IN-KIND COST BOOK FOR ESS INITIAL OPERATIONS

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1. SCOPE

This document provides a list of in-kind opportunities to the ESS Initial Operations. The listed items in this cost book are all included in the P6 resource loaded project plan.

2. ISSUING ORGANISATION

This document is prepared by the European Spallation Source ERIC.

3. CONTEXT AND BOUNDARY CONDITIONS FOR IN-KIND CONTRIBUTIONS

The ESS additional budget request and resource loaded plan has been reviewed by our Project Advisory Committee and tuned to fit within the funding boundaries set by ESS ERIC Council. Within this context, the first condition for any in-kind contributions is that they are an integral part of the resource loaded P6 project plan and accompanying budget [1].

The execution of the technical scope of ESS in the construction phase was undertaken by partner laboratories that have specific and often unique technical capabilities and expertise. In the initial and steady state operations of ESS, in many cases these same partners become the critical supply chain of key components that ensure the ability of ESS to maintain high levels of performance and reliability over its operational life. The strong engagement of these partners and others will support ESS during its operational life and are crucial to its long-term success. In-kind contributions as tested and evolved during the construction phase are an appropriate vehicle for the needed engagement.

Similarly, our partners hold key expertise and know-how over the equipment delivered to ESS, and engagement of their personnel during commissioning and initial operations will be an equally important contribution. Indeed, these partner experts will play a valuable role in diagnosing and solving early problems on equipment that they have designed and built as well as provide critical training to ESS personnel. We expect this situation to be unique to the initial operations phase of ESS. This cost book describes specific examples of staff in-kind opportunities as well as the level of qualifications and experience that would be needed.

The identified line items in the case of spares, replacement parts or consumables are necessary for the operation of ESS. As spares, the items must follow existing designs, specifications and manufacturing requirements established during the construction of ESS. Therefore, these potential in-kind packages *in most cases* include little or no technical development, but instead tend to include build-to-print, procure to specification, or in some cases, sole source procurement.

The staff line items, referred to above, identify the capabilities and skills needed for the commissioning of scientific instruments as well as scope of science support systems.

Present resolution of the P6 plan allows identification of in-kind contributions in the area of accelerator, target and instruments. The timing of these in-kind needs may be subject to change as the plan evolves to address emerging needs and synchronize with the live schedule of the project.

4. COST BOOK VALUES AND INDEXATION

To allow tracking of contributions against commitments, all prices shown in this cost book are in 2013 Euros derived from the P6 project plan. The indexation is done according to the initial operations indexation (see Council resolution C.17.06.c[1]) which is scheduled to be reviewed in 2023. Indexation will need to be applied to all listed prices shown in the cost book.

At present the total value of scope in this initial operations cost book stands at approximately 22.6 M€$_{2013}$.

5. IN-KIND CONTRIBUTIONS TO THE ESS ACCELERATOR

5.1. Scope

This document provides a list of in-kind packages for the Accelerator during initial operations.

At present, the total value of in-kind scope for accelerator stands at 9.3M€$_{2013}$.

5.2. Issuing organisation

Section 5 of this document is prepared by the Accelerator Division.

5.3. Potential In-kind packages

5.3.1. Spare 352 MHz Klystrons

352MHz klystrons are used to power the warm linac. Klystrons have a limited lifetime. Three spares are foreseen, out of which one could potentially be supplied as in-kind (Two spares are already being procured with high priority, as these components are critical single points of failure). The suppliers of the original units are CPI and Thales, but any supplier fulfilling the technical specification in the procurement package [2] would be acceptable.

Note however that ESS has options[2] in existing contracts to buy up to 4 spare 352 MHz klystrons. So procurement is essentially already done and there is a firm price.

No technical development is needed on behalf of the in-kind partner.

