Economic Analysis on ITER-PWR fusion hybrid

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1. Introduction

In this paper, rough economic analyses are given for conceptual design of ITER-PWR fusion hybrid. These brief economic analyses are based on detailed economic analyses of ITER and PWR. ITER-PWR capital costs and operating expenses are estimated based on those of ITER and PWR. These costs and expenses are compared with the PWR. At the conclusion some suggestions are given to improve the economical efficiency of ITER-PWR.

2. ITER-PWR Construction and Operating Costs

Approximations for the construction and operating costs of ITER-PWR fusion hybrid can be obtained by modifying each estimate of ITER and PWR. These modifications give a new estimate for the blanket cost, cost additions from electric plant equipment and reductions on operating costs. Decommissioning costs are assumed to be not changed. it is assumed that just materials costs are added to the original estimate.

Table I: Summary of ITER Direct Capital Costs in Millions of US Dollars (2000 US)

	Direct Capital Cost	Percentage of Total	Deferred Investment
Magnet Systems	$1,059.32	27.67%	$55.88
Vacuum Vessel	$319.70	8.35%	$0.00
Blanket System	$229.63	6.00%	$11.95
Divertor	$105.64	2.76%	$9.59
Machine Assembly	$128.85	3.37%	$0.00
Cryostat	$105.36	2.75%	$0.00
Thermal Shields	$40.03	1.05%	$0.00
Vacuum Pumping & Fueling System	$47.54	1.24%	$9.45
Machine Core, subtotal	$2,036.07	53.17%	$86.88
R/H Equipment	$84.93	2.22%	$72.70
Cooling Water Systems	$182.79	4.77%	$23.35
Tritium Plant	$50.87	1.33%	$62.83
Cryoplant & Distribution	$123.57	3.23%	$10.98
Power Supplies & Distribution	$298.43	7.79%	$4.87
Buildings	$528.62	13.81%	$16.68
Waste Treatment and Storage	$2.92	0.08%	$9.73
Radiological Protection	$1.39	0.04%	$4.45
Auxiliaries, subtotal	$1,273.52	33.26%	$205.58
IC H&CD	$44.76	1.17%	$2.78
EC H&CD	$107.73	2.81%	$4.17
NB H&CD	$133.44	3.48%	$0.28
Heating and CD, subtotal	$285.92	7.47%	$7.23
Diagnostics	$164.02	4.28%	$58.80
CODAC	$69.50	1.82%	$0.00
Grand Total	$3,829.03	100.00%	$358.48

ITER-PWR's blankets holds 17.5 tons of 95% Li6 enriched lithium titanate and 87.2 tons of beryllium. According to "The Effect of Different Blanket Technologies On The Cost of Fusion Electricity", the price of Be is $260/kg and the price of Li_2O is $600/kg. The cost of lithium titanate is calculated from the Li_2O number by assuming that most of the $600/kg for Li_2O stems from the cost of the Li6 enriched lithium (90~95%) because there isn't the estimate for lithium titanate. Since the ratio of the molecular weights for Li_2O/Li_2TiO_3 is about 0.3, the cost for lithium titanate will be around $200/kg. The blanket modules cost an

additional $26,000,000 (for the Be: $23,000,000, for the lithium titanate: $3,000,000)

The cost addition of other related equipment and installation will be $5,000,000,000 for PWR producing 1350MWe. By linearly scaling with electric power, the power generation equipment and installation for ITER-PWR are estimated $500,000,000. Summing this with the ITER capital cost ($3,800,000,000), Management and support during construction ($600,000,000), and the blanket material cost ($26,000,000), the total capital and construction cost for ITER-PWR will be about 5 billion dollars.

As for the operating costs, ITER-PWR's operating costs assumed to be $210,000,000/year because ITER-PWR is self-sufficient in terms of both energy and tritium breeding.

Having determined the construction and operation costs of ITER-PWR, the breakeven COE can be easily estimated. A 90% capacity factor and a useful reactor lifetime of 1 batch cycle is assumed, giving an operating period of 40year. This implies a total of 1.064×10^{10} kW-hour/year for sale from a 1350MWe ITER-PWR. Without considering loan costs, the breakeven COE is simply:

$$X = \frac{TO + C + D}{TE} \quad (1)$$

Where X is the COE, T is the operating period, O the operating costs per period, C the construction costs, D the decommissioning costs, and E the total energy per period for sale. Equation 1 gives a breakeven COE of $0.036/kW-hr for ITER-PWR based on the above assumptions.

3. Economics Discussion

The estimated COE is low, since loan costs are not considered, and the capital cost additions are probably generous. For example, the calculations here does not take into account possible additional safety equipment costs that might be required from adding fission, the possible additional costs incurred from upgrades for steady state operation, the extra costs associated with processing the tritium blankets, or any operating profits.

The main concern is the large operating cost. The operating cost calculated in this paper is approximately 3~4 times larger than that of the PWR when normalized by power output.

4. Conclusions

In this paper, the economics of ITER-PWR are estimated from that of ITER and PWR by assuming the tokamak for ITER-PWR has the same construction and operating costs as ITER, the breakeven COE is approximately $0.036/kW-hr. The operational cost is estimated at $210M/year.

REFERENCES

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