

# An exploration for a feasible fusion energy research strategy in Korea

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## 1. Introduction

Recently, the fierce competition between European Union (EU) and Japan to host the International Thermo-nuclear Experimental Reactor (ITER) has aroused in Korea renewed interests in fusion research and its prospect for commercial fusion power generation. Korea has committed itself in 2003 to the construction and operation of ITER which spans three decades. This 30-years-long commitment to ITER surely is longer than any other scientific and/or technological venture that has ever been taken up after its birth in 1948. ITER poses both as a great opportunity for Korea, allegedly but not convincingly enough, and as a potential ‘black hole’ sucking in all resources for future energy researches, to the domestic technical communities and industries. However, ITER and fusion research is not just a technico-industrial issue but may as well be a politico-security issue, like many other apparent technology issues such as recent participation in the Galileo project. In this article, the authors will explore this situation with an emphasis on domestic and foreign constraints and propose a realistic and verifiable strategy to address these issues and to develop fusion energy in Korea.

## 2. External constraints on fusion research in Korea

### 2.1. The short-term constraint: ITER and ‘Fast Track’

ITER can be best described as an experimental fusion reactor which aims to prove engineering issues required for power plants such as breeding blanket and steady-state operation technologies. The “Fast Track” strategy to commercial fusion has been first proposed in the so-called King Report [1] of European Union. It concludes to shorten the conventional 4-stage roadmap to a 3-stage “Fast Track” roadmap. (see Figure1) This strategy is the direct result of the R&D achievements such as discovery of the “advanced tokamak (AT)”

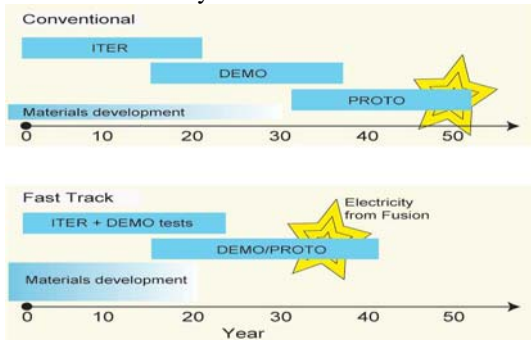


Figure 1. Comparison of the conventional 4-step roadmap and the 3-step “Fast Track” roadmap.(source: Euratom-FOM) operation techniques at present large machines during the 1990’s. In fact, the first generation commercial fusion power plants such as DEMO, which are based on present-day ITER-like AT reactor core physics with minimal additional improvements, are predicted to already achieve realistic cost competitiveness comparable to that of fission power plants.[2]

The Fast Track strategy can seriously influence policies of those governments who intend to develop their own fusion energy technologies: *ITER poses as the last and the only chance currently available* before the first fusion power plant DEMO is built, where risks of large-scale R&D investment can be shared as well as technical resources. In view of this, Korea’s decision to participate in the final ITER negotiation processes must be judged as adequate and timely. But the real problems still remain: is there a timely, realistic, and verifiable plan for Korea to purposefully utilize the ITER project and thus to arrive at the final and essential goal, i.e. commercialization of fusion energy? What are the specific breeder blanket issues to be tested and verified at ITER? Verification for what purposes?

### 2.2. The long-term constraint: the Kyoto Agreement and global CO<sub>2</sub> reduction

The key issue here, as recently substantiated by the Kyoto Agreement, is how to restructure energy production and consumption patterns, especially to reduce the usage of CO<sub>2</sub>-producing fossil fuels in transportation and electricity production. Despite the current un-willingness of some of the major industrial and/or developing countries, global CO<sub>2</sub> reduction is believed by many, especially European countries, to become effective in any foreseeable future. This inevitably will require corresponding restructuring of energy technology investment portfolio and R&D strategies.

