Diesel	600–800 L	1.60 €/L	960–1,280 €	Brent Crude Futures / Diesel CIF Rotterdam
Site Operations	Electricity	1,500	0.15 €/	€225	EEX Baseload Futures
Carbon Emissions	EUA	0.6	80 €/	€48	EUA Futures (ICE / EEX)

Detailed Function Explanations

1. **Reactor Vessel & Pressure Components**
   - **Purpose:** Contain the nuclear fuel and primary coolant under extreme pressure and temperature. Safety-critical.
   - **Materials:** High-quality low-alloy steel (RPV steel) with controlled microstructure.

- **Hedging:** Specialty steel futures or HRC indices as proxy; very few liquid markets for exact RPV steel.

2. **Steam Generators & Heat Exchangers**
   - **Purpose:** Transfer heat from primary reactor loop to secondary loop for turbine generation.
   - **Materials:** Stainless steel or nickel-based alloys for corrosion and temperature resistance.
   - **Hedging:** Stainless steel / nickel futures as proxy.
3. **Turbines & Rotating Machinery**
   - **Purpose:** Convert thermal energy into mechanical and then electrical energy.
   - **Materials:** Alloy steel, copper for windings.
   - **Hedging:** Copper and specialty steel indices.
4. **Piping Systems (Primary & Secondary)**
   - **Purpose:** Transport coolant and steam between reactor, steam generator, turbine, and condensers.
   - **Materials:** Stainless steel for corrosion resistance and high-pressure tolerance.
   - **Hedging:** Stainless steel / nickel proxies.
5. **Instrumentation & Control**
   - **Purpose:** Safety monitoring, automation, and process control.
   - **Materials:** Electronics, specialized alloys for sensors.
   - **Hedging:** Electronics component basket.
6. **Insulation & Protective Systems**
   - **Purpose:** Thermal insulation, radiation shielding, and refractory linings.
   - **Materials:** Refractory concrete or ceramic materials.
   - **Hedging:** Regional RMC or refractory price indices.
7. **Diesel & Electricity**
   - Diesel: Cranes, lifts, heavy transport.
   - Electricity: Pumps, welding, turbine assembly, lighting.
   - Hedging: Brent / EEX forwards.
8. **Carbon (EUA Exposure)**

- Function: Covers CO_2 from energy use and embodied carbon in steel, concrete, and alloys.
- Quantity estimate: ~0.6 tCO_2-eq per MW (higher than civil works due to energy-intensive materials).
- Hedging: EUA futures.

Methodology Notes

1. **Quantity per MW**
   - Based on EPC material take-offs for nuclear island: reactor vessel, turbines, heat exchangers, primary/secondary piping.
   - Diesel and electricity are estimated from construction equipment and heavy installation operations.
2. **Unit Prices (2025)**
   - Metals: LME forward prices + expected inflation.
   - Concrete / refractory: Regional RMC / refractory price indices.
   - Diesel: Brent / CIF Rotterdam.
   - Electricity: EEX forward curve.
   - EUA: ICE / EEX futures.
3. **Euro Equivalent**
   - Quantity × Unit Price.
4. **Hedging**
   - Perfect futures where available (Copper, Aluminum, EUA, Electricity).
   - Proxy indices for specialty steels, stainless steel, refractories, electronics.

Slide 1 — Maintenance & Operational Raw Material Exposure

Title: Maintenance & Operational Costs — Raw Material & Energy Exposure

Function	Material / Energy	Quantity per MW / Year	Unit Price	Euro Equivalent	Market Index / Hedging Proxy
Reactor Maintenance	Spare parts / Alloys	0.005 t	6,500 €/t	32.5 €	Specialty Steel / Alloy P...
Turbine & Generator Maint...	Lubricants & Oils	100 L	10 €/L	€1,000	Industrial Oil Futures / P...

Piping & Instrumentation	Stainless steel parts	0.002 t	5,000 €/t	€10	LME Stainless Steel (proxy)
Site Energy Consumption	Electricity (auxiliary, pumps,	500 kWh	0.15 €/ kWh	€75	EEX Baseload Futures
Site Energy Consumption	Diesel (backup generators)	100 L	1.60 €/ L	€160	Brent / Diesel CIF Rotterdam
Carbon Emissions	EUA	0.2 tCO_2-eq	80 €/	€16	EUA Futures

Notes / Explanation:

- Maintenance of critical components (reactor, turbines, piping) uses **specialty alloys and lubricants**, representing a small but non-negligible cost.
- Energy consumption continues for auxiliary systems; hedging electricity and diesel reduces operational cost volatility.
- EUA exposure accounts for CO_2 from electricity and diesel used during maintenance.

