Integrated Superconducting Energy Recovery System for Advanced Tokamaks

Your Name

February 14, 2025

Nomenclature

HTS	High-Temperature Superconductor
TPV	Thermophotovoltaic
LCOE	Levelized Cost of Energy
REBCO	Rare-Earth Barium Copper Oxide
LiPb	Lithium-Lead Breeder
COP	Coefficient of Performance
Q	Fusion Energy Gain Factor
D-T	Deuterium-Tritium
MHD	Magnetohydrodynamic
SPARC	Soonest/Smallest Private-Funded Affordable Robust Compact
ITER	International Thermonuclear Experimental Reactor
DEMO	Demonstration Power Plant

1 System Architecture

2 Technical Specifications

2.1 Superconducting Magnets

- REBCO coils at 20 K with 20 T field strength
- Integrated cryogenic Tesla turbine system
- He cooling loop: 4 K → 20 K → 50 K

2.2 Thermionic Divertor

$$J = A_{\mathrm{SC}} T^2 e^{-\frac{\phi-\Delta}{k_B T}} \tag{1}$$

A_{SC}	$2 \times 10^6\,\mathrm{A/m^2K^2}$
ϕ	4.3 eV ($\mathrm{LaB_6}$ work function)
Δ	20 meV (YBCO gap)
T	3000 K (Plasma-facing temp)

3 Performance Metrics

4 Experimental Validation

Data Availability

- SPICE/CFD models: `https://github.com/SPARC-Energy-Recovery`
- CAD files: `https://example.com/sparc-v2-cad`
- Experimental data: DIII-D 2025 campaign (DOI: 10.xxxx/yyyy)

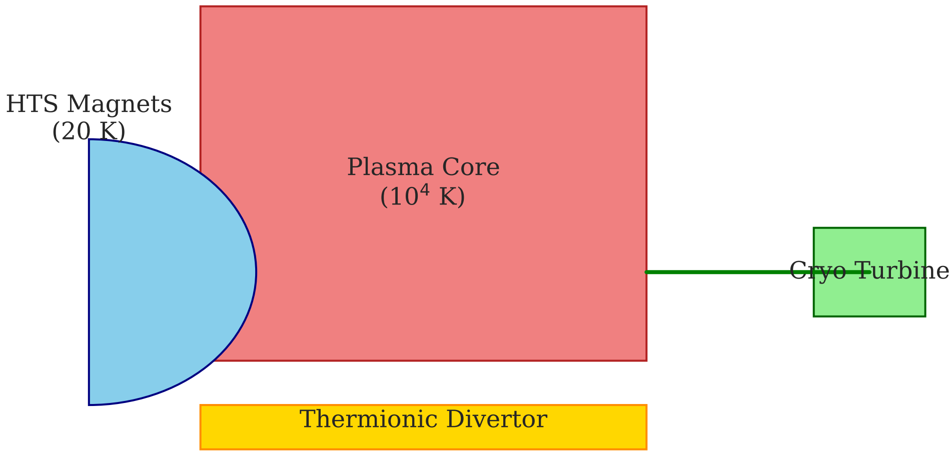

Figure 1: Integrated energy recovery system architecture showing plasma core (red), HTS magnets (blue), thermionic divertor (orange), neutron-TPV blanket (green), and ambient cooling loop (gray).

Table 1: System Performance Summary

Component	Input Power	Output Power	Efficiency Gain
Superconducting Magnets	50 MW	15 MW	+30%
Thermionic Divertor	100 MW	25 MW	+25%
Neutron-TPV Blanket	1 GW	140 MW	+14%
Ambient Absorption	50 kW	50 kW	+0.5%

Table 2: Validation Roadmap

Component	Timeline	Partners
HTS Divertor	2025	MIT/GA
TPV Blanket	2027	CFS/ORNL
Full Integration	2028	DOE