Ministry of Economic Affairs and Climate Policy of the Netherlands

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WORKSTREAM 3 – NPP DELIVERY MODEL ECONOMICS

Appendix to the TFS Scope of Work & Deliverables

MKA 231213

Contents

1. Document Purpose

The purpose of this document is to detail the deliverables related to the Vendors delivery model and its economics.
Those deliverables will be used in the overall economical assessment of the project as well as the preparation of the investment and revenues requirements.

1. References

No	Document reference	Title
1	AEOS-FEET-RE-0001	TFS – Scope of Work & Deliverables

2. Terms & Definitions

TERM	DEFINITION
AIL	Abnormal and Indivisible Loads
ANVS	Dutch Authority for Nuclear safety and Radiation Protection
BAT	Best Available Technology
BIS	Bid Invitation Specification
BOP	Balance Of Plant
CAPEX	CApital EXpenditure
CI	Conventional Island
CIW	Commission for Integral Water Management (Belgium)
COL	Commissioning and Operation License
Deltares	Dutch Research Institute specialized in geo- and hydrology
DGCE	Directorate General Climate & Energy
DNE	Directorate of Nuclear Energy (The Hague)
EIA	Environmental Impact Assessment
EZK	Ministerie van Economische Zaken en Klimaat
EPC	Engineering Procurement Construction (Contact)
EPZ	Operator of existing Borssele NPP
FC	First Concrete
FEED	Front End Engineering & Design
FSS	Full Scope Simulator
FID	Final Investment Decision
GIS	Geographical Information System
HSE	Health Safety & Environmental
IAEA	International Atomic Energy Agency
IID	Intermediate Investment Decision
KNMI	Royal Netherlands Meteorological Institute
MER	Milieu Effect Rapportage/ Environmental Impact Assessment
NCEA	Dutch Commission for Environmental Assessment
NDA	Non Disclosure Agreement
NI	Nuclear Island
NNB	Nuclear New Build
NPA	Nature Protection Act
NPP	Nuclear Power Plant

NSPA	North Sea Port Authority
OPEX	Operational Expenditure
RFG	Requirements For Generators
RFI	Request For Information
RWS	Ministry of infrastructure and water management
SEA	Strategic Environmental Assessment
SITO	SITO Program
Site	Site for NNB (Borssele)
SSC	Structures, Systems and Components
Tenne-T	TSO for Netherlands
TFS	Technical Feasibility Study
TSO	Transmission System Operator
Technology Vendor	Technology Vendor means EPC contractor
WENRA	Western European Nuclear Regulators' Association

3. Scope

The following Work Packages are identified under the "NPP delivery model economics" workstream:

- WP 01: Vendor Project Execution Strategy
- WP 02: CAPEX estimate
- WP 03: OPEX estimate
- WP 04: Timeline
- WP 05: Risk Management
- WP 06: Lessons Learned
- WP 07: Supply Chain

4. Vendors Project Execution Strategy (WP 01)

The Vendor shall issue a high level Project Execution Strategy. It shall indicate how he intends to deliver the project, its structure and the governance of his organization consistent with the objective of the project. It shall cover at least the following topics:

Project delivery governance

If the Vendor forms a consortium or a JV, he shall describe the role and responsibilities of each member and confirm if the partners are joint and several.

The Vendor shall describe how he intends to embed a collaborative partnership culture with the Owner during project, and how this will bring economical value to the project. In particular, the Vendor shall propose:

- a joint PMO organization enabling both parties to an optimal collaboration,

- a joint mechanism to identify and mitigate risks (such as for example sharing dedicated contingencies).

Environmental Social Governance

The nuclear programme will have to report on Environmental Social Governance (ESG) issues in accordance with Corporate Sustainability Reporting Directives (CSRD) for its funding and political approval. The Vendor shall therefor provide references, methodologies and metrics for CSRD compliance and Life Cycle Analysis reporting (CO2 emissions per kWh, Energy Return on Investment, materials footprint, sustainability criteria…).

The Vendor shall provide a typical estimate of the CO2 emissions per kWh during the lifecycle and explain his methodology to confirm those emissions during project execution.

Final EPC Contract model

As a basis assumption, and without prejudice of the future BIS requirements, the final contracting model will be EPC turnkey. The Vendor is entitled to propose an alternative or innovating contracting contractual model and argue their benefits to the project.
The Vendor shall set out claims/dispute mitigation features, and other contractual methods to maintain strong incentives between the Owner/Vendor.