5.3.2. Spare 704MHz Klystrons

704 MHz klystrons are used to power the medium and high beta elliptical cavities in the superconducting linac. 16 spares on the shelf at ESS are required with an additional 1-2 klystrons being bought annually to build a spare stock of at least 30 klystrons, and all of them could potentially be supplied as in-kind. The suppliers of the original units are CPI, Thales and Canon, but any supplier fulfilling the technical specification in the procurement package would be acceptable [3].

Note that ESS has options[3] in existing contracts to buy up to 12 spare 704 MHz klystrons from Thales and Canon (so 24 in total). Hence, procurements of the first 16 are already done, and there is a firm price for another 8 klystrons.

[1] See document C.17.99 Resolutions.
[2] Note that the option needs to be exercised early 2022 to be valid.
[3] Note that the option needs to be exercised early 2022 to be valid.

Due to the existing options, this package could be split up in several parts, as indicated in the table below.

No technical development is needed on behalf of the in-kind partner.

5.3.3. Spare Medium beta cavities

A spare medium beta cryomodule will be built by CEA-IRFU who builds the original Medium and High-beta cryomodules (9 and 21). The medium beta cavities for this cryomodule (4pcs) can be provided as in-kind [4].

5.3.4. Spare Modulator, Modulator Spare Parts, Oil and Oil treatment.

Modulators are used to provide pulsed high voltage to the klystrons. Two spares are foreseen and can potentially be supplied as in-kind. The supplier of the original units is JEMA. These devices were supplied as build-to-print, and the same should apply to the spares.

Note that ESS has an option in the existing contract to buy the spares so the procurement is in principle done and the price is fixed.

Spare parts for all the modulators could also in principle be supplied as in-kind. While the spare modulator is well-defined, the fraction of the spare budget that could be packaged as a pre-determined in-kind package needs further study, but an estimate value can be provided.

Replacement oil and oil treatment for the modulators could also be supplied as in-kind.

No technical development is needed on behalf of the in-kind partner.

5.3.5. Backup Cryo-Compressor and Cryogenic liquids

A backup cryo compressor and oil system is planned and could be provided as in-kind. It should fulfil the specification of the original system [5]. The requirements and study of the integration of the back-up compressor in the existing accelerator cryoplant is already under way at ESS while the order and integration of the back-up compressor can be provided as in-kind. The original supplier of the accelerator cryoplant is Linde with Aerzen being the sub-contractor for the compressors. Cryogenic liquids need to be replenished over time due to losses, and this could also potentially be supplied as in-kind. Approximately 26600 liters of Liquid Helium is foreseen to be needed during the initial operations phase.

5.3.6. Technical support for Test stand 2, RF and Beam instrumentation

Technical support is provided through regular contract with companies. This could potentially be converted to in-kind agreements.

5.3.7. EMU for TS4

This is essentially a copy of the Emittance Measurement Unit installed at the LEBT, possibly with further developments and improvements based on experiences from current beam commissioning activities.

5.4. Monetary Value of In-Kind Contribution for Accelerator

The following table provides the budgeted value for the items listed above.

In-kind value for the contributions below at present is approximate and will be revised at a later date.

Package	Definition	Value (k€$_{2013}$)
352 MHz Klystron spare	1 spare 352 MHz Klystron	980
704 MHz Klystron spares	Initially 2 spare 704 MHz Klystrons	440
Spare modulators	Two complete spare modulators build to print	1 707
Modulator oil and oil treatment	Spare oil and oil treatment for all modulators	676
Backup cryo compressor	Backup compressor and oils system for the accelerator cryo plant	3 165
Cryogenic Liquids	Approximately 26600 liters of LHe	527
Spare medium-beta cavities	4pcs	879
RFPS installation		176
Contracted RF technicians for test and commissioning	2 FTE, starting July 2022	176
Contracted BI technicians for test and commissioning	1 FTE, starting July 2022	88
EMU for TS4	Copy of existing unit	120
Support for test stand 2 programme	Manpower to operate test stand 2	440

6. IN-KIND CONTRIBUTIONS FOR THE ESS TARGET

6.1. Scope

This document provides a list of possible in-kind packages for the Target during initial operations.