Slide 2 — Electricity Production & Hedging

Title: Electricity Production & Hedging Strategy

Aspect	Description / Strategy
Production	Expected electricity output per MW: ~8,000 MWh/year
Revenue	Market price volatility in wholesale electricity markets (EEX, Powernext)
Hedging Instruments	- Forward/futures contracts (Baseload, Peakload) - Power Purchase Agreements (PPA) - Options for price caps / floors
Hedging	Lock in a minimum price for a portion of production to stabilize cash flows, reduce
Example	Hedge 50–70% of projected annual production via forward contracts; leave remaining unhedged to capture upside

Notes:

- Electricity sales are the plant's main revenue stream; risk management focuses on **price stability**.
- Hedging instruments (futures, PPAs, options) depend on market liquidity and regulatory environment.
- Correlation with carbon price (EUA) should be considered since high CO_2 prices can affect wholesale electricity prices.

Slide 3 — Uranium Supply & Hedging

Title: Uranium Fuel Supply & Price Risk Management

Aspect	Description / Strategy
Uranium Consumption	~0.025 tU/MW/year (varies by reactor type)
Raw Material	Uranium oxide (U_3O_8)
Price Exposure	Uranium spot and long-term contracts (e.g., UxC, Cameco prices)
Hedging Instruments	- Long-term supply contracts (10–20 years) - Uranium futures (limited liquidity) - Physical forward purchase agreements
Hedging	Secure stable fuel supply and price, reduce spot market volatility risk
Example	Cover 100% of annual fuel requirements via a mix of long-term contract and spot purchases for flexibility

Notes:

- Uranium price risk is **relatively low compared to electricity price risk**, but critical for operational continuity.
- Long-term contracts are standard in the industry to ensure both supply security and predictable cost.

Slide 1 — Overview

This presentation provides a detailed analysis of the key raw material, energy, and carbon exposures associated with the construction and operation of a nuclear power plant. The plant is divided into three main construction zones: Civil Works, Electrical Network and Piping, and the Nuclear and Conventional Island. Each zone has specific material and energy requirements that contribute to both the financial cost and the operational risk of the project. The objective of this analysis is to identify the exposures that can be hedged directly, such as electricity or EUA futures, and those for which proxy hedges are appropriate, such as construction materials. This framework will also inform the strategy for operational phase risk management, including electricity production and uranium supply.

Slide 2 — Civil Works Exposure

Civil works represent the foundation of the nuclear power plant and include site preparation, excavation, construction of structural elements, reinforcement, and the installation of heavy infrastructure. Excavation and earthworks require large quantities of crushed stone and sand to stabilize the soil, create foundations, and provide drainage. Structural construction relies heavily on cement and ready-mix concrete to form basements, containment buildings, and support structures, while steel rebar and structural steel provide the tensile strength needed to maintain stability and resist seismic and operational stresses.

In addition to material requirements, civil works consume significant energy. Diesel is used to power heavy machinery such as excavators, cranes, and trucks, while electricity powers pumps, lighting, and concrete mixers on site. These energy uses also generate CO_2 emissions, which are represented by EUA (European Union Allowance) exposure.

Hedging strategies for civil works should consider both directly hedgable exposures and proxies. Electricity and EUA prices can be hedged through forward contracts or futures, whereas construction materials like concrete, steel, and cement generally require proxy indices due to the lack of liquid futures markets. By identifying these exposures early, the project can stabilize costs and reduce the impact of market volatility on the overall budget.

Slide 3 — Electrical Network and Piping Exposure

The electrical network and piping systems are critical for the operation of the plant. High-voltage copper cables are used to transmit electricity from the plant to the grid, while low-voltage aluminum wiring distributes power internally. Transformers and switchgear contain electrical steel, which is essential for magnetic efficiency and durability. Piping systems, both for cooling and process fluids, are constructed from stainless steel and plastics such as PVC or HDPE, providing corrosion resistance and reliability under operational pressures and temperatures.