Specific contractual arrangements are not part of the scope of the TFS. However, the Owner might at his own discretion engage discussions with the Vendor on inter alia following topics:

- Choice of Terms and Conditions (Fidic, NEC…),
- Advance payments, bonding (advance payments, retentions, performances),
- Payment terms,
- Liquidated damages,
- Any contractual arrangement before final contract signature (early works agreement, Long Lead Items…).

5. Economical modelling (WP 02 & 03)

The objective of this section is to establish the economical case of the project.

5.1 Cost estimates

The Vendor shall provide all the cost elements required by EZK to estimate the economic viability of the project, including its Net Present Value (NPV) and Levelized Cost of Electricity (LCOE). For the sake of clarity:

- CAPEX, OPEX (including maintenance and major overhauls) shall be broken down in accordance with IAEA TECH 396. The Vendor is entitled to propose his breakdown within 2 months after start of TFS.
- Revenues: the Vendor is not required to make any assumptions on future revenues of sales or services.
- Interest rates: unless otherwise agreed with EZK, the Vendor shall give overnight cost and make no assumptions on interest rates.

The Vendor shall provide cost breakdowns as follows:

- for generic Proposed Plant: benchmark costs per major component/system,
- for site-specifics scope (such as deep foundations, earth works, cooling system, supporting logistics): estimates based on Workstream 1 and 2 studies.

The Vendor shall summarize the costs of its Reference Design and the changes (plus or minus) to adapt to the Borssele site as per table below:

- Technical changes,
- Market changes (such as commodity & labour rates, FX, taxes…),
- Contingencies (with allocation to Owner or Vendor) if applicable,
- Range (low / high estimate) if applicable,

The vendor shall give a qualitative appreciation of the variation between local and reference cost due to labor laws, local productivity, local supply chain…

For each cost item, the Vendor shall indicate:

- The methodology used for costing (top down or bottom up),
- the class of maturity,
- its proposed commercial pricing mechanism (firm price, target price, remeasurable price…),
- the proposed currency, escalations and indexations formulas (labor, materials, commodities…).

The Vendor shall present the costing methodology and a maturity class for each cost position for the Client review within a month after start of the TFS. The costing methodology shall ensure traceability for the Owner to understand and if necessary to challenge the cost proposal. An open book approach will be preferred during the TFS, without prejudice of the costing model of the final contract.

TECH 396 IAEA			REF PLANT		technical changes	market changes	Contigencies	Total cost (ref + changes+contingencies)		
IAEA cod		Description	Equipment& Mat	Labor						Costing model (firm/target/re
		BASE COST								
21		Buildings and structures at the plant site								
22		Reactor plant equipment								
22	1	Reactor equipment								
22	2	Main heat transfer and transport system								
22	3	Reactor auxiliary systems								
22	4	Reactor ancillary systems								
22	5	Nuclear fuel handling and storage systems								
22	6	Other reactor plant systems and components								
23		Turbine generator plant equipment								
23	1	Turbine plant								
23	2	Generator plant								
23	3	Condensate systems								
23	4	Feedwater and main steam systems								
23	5	Drain systems								
23	6	Other secondary side systems								
23	7	Other turbine auxiliary systems								
24		Electrical equipment and I&C plant equipment								
24	1	Generator and house load equipment								
24	2	Diesel and diesel control equipment								
24	3	Auxiliary electrical equipment								
24	4	Ancillary and communication systems								
24	5	I&C equipment (conventional and nuclear)								
25		Water intake and heat rejection								
25	1	Circulation water intake structures								
25	2	Structures for circulation water pumping and outfall included in code № 253								
25	3	Structures for recirculation water cooling								
25	4	Main circulation water piping								
25	5	Secured service water piping								
25	6	Service water piping for conventional plant								
25	7	Equipment								
26		Miscellaneous plant equipment								
27		Special materials								
28		Simulators								
30		Engineering, design, and layout services provided by the supplier(s) at the home office(s)								
31		Project management services provided by the suppliers at the home offices								
32		Engineering, design, and layout services provided by the supplier(s) at the plant service								
33		Project management service(s) provided by the supplier at the plant site								
34		Construction site supervision by the supplier(s)								
35		Construction labor provided by the supplier(s) or construction companies at the plant site								
36		Commissioning services provided by the supplier(s) at the plant site								
37		Trial test run services provided by the suppliers								
38		Construction facilities, tools and materials at the at the plant site								
39		Commissioning materials, consumables, tools,and equipment at the plant site								
40		Staff training, technology transfer, and other services								
41		Housing facilities and related infrastructure								
		SUPPLEMENTARY COSTS								
50		Transportation and transportation insurance								
51		Spare parts included in code № 21-28								
52		Contingencies								
53		Insurance								
55		Custom duties								
56		Sales tax								
		FINANCIAL COSTS								
60		Escalation costs								
61		IDC								
62		Fees								
		OWNER'S COSTS								
70		Owner's capital investment and services costs								
71		Escalation of Owner's costs								
72		Financing of Ower's costs								
		NUCLEAR FUEL COSTS								
100		Fuel assembly supply, first core								
110		Service, first core								
120		Fuel assembly supply, reloads								
130		Service, reloads								
140		Reprocessing of irradiated fuel assemblies								
170		Financila cost of the nuclear fuel cycle								
		OPERATION AND MAINTENANCE COSTS								
800		Wages and salaries								
810		Consumable operating materials and equipment								
820		Repair costs, including interim replacements								
830		Charges on working capital								
840		Purchased services								
850		Insurance and taxes								
860		Fees, inspections, and review expenses								
870		Decommissioning allowances								
880		Radioactive waste management costs								
890		Miscellaneous costs								

