Inconsistencies in the European Spallation Source (ESS) Project: Costs levels, User Basis, Scientific Legitimacy and Application of Transmutation Research

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Cost levels: How expensive is ESS? FIVE SCENARIOS

THE SWEDISH GOVERNMENT, February 2007:

- Investments in ESS are set at **1.2 billion euros** (11 billion SEK, 8.9 billion DKK) over a 10-year period
- Operating costs are set at **100 million euros** (930 million SEK, 750 million DKK) per annum in English press release and **130 million euros** (960 million DKK, 1.2 billion SEK) in Swedish press release
- Cost levels are similar to estimates in **Allan Larsson June 2005 report** - *Svenskt värdskap för ESS*
- The Swedish government offers to cover approximately 30% of the planning and construction costs and approximately 10% of the operating costs
- The rest of the financing to come from OECD-countries, whose researchers use ESS in their research, based on GNP, and from the EU as well as from private investors. EU co-financing could cover up to 10% of the investment costs and 50% of the project planning costs
- **THE SWEDISH GOVERNMENT SETS COST LEVELS LOWER THAN ALMOST ALL OTHER SCENARIOS**

Cost levels: How expensive is ESS? FIVE SCENARIOS

THE DANISH GOVERNMENT, October 2003:

- The Danish Minister of Science, Technology and Research, Helge Sander, in the Committee for Science and Technology in the Danish Parliament: Construction costs ("investment costs") for the ESS facility estimated at **1.6 billion euros** (15.1 billion SEK, 12 billion DKK)

Cost levels: How expensive is ESS? FIVE SCENARIOS

THE ESS ORGANISATION 2002 and 2005, ESFRI WORKING GROUP ON NEUTRON FACILITIES, 2003:

- **Second ESS study**, May 2002: Construction costs (staged) **1.6 billion euros** (14.4 billion SEK, 11.6 billion DKK) at 2000-prices, 15% contingency included
- If inflation is included (2.5 % p.a.) until 2009/2010: **2-2.1 billion euros** (18.2-19.5 billion SEK, 14.8-15.9 billion DKK)
- Annual operating costs **142 million euros** (1.3 billion SEK, 1.1 billion DKK,) at 2000-prices, 15% contingency included. If inflation is taken into consideration, operating costs amounts to **182 million euros** (1.7 billion SEK 1.4 billion DKK)
- **The ESS Project, Volume III Update Report**, 2005: Same estimates
- **ESFRI Working Group on Neutron Facilities, Medium to long-term future scenarios for neutron-based science in Europe**, January 2003: Same estimates

Cost levels: How expensive is ESS? FIVE SCENARIOS

SWEDISH GREEN PARTY, October 2005, SWEDISH AGENCY FOR PUBLIC MANAGEMENT, September 2005:

- **Motion in the Swedish Parliament by the Swedish Green Party**, October 2005: Considering that costs of large facilities can grow uncontrollably, the final bill for ESS could be twice the Swedish government/Allan Larsson estimate, i.e. in the order of **2.2 billion euros** (20 billion SEK, 16 billion DKK)
- This scenario is further elaborated by **position paper by the Swedish Agency for Public Management**, September 2005: ESS is mainly financed by contributions from OECD-countries whose neutron researchers use the facility for their research. However, there are significant uncertainties with respect to the size of the contributions that even binding agreements cannot resolve and the risk that these countries abandon these agreements is very real

Cost levels: How expensive is ESS? FIVE SCENARIOS

ESFRI, October 2006:

- **ESFRI, European roadmap for research infrastructures**, October 2006: The roadmap describes Europe's need of research infrastructures over the next 10-20 years, identifying 35 new large scale research infrastructure projects worthy of financial support from EU's R&D budgets
- The roadmap is peer-reviewed
- ESS construction costs: **1-1.1 billion euros** (9.3-9.8 billion SEK, 7.4-7.8 billion DKK)
- Annual operating costs: **80 million euros** (740 million SEK, 600 million DKK)
- THE ESFRI ROADMAP SETS ESS COST LEVELS LOWER THAN ALL OTHER SCENARIOS. NO EXPLANATION IS GIVEN WHY

Cost levels: How expensive is ESS? FIVE SCENARIOS

CONCLUSIONS (I):

- **Costs are generally higher than depicted in the scenarios:** In addition to share of construction and operating costs (plus or minus basic financing originating from the host country's GNP-share among the participating OECD-countries), the host country must donate a site for the facility
- For the most advanced version of the ESS, site requirements are **1-1.2 km2**. Working Group against ESS in Lund: **2.25 km2**

Cost levels: How expensive is ESS? FIVE SCENARIOS

CONCLUSIONS (II):

- Site donated free of charge without tax payments, including access roads, infrastructures, electrical power supplies, telephone and computer links, water mains, emergency preparedness, etc.
- Technical and administrative support will be given by the host country during the first period of the construction phase
- Host country covers any cost arising from site conditions deviating from the reference site specifications
- Also to be taken into consideration: Total costs include completion of more than 40 sets of instruments that must be maintained and replaced over a 40-year period
- **ESFRI Working Group on Neutron Facilities:** SITE SELECTION A DECISIVE FACTOR CONCERNING COSTS OF CONSTRUCTION, MATERIALS, LABOUR, ETC.