At present, the total value of in-kind scope for target stands at 3.7M€$_{2013}$.

6.2. Issuing organisation

Section 6 of this document is prepared by the Target Division.

6.3. Context and boundary conditions for in-kind contributions to the Target during initial operations

The identified items described below, are critical components, necessary for the operation of the ESS target system. Unlike other types of components in this cost book, specific target spares will require design updates in order to implement improvements in safety, maintenance, operability and neutron source performance. Although baseline design will be based on that executed during the construction project, ESS will significantly befit from the engagement of partners with significant specialised expertise to support continuous improvement of these critical components.

6.4. Potential In-kind packages

6.4.1. Mark-2 Moderator/Reflector unit

The ESS Moderator/Reflector (MR) unit is a lifetime-limited component that will need to be exchanged due to the accumulated radiation damage incurred by the received radiation load.

Considering the prevalent ramp-up plan for the accelerator, replacement of one MR due to reach of its radiation damage threshold, is expected during the initial operation phase. Also, it should be noted that the Mark-1 MR, which is of the so-called BF-2 type, is sub-optimal for the neutron science instruments being built. To reach optimal conditions for the instruments, the planned Mark-2 MR shall be of the BF-1 type, which will require further technical development and design improvement, to be qualified for full 5 MW operation.

It is suggested to initiate development and acquisition for the Mark-2 MR as early as is feasible to more effectively utilise the scientific instruments and mitigate the risk of an early infant mortality related to the MR assembly.

6.4.2. Mark-2 Proton Beam Windows

The ESS Proton Beam Window (PBW) unit is a lifetime-limited component that will need to be exchanged due to the accumulated radiation damage incurred by the received radiation load.

Considering the prevalent ramp-up plan for the accelerator, replacement of two PBWs due to reach of their radiation damage threshold, is expected during the initial operation phase. The technical development for the Mark-2 PBWs shall aim at prolongation of their lifetime, primarily through the experience gained from the first years of operation on the radiation effect of the PBW materials.

6.4.3. Active Cells Facility Supplier Support

Support scope for the active cell facility will be developed and made available at a later time.

6.5. Monetary Value of In-Kind Contribution for Target

The following table provides the budgeted value for the items listed above.

Package	Definition	Value (k€$_{2013}$)
Mark-2 MR	Technical development of the Mark-2 MR, i.e. of the BF-1 type, including timely delivery of the actual hardware item as required.	3 183
Mark-2 PBW	Two replacement items of the PBW, including moderate technical development and timely delivery of the actual hardware items as required.	560
ACF supplier support	As described above	To be costed

7. IN-KIND CONTRIBUTIONS TO THE SCIENCE AND INSTRUMENT PROGRAM

7.1. Scope

This section provides a list of possible in-kind contributions to the Science and Instrument Program during initial operations with a focus on instrument commissioning, DMSC and science support systems.

At present, the total value of in-kind scope for science and instruments stands at approximately 9.6M€$_{2013}$.

7.2. Issuing organisation

Section 7 of this document is prepared by the Science Directorate.

7.3. Context and boundary conditions for in-kind contributions to the Science and Instrument program during initial operations

The ESS Initial Operations budget and its corresponding scope are under frequent review in order to ensure that they fit within the funding boundaries given by the ESS Council. The first condition for any in-kind contributions is therefore that they are a part of the initial operations plan and budget [1]. With this in mind, budget line items that may potentially be suitable for in-kind have been identified and are listed below.

There are three main types of possible in-kind contributions:

- Seconded staff – *e.g.* a scientist or technician employed by the partner but based at ESS
- Equipment – *e.g.* design and delivery of a piece of sample environment
- Service provision – *e.g.* staff based at a partner performs neutronic calculations for ESS

In the case of seconded staff, ESS will set the requirements for each position and will make the final decision on selection of the suitable candidate. The seconded staff member will report within the ESS management structure, will adhere to ESS safety and security regulations and be integrated within the ESS environment. The work place will be either at the ESS site in Lund, Sweden, or at the DMSC in Copenhagen, Denmark.