5.2 Cost accuracy definition

For each cost positions, the Vendor shall provide a cost accuracy as per class 4 defined hereafter:

	Primary Characteristic	***Secondary Characteristic***		
ESTIMATE CLASS	**MATURITY LEVEL OF PROJECT DEFINITION DELIVERABLES** Expressed as % of complete project definition	**END USAGE** Typical purpose of estimate	**METHODOLOGY** Typical estimating method	**EXPECTED ACCURACY RANGE** Typical variation in low and high ranges at an 80% confidence interval
Class 5	0% to 2%	Concept screening	Capacity factored, parametric models, judgment, or analogy	L: -20% to -50% H: +60% to +200%
Class 4	1% to 15%	Study or feasibility	Equipment factored or parametric models	L: -15% to -30% H: +40% to +100%
Class 3	10% to 40%	Budget authorization or control	Semi-detailed unit costs with assembly level line items	L: -10% to -20% H: +20% to +60%
Class 2	30% to 75%	Control or bid/tender	Detailed unit cost with forced detailed take-off	L: -5% to -15% H: +10% to +40%
Class 1	65% to 100%	Check estimate or bid/tender	Detailed unit cost with detailed take-off	L: -3% to -10% H: +6% to +30%

Table 1 – Cost Estimate Classification Matrix for the Nuclear Power Industries

The spread of the total cost estimate shall be assessed by an appropriate tool such as a Monte Carlo simulation or a standard vendor tool.
The Vendor shall explain his cost firming trajectory and evaluate the resulting accuracy.

5.3 Cost estimating methodology

For each cost position, the Vendor shall choose between a top-down (analogical) and bottom-up (analytical) costing mechanism as described below, or describe another mechanism if he elects to do so.

Top-down Versus Bottom-up Cost Estimating
The models needed to assess the economics of Generation III+ nuclear energy systems must be more than the arithmetical manipulation of dozens of two-digit level cost accounting categories and calculated figures of merit based upon the EMWG guidelines. They must be