Cost levels: How expensive is ESS? FIVE SCENARIOS

CONCLUSIONS (III):

- **ECONOMIC WORST-CASE SCENARIO:** ESS construction costs doubled (Swedish Green Party assessment) in combination with staged ESS facility (ESS organisation assessment): 4-4.3 billion euros (36-39 billion SEK, 30-32 billion DKK)
- EQUIVALENT TO MORE THAN 1 ½ TIMES THE CONSTRUCTIONS COSTS OF THE ØRESUND BRIDGE

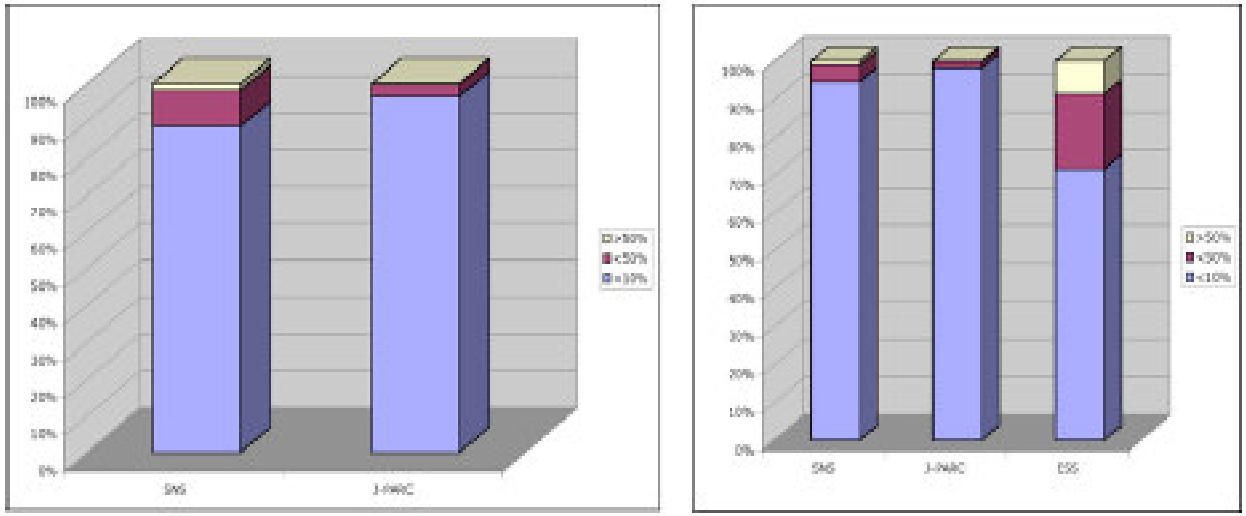
THE ESS SCIENCE CASE: How many researchers?

- **ESS is mainly marketed as a regional development project. Hence, the number of visiting researchers is one of the most important factors**
- **ESS Scandinavia:** ESS facility expected to be visited by **5.000 neutron researchers** annually. This roughly corresponds to the entire European neutron scattering community
- The figure also underpins the Swedish government's decision to financially support ESS in Lund
- **ESS Council report**, March 1997, and **ESS R&D Council**, 1997 and 2000: **Only 2500 visiting researchers** annually with 250 on site at any one time
- **Council of the European Spallation Source Project** in its guideline on how to submit an expression of interest to host the ESS project, November 2001: **2000 visiting researchers**

THE ESS SCIENCE CASE: How many researchers?