All in-kind opportunities are listed at the end of this section.

7.4. Instrument Commissioning Scientists

The commissioning scientists will lead or participate in the hot (with neutrons) commissioning of the neutron scattering instrument. They will record and assess the technical performance of the instrument's critical components with the aim of ensuring its successful scientific operation. Further, they will identify technical issues that prohibit successful operation of the instrument, and supervise and verify their resolution. They will also develop research activities that will be able to make effective early use of the instrument, and lead or assist scientific commissioning experiments.

Qualifications: A Ph.D. in physics, chemistry, materials science or other discipline relevant to the instrument. 5 years' experience with neutron scattering instruments, including significant experience with relevant neutron scattering techniques. A scientific background in a topic area relevant to the science case of the instrument is expected.

These are primarily full-time positions and the starting date is usually 12 months before the start of hot commissioning activities for the instrument. The duration of the position is up to three years. LoKI, ODIN, BIFROST, Estia and NMX have potential for such a position.

Such roles would be expected to spend approximately 20% of their time on research and outreach/education activities related to the beamline in question.

7.5. NMX lead scientist

The Lead Scientist for NMX, who is already working at ESS, could also be employed by or associated with a relevant university department. His work on NMX during the remainder of construction and through initial operations would then be delivered to ESS as an in-kind contribution or via another funding route. The aim would be to strongly root NMX in the protein crystallography research community to the benefit of both ESS and the participating university.

7.6. Instrument Data Scientists

The role of the instrument data scientist is to provide close support for commissioning and scientific computing to each neutron instrument. In the long term, the role is expected to include direct user support and development of scientific computing tools specific for the assigned instrument. During initial operations, the focus will be on commissioning activities.

The role will require close collaboration with the instrument scientists and staff from the DMSC, primarily from the Data Reduction and Analysis group and the Experimental Control and Data curation group.

Qualifications: The candidates will have a PhD in a relevant area and both:

- Expertise and a proven track record in scientific computing for Neutron (or photon) controls and data acquisition or data processing and data analysis, with an excellent understanding of Python (essential), C++ (optional) and modern software development methods and practices (essential).
- Expertise and a proven track record in any of the following scattering methods: Small Angle Scattering, Reflectometry, Diffraction, Inelastic scattering, Imaging.

On average two instruments within the same instrument class will share one data scientist.

The Instrument Data Scientists are based at the DMSC in Copenhagen but will spend significant time at the ESS site in Lund as well.

7.7. Technicians for Sample Environment Systems

Sample Environment Systems provide the control parameters for the sample during a neutron experiment, including pressure, temperature, magnetic fields, humidity, gas mixtures, and fluid control. The Technicians for Sample Environment will integrate, calibrate, test, optimize, and maintain Sample Environment Systems and its various components, in close collaboration with scientists, engineers and other technicians during the ESS initial operations phase. They will also operate such systems during the hot commissioning phase of each neutron instrument to enable hot commissioning and first science.

Qualifications: bachelor-level qualification or a successfully completed mechanical technical training and at least 3 years of experience in a work environment requiring similar skills. Experience in machine shop work is required with a high regard for precision and quality of workmanship. Experience of scientific instrumentation would be an advantage.

7.8. User and Sample Support Staff

During the ESS initial operations phase the ESS laboratory facilities provide the chemistry/life science services required for first science on the initial instrument suite and support sample management. Working closely with the group leader for the user laboratories, the laboratory technician will focus on commissioning the on-site laboratories, maintaining laboratory equipment and developing short instructions for equipment. When hot commissioning of instruments starts, scientists will begin to use the laboratories. The job will then also require giving introductions on working in the laboratories, keeping the chemistry laboratories stocked, providing assistance to users and assuring that everyone is working safely in the labs.