Energy requirements in this zone are also significant. Diesel powers construction machinery used for installation of cables and piping, while electricity is needed for pumps, welding equipment, and site lighting. Carbon emissions are incurred from both material production and energy use, which can be partially hedged through EUA futures.

The hedging strategy should include direct hedges for metals where liquid markets exist, such as copper and aluminum futures, while relying on proxy indices for plastics, stainless steel, and specialized electrical steel. By combining material and energy hedging, the project can mitigate financial risks associated with price fluctuations during construction.

Slide 4 — Nuclear and Conventional Island Exposure

The Nuclear and Conventional Island contains the most critical and technically complex components of the plant. The reactor vessel and associated pressure components are constructed from low-alloy steels capable of withstanding extreme temperatures and pressures. Steam generators and heat exchangers are made from stainless steel or nickel-based alloys to ensure corrosion resistance and longevity. Turbines and rotating machinery rely on alloy steels and copper for efficiency and durability. Piping systems for primary and secondary loops use stainless steel to resist high pressure and temperature, while instrumentation and control systems require specialized alloys and electronic components.

Energy use remains a significant cost factor, with diesel required for heavy lifting and machinery, and electricity for installation, testing, and commissioning of systems. The production of these high-performance materials and operational energy use contribute to CO_2 emissions, represented by EUA exposure.

Given the complexity of materials in the nuclear island, hedging relies primarily on proxies. Futures contracts exist for some metals like copper, while stainless steel and low-alloy specialty steels generally require price index proxies. Energy and carbon can be hedged directly, providing some protection against cost volatility. Properly managing these exposures ensures that both construction and early operational phases remain financially stable and predictable.

Slide 5 — Maintenance and Operational Exposure

After construction, maintenance and operational activities continue to generate material, energy, and carbon exposures. Regular maintenance of turbines, generators, piping, and the reactor vessel requires spare parts, lubricants, and specialty alloys. Electricity continues to power auxiliary systems such as pumps, lighting, and control equipment, while diesel is used for backup generators and heavy maintenance machinery. These activities generate ongoing CO_2 emissions, which can be priced or hedged using EUA futures.

The objective of operational hedging is to stabilize annual maintenance costs and avoid unexpected financial shocks caused by market volatility in materials or energy. By identifying the key cost drivers and mapping them to available hedging instruments, the plant can maintain predictable operational expenses and ensure long-term financial efficiency.

Slide 6 — Electricity Production and Hedging Strategy

The nuclear power plant generates electricity as its primary revenue source. Expected annual production per MW is approximately 8,000 MWh, which exposes the operator to fluctuations in wholesale electricity prices. Hedging strategies include forward contracts, power purchase agreements (PPAs), and options to set minimum and maximum prices.

The goal is to lock in predictable cash flows while retaining some flexibility to capture potential upside in electricity prices. Typically, 50–70% of projected production is hedged through forward contracts, while the remaining output is sold at spot prices. Hedging must also consider the interaction with EUA prices, as high carbon prices can influence wholesale electricity markets.

Slide 7 — Uranium Fuel Supply and Hedging

The nuclear fuel cycle requires a stable supply of uranium, typically around 0.025 tons per MW per year, in the form of uranium oxide (U_3O_8). Uranium price risk is generally less volatile than electricity prices but is critical for operational continuity.

Long-term supply contracts are the standard method for securing both price and availability of uranium. Futures contracts exist but have limited liquidity. A combination of long-term contracts and spot purchases ensures the plant has a reliable fuel supply while mitigating price volatility. Proper management of uranium procurement is essential for both financial planning and operational reliability.

Slide 8 — Integrated Hedging Summary

The hedging framework combines exposures from construction, energy, carbon, electricity production, and fuel supply. Construction materials such as cement, concrete, steel, and plastics are largely hedged using proxy indices. Diesel and electricity consumption during construction and operation are hedged using Brent crude and electricity forward contracts, respectively. Carbon exposure is managed through EUA futures.

Operational revenue from electricity sales is stabilized through forward contracts, PPAs, and options, while uranium procurement is secured through long-term contracts. By coordinating these hedging strategies, the plant can reduce financial risk, stabilize costs, and ensure predictable cash flows throughout both construction and operational phases.