- **European Neutron Scattering Association (ENSA) survey**, April 2005: **Less than 30%** of the European neutron researchers expect to use ESS (and SNS and J-Parc) in **more than 10%** of their research and **less than 15%** in **more than 50%** of their research, cf. **Figure** below

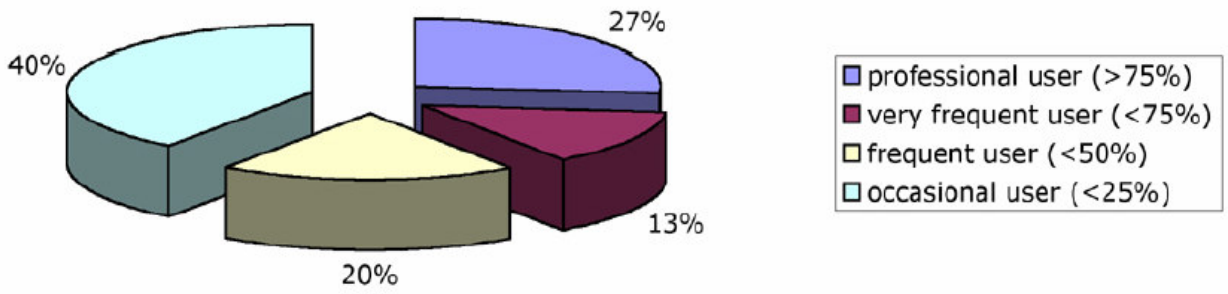
6.2 How large do you estimate the percentage of your research work done with neutrons which will be performed at SNS or J-Parc? and 6.3 How would the situation be with ESS realized during the next 12 years?



THE ESS SCIENCE CASE: How many researchers?

- **ENSA 2005 survey**: 40% of all ENSA-members apply neutrons in less that 25% of their research (”occasional user”) and 20% of all members between 25% and 50% of their research (”frequent user”). 27% of the members apply neutrons in more than 75% (”professional user”) and 13% between 50% and 75% of their research (”very frequent user”), cf. **Figure** below
- ENSA 2005 survey still not published in its entirety

2.4 What percentage of your research programme is related to neutron work?
(This includes also related work, e.g., experiment preparation, data analysis, publication work, etc.))



THE ESS SCIENCE CASE: How many researchers?

- **ENSA survey**, August 1998: 30 Danish neutron researchers in 1997 – a figure that did not change from 1995 to 1997
- 80 Swedish neutron researchers
- 20 Norwegian researchers
- Finland: No neutron researchers in 1995 and 10 in 1997
- TOTAL AMOUNT OF SCANDINAVIAN NEUTRON RESEARCHERS 108 IN 1995 AND 140 IN 1997

THE ESS SCIENCE CASE: Scientific legitimacy

The scientific legitimacy of ESS depends mainly on two things: Limitations of neutron research in general and ESS in particular compared to competing technologies and limitations of ESS in the light of continued neutron development

- **COMPETING TECHNOLOGIES – German Science Council (GSC)**, July 2002: ESS scientific case should be advanced intensively and be better intertwined with the rapid development of other characterisation tools, such as synchrotron radiation, microscopy, spectroscopy (in particular Nuclear Magnetic Resonance (NMR)) and computer simulation
- In GSC assessment of 9 large scale research infrastructure projects, ESS is placed in the third and lowest category
- Continued work on the scientific programmes and technical design of the facilities in this category is required
- As regards ESS, the GSC would consider it necessary to carry out a new assessment

THE ESS SCIENCE CASE: Scientific legitimacy

- **CONTINUED NEUTRON DEVELOPMENT - Paper in the Journal Science**, February 2007: Leading neutron scientists at CCLRC Rutherford Appleton Laboratory and Edinburgh University describe how fusion research can be applied to develop the world's most powerful neutron source for materials science research
- According to the paper, conventional neutron sources such as fission reactors and particle accelerators have already reached their technical limits. In contrast to developments in synchrotron and laser science, in the past 40 years they have seen only a factor of 10 increase in neutron source brightness
- The alternative is powerful lasers to compress and ignite a small pellet of tritium and deuterium, two forms of hydrogen
- The new neutron source is expected to be a least 1000 times more powerful than the best neutron sources currently available worldwide
- The neutron source can be envisaged on a 20- to 30-year time scale
- This leap forward in neutron source capacity is expected to revolutionise neutron science

THE ESS SCIENCE CASE: Application of transmutation research

- By some people, transmutation of nuclear waste is considered to be the hope for the future of a nuclear industry in decline
- Transmutation is the idea of converting long-lived radioactive waste into non-radioactive isotopes or into radioactive isotopes with shorter half-lives
- This will only work if the waste is first reprocessed to remove plutonium and uranium
- Reprocessing, as at Sellafield and La Hague, leads to radioactive discharges considerably greater than those of nuclear power plants, and production of plutonium
- After removal of plutonium and uranium, the remaining waste undergo "partitioning" – which is more complex and potentially more polluting than reprocessing – to separate the long-lived radioactive isotopes from the short-lived and stable isotopes
- The application of transmutation is only meaningful in countries that rely heavily on nuclear power.