Qualifications: bachelor-level qualification or at least two years of education in chemistry / laboratory work. Hands-on experience from existing facilities will be an advantage.

Concerning user services, possibilities for seconded administration staff have been identified for several roles. For example we could second a librarian or bibliographer (part time) to properly assess the work already produced at ESS and help establish efficient systems to develop and maintain that record in to the future, possibly using the existing tools at other facilities. We could also use seconded staff in the user office for academic and industrial users that provide value to our early outreach to industry where it will be critical that we are accurate and professional. As long as the work term is long enough (so that training is minimized) we could benefit by secondment for any of the user-office roles still available.

Qualifications: Typically at least MSc is required.

7.9. Polarization equipment design engineer

Ten instruments will have polarization capabilities, which require equipment design tasks performed during the next three years.

The polarization equipment design engineer is a two-year full-time mechanical engineer position starting in January 2023. The tasks include carrying out the design works on equipment shared across multiple instruments as well as instrument-specific equipment, subsequently assisting the construction and implementation of polarization capabilities on instruments.

7.10. Potential equipment contributions

Some equipment within the ESS scope can be delivered as in-kind contributions to Initial Operations. These projects are found within sample environment, instrument technologies and data management.

7.11. Potential Service Provision Contributions

The opportunities for service provision contributions are perhaps not as numerous as the other possibilities, but some possible examples are included in the list below. The focus of these possibilities is in linking existing facilities, infrastructures, and competence centres at universities and research institutes with ESS.

Possibilities for in-kind:

- Use of/contracting of work to university or institute workshops
- Sharing of lab facilities (*e.g.* Collaboration between ESS DEMAX and Lund University LP3)

7.12. Monetary Value for In-Kind Contribution to the Science and Instrument program

The following tables provides the planned timing and budgeted value for the positions and items described above. This list is subject to modifications and will be revised annually.

7.12.1. Labour Costs

The table below lists in-kind values for labour contributions to the Science and Instrument program.

Start and end dates for these labour contributions are subject to change depending on the performance of the ESS construction project.

Below values include:

- *costs for salary, relocation allowance and allowance for non-working partner as per the ESS Relocation Package.*
- *cost for social security charges, pension contributions and employer insurances*
- *costs for installation allowance. For assignment of 12 months or shorter the value is based on the salary costs but no costs for additional relocation.*
- *one-off costs for mobile phone, laptop, screen, keyboard, mouse, access card*
- *monthly costs for mobile phone subscription, healthcare/training, office space cost (low estimate) and general overhead including consumables, salary administration, insurances, etc. .*
- *Cost for induction and mandatory trainings*

*Below values do **not** include:*

- *costs for moving of household goods or other relocation related items (except those listed above)*
- *travel, specific training, PPE if needed*

ACTIVITY	START	END	VALUE (k€$_{2013}$)	PERSON MONTHS	COST BASIS
LOKI commissioning scientist	2025 Jan	2027 Dec	241 279	36	level F or E scientist
ODIN commissioning scientist	2025 Jan	2027 Dec	241 279	36	level F or E scientist
ESTIA commissioning scientist	2025 Jan	2027 Dec	241 279	36	level F or E scientist