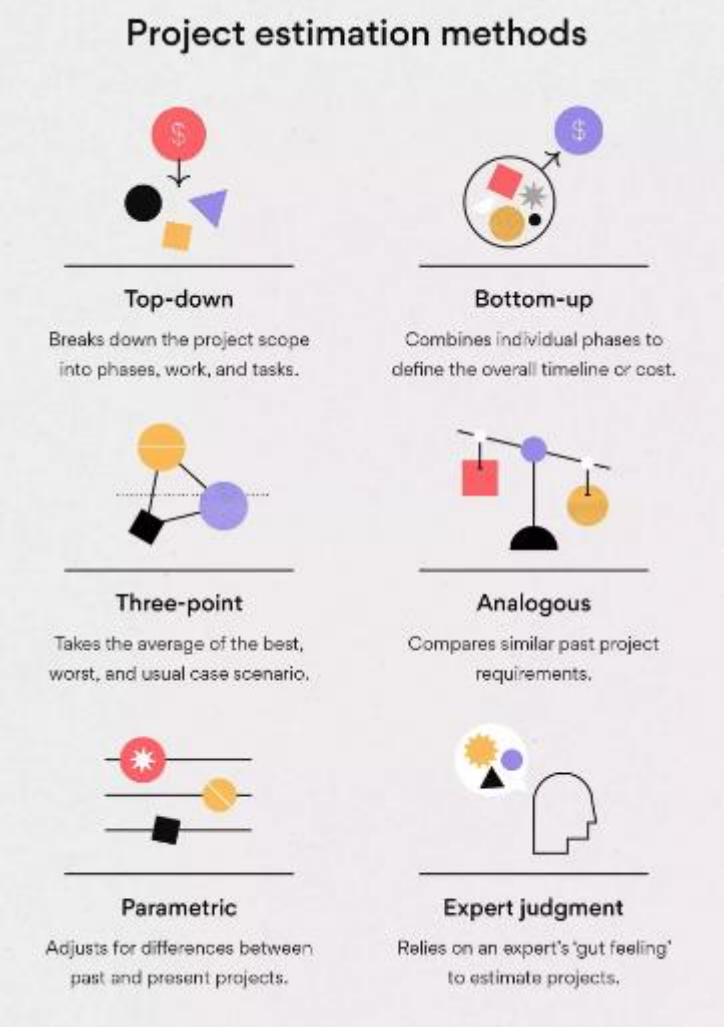
backed up by more detailed concept specific cost estimates. This detailed estimating is the responsibility of the system development teams. The preparation of an estimate can take two paths: top-down or bottom-up, depending on the maturity of the concept, the financial resources available to the design/estimating team, and the type of scientific/engineering individuals on the system development team. These two paths are discussed below.

1) Bottom-up Estimating

This is the more familiar type of estimating applied to projects as they near construction. For large nuclear projects Architect/Engineering (A/E) teams generally perform bottom-up estimating in conjunction with a utility. The A/E prepares a detailed baseline design with layout diagrams for all major systems. This estimate is prepared from the bottom up, i.e., from very detailed items, such as equipment lists, commodity quantity estimates by take-off from drawings or direct from conceptual 3D design models (“bricks and mortar”). Unit prices and unit labor-hour rates are then applied to the estimated quantities, extended and summarized to the code of accounts for the direct cost elements. Project execution plans provide basis for detail estimates of the field indirect costs, together with the construction schedule for the time related field indirect costs. This process is often described as working from “engineering take-offs” and requires a staff of at least a dozen engineers and estimators, even at the conceptual design level. The thousands of detail items and activities are then organized into a Code of Accounts (COA) at least to the three-or-four-digit level for all categories. Activities are often subdivided into a “Work Breakdown Structure” or WBS that conforms to the COA and task schedule. The scheduling activity is also at a high level of detail and requires the use of scheduling software, such as “Primavera” systems. For use in the EMWG models, the highly detailed 3 to 6 digit COA entries must be rolled up to the two-digit level. Other estimates, such as those for operations, would require similar rollups from highly detailed staffing and consumables information. As bottom-up estimating proceeds, cost contingencies decline (expressed as a percentage of base costs at a fixed confidence level, e.g., 80% chance that an overrun of the base cost plus assigned contingency will not occur). As expected, this method must be backed up by data, such as unit costs of labor, commodities, installation rates, construction labor-hour estimates, and siting requirements.

2) Top-down Cost Estimating

For projects early in their life cycle, top-down estimating techniques can be used. At this stage, the design/development/estimating staff is usually small, and financial resources are limited. The first task is to develop a reference design to which cost estimating techniques can be applied. The cost estimating part of this task generally is accomplished by considering the costs of systems and equipment used for similar projects and then scaling the system or equipment upwards or downwards. Auxiliary costs and indirect costs are often calculated with standardized factors or formulas. For example, calculating design costs as a fixed fraction, based on historical experience, of construction costs, can be done. With these formulas are sometimes found cost-scaling equations; however, at this time there exists no set of equations that can be used for all projects. These equations are equipment specific and must be developed by the designers and cost estimators working jointly. Despite its lack of cost detail, this method has the advantage that it can be used to optimize designs such that the lowest LUEC can be realized.



5.4 Levelized cost of electricity (LCOE)

The Vendor shall calculate the LCOE of his proposed plant.

$$\mathrm{LCOE} = \frac{\text{sum of costs over lifetime}}{\text{sum of electrical energy produced over lifetime}} = \frac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}}$$

It	investment expenditure (Capex) in year t
Mt	operations and maintenance expenditures in the year t
Ft	fuel expenditures in the year t
Et	electrical energy generated in the year t
R	discount rate
N	expected lifetime of system or power station (or time before transfer)

- The Capex, Opex and major overhaul expenditures should be in line with the proposed

project schedule, the fuel loading schedule and the maintenance schedule.
- The Owner will provide assumptions for the discount rate
- The Vendor shall provide an assumed availability and Life time after commercial operation date
- As load factor, the Vendor shall consider 2 scenarios:
    - A base load operation,
    - A daily cycle (linear decrease from 100% to 50% between 9:00 to 11:00, 50% between 11:00 to 13:00, increase from 50% to 100% between 13:00 and 15:00)
- Financial & Owners cost shall be discarded until provided by Owner
- An excel spreadsheet format will be provided to the Vendor.