THE ESS SCIENCE CASE: Application of transmutation research

A LEGITIMATE CONCERN: Can ESS be applied to transmutation research? And if so, if ESS is built in Lund, could the Oeresund region end up as "the nuclear waste transmutation capital of the world"?

- **WISE-Paris memorandum**, November 2002: Double strategy in the ESS project management process concerning transmutation research
- Transmutation experimentation has clearly been a strategic and logical orientation of the project throughout its development
- Redefinition of the project in 2001 no longer mentions transmutation. However, future adaptation of the redefined project in order to carry out transmutation experiments is both feasible without major technical challenge and economically achievable
- The reasons preventing the ESS Council from maintaining the transmutation option are not technical, but political and financial

THE ESS SCIENCE CASE: Application of transmutation research

- **ESS Scandinavia and ESS Council**, November 2002: ESS will not be used for any activities linked to transmutation, partitioning or reprocessing of spent nuclear fuel or any transmutation related experiments
- **This was the first time that representatives of ESS ever publicly rejected the transmutation option**
- However, it is not contested that the strategic core of transmutation technology, i.e. the advanced accelerator and adapted spallation target, is present in the latest design of ESS and will allow future developments to reintegrate transmutation
- 7 of the 26 neutron scattering facilities around the world have designs comparable with the ESS and most of them are equipped with sub-critical reactors allowing transmutation studies

ESS – a sustainable project?

A LOT OF UNANSWERED QUESTIONS LINGER: Mainly, what would be the result of a comprehensive social, environmental and economical analysis of yet another accelerator based system in Europe, considering:

- **Risk assessments of all parts of the outlined ESS facility and elaboration of worst-case scenarios**. The target stations consist of 30-35 t. mercury, which becomes radioactive during use and have to be stored in a nuclear waste repository for 3000 years after the decommissioning of the research centre
- If the cooling fails, there could be an explosion, which could spread mercury not only over the city of Lund, but the whole region

ESS – a sustainable project?

- **Impact assessments of worst case scenarios on a local and regional scale**: Larger cities near the proposed location of the ESS facility are: Lund (ESS facility 5 km from city centre, 100.000 inhabitants), Malmö (ESS facility 25 km from city centre, 262.000 inhabitants), Copenhagen and the Danish metropolitan region (ESS facility 40 km from city centre, 1.810.000 inhabitants) and Helsingborg (ESS facility 50 km from city centre, 119.000 inhabitants)
- **As of now, four types of facility-specific accidents have been identified**: Traffic accidents with hazardous material, mercury leakage, hydrogen explosion/fire and hydrogen explosion/fire with mercury leakage as a consequence

ESS – a sustainable project?

- **WORST-CASE SCENARIO**: Explosion or fire in a target station weakens the containment, while at the same time the mercury is heated. This causes further evaporation which leads to even higher concentrations in the air. These concurrent factors could cause a dispersal of radioactive and toxic mercury and other material over a vast area
- ESS is a nuclear facility, although not a nuclear power station. The content of radioactive heavy metal in the target stations is equivalent to a little under half of the content of radioactive heavy metal in the Barsebaeck 2 reactor, although the potential release of radioactive substances does not comprise the same elements
- **Nevertheless, impact scenarios regarding a serious accident in the ESS facility in Lund, including the possible negative environmental and economic consequences for the Øresund region, have not been produced**

ESS – a sustainable project?

- **The huge projected investment cost and the projected annual expenditure**. What other budget lines are influenced by this investment in spallation-related science and could the money be used better in order to pursue EU's sustainability strategy?
- **Questionable economic sustainability:** In its position paper (September 2005), **the Swedish Agency for Public Management** questions the ability of ESS to function as a regional development project
- **The significant electricity needs**: Electricity consumption of the facility is set at **120-150 MW**, which is equivalent to the consumption of a Danish city of 89.000 (120 MW) – i.e. 1.2 times the inhabitants of Esbjerg - and 111.000 (150 MW) inhabitants – i.e. a little less than the inhabitants of Ålborg
- **The underlying driving force** is motivated by competition with the US and Japan beyond identifiable scientific rationale
- **Contribution to sustainable development**

ESS – a sustainable project?

CONCLUSIONS

- A thorough, independent investigation on the impact of the ESS project should be made **before** any decision on the viability of the project is taken
- Considering that some of the funding of ESS derives from The European Union and to some degree from the hosting country, the investigation should be a joint enterprise between the EU and the applicant countries
- The investigation should comprise an independent in-depth assessment of the justification, long-term orientation, environmental and social benefit and effects of the project

ESS – a sustainable project?