ACTIVITY	START	END	VALUE (k€$_{2013}$)	PERSON MONTHS	COST BASIS
MAGIC commissioning scientist	2025 Jan	2027 Dec	241 279	36	level F or E scientist
BEER commissioning scientist	2025 Jan	2027 Dec	241 279	36	level F or E scientist
NMX lead scientist	2023 Jan	2027 Dec	434	48	level D scientist
NMX commissioning scientist	2025 Jan	2027 Dec	241 279	36	level F or E scientist
BIFROST commissioning scientist	2025 Jan	2027 Dec	241 279	36	level F or E scientist
Test beamline commissioning scientist	2024 Jan	2026 Dec	241	36	level F scientist
User office officer 50%	2025 Jul	2026 Dec	61 53	9	level F or G officer
User office officer 100%	2027 Jan	2027 Dec	81 69	12	level F or G officer
Lab technician 50%	2026 Jan	2026 Dec	42 36	6	level F or G technician
Lab technician 100%	2027 Jan	2027 Dec	81 69	12	level F or G technician
Sample environment technician	2023 Jan	2027 Dec	343	60	level G technician
Sample environment technician	2027 Jan	2027 Dec	69	12	level G technician
Instrument Data Scientist for diffraction	2025 Jan	2027 Dec	322	36	Job level D
Instrument Data Scientist for spectroscopy	2026 Jul	2027 Dec	163	18	Job level D
Lead developer for imaging analysis software	2023 Oct	2027 Dec	454	51	Job level D
Scipp (data reduction) developer	2023 May	2027 Dec	432	56	Job level E

ACTIVITY	START	END	VALUE (k€2013)	PERSON MONTHS	COST BASIS
Scipp (data reduction) developer	2023 Nov	2027 Dec	387	50	Job level E
Instrument simulation and integration testing (scientist/developer)	2023 Jan	2027 Dec	463 533	60	Job level E or D
HPC system officer 1	2023 Apr	2027 Dec	439	57	Job level E
HPC system officer 2	2026 Jan	2027 Dec	188	24	Job level E
HPC system officer 3	2023 Aug	2027 Dec	409 472	53	Job level E or D
Polarization equipment design	2023 Jan	2024 Dec	217	24	Job level D
Motion control and automation	2024 Jan	2026 Dec	279 322	36	Job level E or D

7.12.2. List of Non-Labour Contributions

The table below lists in-kind values for non-labour contributions to the Science and Instrument program.

Start and end dates for these non-labour contributions are subject to change depending on the performance of the ESS construction project.

ACTIVITY	START	END	VALUE (k€2013)
Detector Spares (diffraction)	2022	2027	197
Instrument Dedicated Sample Environment	2025	2027	155
NMX sample station hardware	2023	2024	161
User office publication database and scientific KPIs	2023 Jan	2027 Dec	59
Deuteration lab services	2022 Jan	2027 Dec	378
Wet cryostat IK package	2024 Jul	2026 Mar	189

ACTIVITY	START	END	VALUE (k€$_{2013}$)
Dry cryostat IK package	2023 Jul	2026 Mar	378
Spectroscopy magnet	2022 Jul	2025 Mar	1 161
Heat gun/cryojet and induction furnace	2022 Jul	2022 Dec	151
Dilatometer	2022 Sep	2024 May	386
Troughs and cells	2024 Jan	2025 Dec	426
Polarization ODIN	2023 Jan	2025 Jul	326
Polarization DREAM	2023 Apr	2023 Nov	24
Polarization BIFROST	2023 Jan	2024 Mar	133
Polarization SKADI	2024 Oct	2026 Jan	24
Polarization FREIA	2023 Jan	2026 May	28
Polarization TREX	2023 Jan	2026 Mar	24
Polarized gas transfer stations	2023 Sep	2025 Dec	79
Magnetic field devices	2022 Aug	2026 Apr	83
Spin filter assembly	2022 Aug	2026 Sep	57
3He cell IK package	2022 Jan	2026 Jun	64
Source facility for detector testing	2023 Jan	2025 Dec	28

8. REFERENCES

[1] See ESS Re-baselining documents C.26.06.a and Council resolutions C.26.06.c & d in document C.26.99 and resolution C.27.05.c in document C.27.99.
[2] Procurement package for 352 MHz Klystrons
[3] Procurement package for 704 MHz Klystrons
[4] Technical specifications for spoke power stations
[5] Procurement package for the ESS Modulators

DOCUMENT REVISION HISTORY

Revision	Reason for and description of change	Author	Date
1	First issue	Dimitri Argyriou	2022-05-17