6. Scheduling (WP 04)

This Work Package shall cover following topics:

Overall project schedule
- The Vendor shall produce a level-one milestone schedule, from TFS to commercial operation,
- The Vendor shall indicate the optimal stagger between unit 1 and 2 (which shall not exceed 2 years),
- The schedule shall indicate the dependencies and critical path(s) of the project.
- The duration of critical path activities shall be assessed through a 3 point estimate (or equivalent) as per good project management practices and a Monte Carlo simulation if possible,
- The Vendor shall identify additional engineering for design changes,
- The Vendor state the availability of critical resources at the estimated time of delivery,
- The Vendor can propose Early Works and Long Lead Items, or any possibilities to shorten the project duration.

Site preparation & licensing schedule

In the frame of the above overall schedule, the Vendor shall detail:
- the site preparation, deep foundations (up to 1st Nuclear Concrete) and Cooling Water Systems to the level required to illustrate the feasibility of his technical proposals.
- the tendering and licensing sequence to the level required to prove the timely availability of the Construction License.

Payment curve

The Vendor shall produce a typical CAPEX payment curve as well as a typical physical progress curve, and state whether he is cash-neutral, positive or negative.

Resourcing

The Vendor shall produce a project mobilization histogramme.

For the sake of clarity, the Vendor shall ensure complementarity and avoid overlapping with the WP-06 “Integrated Early Works program till First Concrete” and the WP 10 “ Overall mobilization plan” from Workstream 2.

7. Risk Management (WP 05)

The Vendor shall produce a risk register with the main risks identified at the time of the TFS.

- The risk register shall indicate necessary time and cost contingencies, and the responsible party. The cost contingency shall be coded as per the cost breakdown for easy reference.
- The risks shall be broken down according to the following Risk Breakdown Structure:
    - Level 1 Risk Area:
      Design, Licensing & Technology, Procurement, Manufacturing, Civil Work, Construction, Commissioning, Environmental, Political &Legal, Social acceptance, Financing, Market design & PPA.

    - Level 2 Risk cause:
      Human resources (quantity, quality),
      Commodity market (shortage, overheating), supply chain (shortage, overheating, default),
      Procedures, control & governance (not adapted), scheduling, sequencing, interfacing,
      Change in Law, Force Majeur, safety, security, negligence, fraud
      Maturity (design, organization…), poor specifications, risk on quantities, poor quality, faulty workmanship.

- The risk register shall contain as per good project management practice:
    - The description sorted by Area and Cause
    - Mitigation measure
    - Responsibility allocation
    - Severity, Impact and probability of occurrence
    - Contingency with cost breakdown code and allocation proposal (Vendor or Owner)

The level of detail shall be adapted to support political decision making. As for the cost breakdown, the Vendor is entitled to propose his RBS within 2 months after TFS start.

8. Lessons Learned & Continuous improvement (WP 06)

The Vendor shall explain his continuous improvement processes and illustrate them with cases relevant to this project.

Firstly, the Vendor shall explain how he captures lessons learned, how he ensured best practices are retained and how continuous improvement is ensured.

Secondly, the Vendor shall list the lessons learned from his last projects. In particular, the vendor shall illustrate how biggest cost and time overrun occurred, and how he intends to avoid re-occurrence in the future.

The Vendor shall describe a value engineering process to optimize or improve the plant design whilst minimizing the licensing impact of such design changes.

9. Supply chain plan (WP 07)

The Vendor shall provide a supply chain plan to demonstrate the robustness, sustainability and localization of its supply chain.
This includes, but is not limited to:

- Methodology to identify potential suppliers and subcontractors (local, non local),
- Methodology to ensure nuclear qualification of suppliers and subcontractors,
- Resourcing: identifying, hiring, training and retaining personnel,
- Lessons learned from previous projects.

The Vendor is not expected to enter into contractual agreements with local players during the TFS. More generally, the first issue of the supply chain plan shall be discussed between the Vendor and EZK before entering in discussion with local industry..