A long-term study on energy market changes under this policy, utilizing sophisticated tools such as MARKAL, can be exemplified by the recent European “Socio-Economic Research on Fusion (SERF)” program. According to SERF projections for the year 2100 [3], the EU energy market is likely to be restructured around the combination of renewable energy and advanced nuclear energy (fusion and fission). Minimized consumption of fossil fuels is inevitable. (see Figure2 below) As this SERF prediction exemplifies, almost all long-term projection studies of energy market produce a similar conclusion: *global*

CO<sub>2</sub> reduction is doubtlessly the single most important factor for nuclear energy to remain competitive in future energy market. With a global CO<sub>2</sub> reduction in effect, nuclear energy is very much likely to remain an important source of electricity in future society. Fusion will penetrate fast into the market once commercial plants become available in 2040~2050, and its market share will grow fast to ~15%.

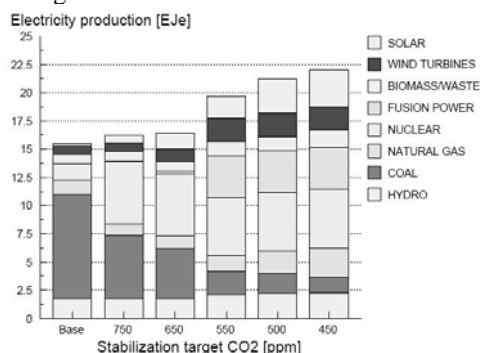


Figure 2. Market share by target energy source in 2100 for different target CO<sub>2</sub> concentrations. A “rational perspective” is assumed, instead of “market-driven” condition. From ref.[3].

### 3. Fusion: another key to sustainable nuclear energy

*Sustainability* has become one of the key issues of the energy industry, as well as of macroeconomics. For energy industry, revolutionized in the past century by the deregulation process and the collapse of traditional monopoly, the consumers (or voters) became the inescapable primary factor in its business. Sustainability viewed in this way necessarily invokes intergenerational consumer-oriented issues such as quality of life and lifestyles, public acceptance, and so on.

Despite the deteriorating public acceptance of nuclear energy in Korea, recent developments shed some new light on the prospect for a more rational decision-making processes based on autonomous and democratic communications among the parties involved including the voters. Such positive developments *must* be accompanied by corresponding advances in industry and technologies to supply the consumers with “acceptable” energy products, hence establishing a “sustainable” nuclear energy market for the future generations. In this regard, it must be pointed out that advanced fission reactors such as HTGCR and fusion reactor share sufficient technological common grounds and common needs that deserve and necessitate a carefully examined coordination of joint development plans and strategies. They are all essential components of sustainable nuclear energy program in Korea, as evidenced by SERF results.

Such a *holistic approach to nuclear energy* can be best exemplified by the case of France and Japan, where various nuclear resources are coordinated and relocated timely and effectively, leading to successful modernization of domestic nuclear industries. Another case worth considering will be that of Germany, where various nuclear resources have been successfully relocated to fusion with public support [4].

Consequently, Germany continue to play a leading role in European and world fusion energy research, similar to UK and Italy.

### 4. Fusion as a potential new nuclear industry

Unlike previous fusion projects ITER is being approached in a business-like fashion, both in practice and in policy, as a large-scale construction project [6]. The most significant effect of this on the industries is that it offers a *visible* possibility of a whole new nuclear energy industry, and thus a novel energy *market*. In addition, supports from governments and other public sectors can motivate and encourage risk-taking long-term investments from the interested industries. This in return will accelerate the industrialization of new fusion nuclear technologies previously bounded within research institutions and universities, as well as expansion of existing nuclear power technologies.

The long, large-scale investment in fusion research can be justified only by the achievement of its essential goal, a new nuclear energy industry and a new energy market. This is possible only when fusion energy research is carried out under a engineering-oriented, plant-driven strategy.

### 5. Conclusion: KDEMO, a vision and reference frame for fusion energy research in Korea

The key element of this strategy is a *vision* that can serve as a reference frame to coordinate and organize all the fusion research activities, including ITER participation. A Korean demonstration fusion power plant, KDEMO, can play the role and provide with the vision both feasible and verifiable.

KDEMO will proceed in three stages. Phase-I is for the conceptual design of KDEMO as well as preparation for verification experiments at ITER. Phase-II is for the engineering design, along with tests of various blanket modules at ITER which in the end will finalize KDEMO blanket design. Phase-III is for KDEMO construction and operation, hence contingent upon the conclusion from Phase-II, domestic policy considerations at the time, and international discussions on DEMO.

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