CONCLUSIONS (continued)

- The project's local and regional safety implications should be analysed as well as the project's role in the EU policy for sustainable development, especially as regards the enormous energy consumption of the research facility
- In order to guarantee the neutrality of the investigation one or more independent research agencies should participate in the enterprise

THE IMMEDIATE FUTURE OF ESS :
Will Denmark co-host ESS in Lund?

- **Danish economic burden in case of parity with the Swedish government:** 440 million euros (3.3 billion DKK, 4.1 billion SEK)
- This estimate is based on the Swedish government's Swedish press release and covers the total costs (construction costs plus operating costs during a 40-year period). Basic financing originating from Denmark's BNP-share among the participating OECD-countries is not included in the estimate
- In September 2003, the Swedish Minister of Education, Thomas Östros, contacted the Danish Minister of Science, Technology and Research, Helge Sander, to inquire whether Denmark would co-host ESS in Lund
- **The Danish Science Minister in the Danish Parliament**, October 2003: **Only 20 Danish neutron researchers** (physics, chemistry and bio-science) can apply ESS in their research. They are mainly scientists from the Risø National Laboratory and Denmark's Technical University

THE IMMEDIATE FUTURE OF ESS :
Will Denmark co-host ESS in Lund?

- Based on the Swedish government's recent proposal and a Danish user community of 20 neutron researchers, Danish/Swedish parity concerning the economic burden of co-hosting ESS in Lund will require a Danish investment of **22 million euros** (165 million DKK, 205 million SEK) for each researcher
- E.g., 22 million euros is equivalent to 57% of the total public and user financed funds, which was appropriated for RD&D in the field of energy in Denmark in 2005, including renewables, or 165% of the funds that were transferred to the R&D budget items "culture, mass media and leisure" in the public research budgets the same year
- **CONCLUSION: Although actual co-hosting seems unlikely, the Danish government might involve itself on a lower level**

THE IMMEDIATE FUTURE OF ESS :
Will Denmark co-host ESS in Lund?

Due to its size, location and potential negative transboundary environmental effects, ESS in Lund is probably more interesting to the Danish Ministry of the Environment than the Danish Ministry of Science, Technology and Research

- Pursuant to Article 3 in the **Espoo-convention** and Article 7 in the **Directive 2001/42/EC of the European Parliament and of the Council on the assessment of the effects of certain plans and programmes on the environment**, the Danish authorities will have to participate in the transnational consultation process with respect to the municipal licensing procedure regarding the ESS facility

THE IMMEDIATE FUTURE OF ESS :
Will Denmark co-host ESS in Lund?

- **So far no invitation to participate has been extended to the relevant Danish authorities**
- ESPECIALLY INTERESTING: Lund Municipality which constitutes the independent public supervisory and licensing authority is itself partner in the private consortium ESS Scandinavia that is responsible for the project
- **This constitutes an argument for early Danish participation and perhaps even intervention in the licensing procedure**

THE IMMEDIATE FUTURE OF ESS:
New ESFRI developments?

- **ESFRI European roadmap for research infrastructures**, October 2006: Identifies 35 projects for new large scale research infrastructures that are considered crucial pillars to strengthen the European research area
- The projects listed in the road map could – if they materialise – expect financial support from EU's R&D budgets
- The road map lists the ESS project together with 6 other projects in the field of material sciences, stating among others that in order to maintain EU leadership, "the ESS represents a high priority on an international basis"
- **EU co-financing could cover up to 10% of the investment costs and 50% of the project planning costs**

THE IMMEDIATE FUTURE OF ESS:
New ESFRI developments?

NEW ESFRI APPROACH:

Carlo Rizzuto, Future chairman of ESFRI, present chairman of the Roadmap Working Groups, September 2007: **LESSONS LEARNED IN THE FIRST EDITION OF THE ROADMAP - What is needed?**

- **Transparency**: Open internal discussion and clear external communication
- **Clarity**: Scientific case and all other relevant aspects must be well defined
- **Long term view**: Which commitments required to ensure realisation and access?
- **Credibility**: Is there in Europe the capability of realising the proposal and operating it?

THE IMMEDIATE FUTURE OF ESS: New ESFRI developments?

- **COULD EUROPEAN ESS FINANCING BE IN JEOPARDY?** If negotiations drag on, possibly. It could be argued that the ESS project does not live up to revised ESFRI standards for transparency, clarity, long-term scientific legitimacy or credibility
- **LOOK FOR ESS SCANDINAVIA TO OPT FOR QUICK FINANCIAL SOLUTION**. Time works against, not for the ESS project
- **Timing and outlook for new Roadmap:** ESFRI will finally decide projects on updated Roadmap by July 2008. The update will be published October 2008