§20. Characteristics of D-^{3}He Fueled FRC Reactor: ARTEMIS-L

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This report introduces briefly the scenario and discusses the attractive characteristics of D-^{3}He fueled commercial fusion reactor ARTEMIS-L.

The selection of the plasma temperature of 83.5 keV and helium-3 density of 1.35 times the deuterium density makes the minimal of the neutron yields [Table.1].

Table.1 Plasma parameters of ARTEMIS-L

Electron Density	5.1×10^{20} m^{-3}
Density Ratio of ^{3}He and D	1.35
Averaged Plasma Temperature	83.5 keV
External Magnetic Field	5.36 T
Averaged Beta-Value	98 %
Energy Confinement Time	6.9 s
Fusion Power	1757 MW
Neutron Power Fraction	0.032
Heating Power (NBI)	100 MW
Plasma Radius×Plasma Length	1.68 m×22.2 m
Plasma Current	189 MA

A field-reversed configuration (FRC) appears to meet these requirements for D-^{3}He fusion, which is experimentally stable with high plasma-beta value much higher than 50% if their averaged gyroradius is comparable to the plasma radius. Open lines of force in free space surround an FRC plasma, that allow us to install a high power direct energy converter system [1]. Table 2 lists engineering characteristics of ARTEMIS-L reactor. The neutron load gives us the life of structural materials of 30 years.

The cost of electricity (COE) from ARTEMIS-L can be estimated after ESECOM [2] studies approximately [Table 3]. The assumed cost of helium-3 is 0.2 M$/kg. This assumption affects slightly the cost of electricity and an expensive cost of helium-3 by a factor 5 gives still a cheep COE as 38.4 mill/kW.h.

We are now studying a possibility of introduction of an advanced direct production of hydrogen and thermoelectric and galvano-magnetic converters instead of a turbine-generator [3].

Table 2 Engineering characteristics of the reactor

Fusion Power	1,757 MW
Output Electric Power	1,000 MWe
Power to Heat Converters	668 MW
Power to TWDECs	526 MW
Power to Cusp DECs	563 MW
Total Weight	4,900 tons
Total Length	160 m
Maximum Magnetic Field	6.3 T
Radius of the First Wall	2.28 m
Heat Load on the First Wall	2.0 MW/m^2
Neutron Load on the First Wall	0.18 MW/m^2

Table 3 The estimated cost of electricity

Net Electric Rating (P_E)	1,000,000 kW
Total Direct Cost	1,030,000,000 $
Total Capital Cost (C_T)	1,800,000,000 $
Annual Capital Cost ($C_a = C_T\times0.0844$)	
O&M Cost (C_{om})	36,000,000 $
Fuel Cost (C_f)	13,000,000 $
COE = $[C_a + C_{om} + C_f]/[P_E\times8760\times0.75]$ = 0.0304 $/kW.h	
Assumptions: a fixed-charge rate of 0.0844, interest during the construction of 8.56%/yr, and a capacity factor of 75 %.Costs are in constant 1986 U.S.Dollars.	

We conclude as follows :

1: A complete scenario to obtain and sustain a burning plasma is available. Nevertheless, experimental data bases available to construct the reactor are very poor. Extensive studies on FRCs and experimental verifications of the scenario (the Proof of Principle) are urgent.

2: Engineering bases applied in D-^{3}He fueled ARTEMIS-L design are conventional. Developments of high power-high energy neutral beam injectors and highly efficient direct energy converter systems are necessary.

3: The cost of electricity (COE) from ARTEMIS-L reactor is estimated to be cheaper than that obtained with a present power plant. The cost of ^{3}He affects only slightly on the COE.

4: Inherently safe and environmentally sound characteristics of ARTEMIS-L is intrinsic to D-^{3}He Fusion.

References

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2) Holdren,J.P.,, et al., UCRL-53766 (1989)
3) Sudo,S., et al., ICENES'93, (1993) 507 and Yamaguchi,S., et al., ICENES'93, (1993) 502.