



MIRA: a Multiphysics Approach to Designing a Fusion Power Plant

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Motivation

- ☐ Systems codes (SC) are vital tools for the design of fusion power plants (FPP)
- ☐ Existing SCs in the EU-DEMO conceptual design (PROCESS, and SYCOMORE) rely on rather basic physics and engineering models (0D/1D)
- ☐ Main goal: refine SC modelling (up to 3D) to improve interfaces between SCs and detailed design codes
- ☐ MIRA → a multi-fidelity reactor design code for a multiphysics approach towards an integrated FPP design

MIRA Physics and Engineering Modelling

Reactor Integration into Plant System



- ☐ Integral plant power balance
- ☐ Reactor pulse characterization

Reactor Architecture



- 2D geometric construction
- Blanket material composition
- □ Coil cable technology

Coils Engineering





- □ 3D magnetostatics
- Magnetic field, force, energy
- □ Toroidal field ripple
- □ Conductor design

MIRA **Multiphysics Approach**

Reactor neutronics

- 2D n-γ plasma chamber
- □ 1D n-γ reactor
- □ TBR, nuclear heating
- ☐ Neutron shielding, dpa

Magnetic Equilbrium & Plasma Physics

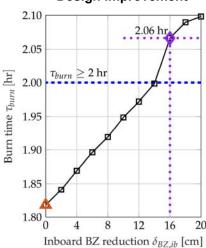


- ☐ 2D free-boundary equilibrium
- ☐ 0D plasma power, particle, current integral balances
- SOL plasma power balance
- Divertor peak heat flux

MIRA Analysis of the EU-DEMO 2015 baseline from PROCESS

Parameter [unit]	MIRA	PROCESS	Type
Plasma major radius [m]	9.07	9.07	
Plasma aspect ratio [-]	3.1	3.1	1
Toroidal field at plasma center [T]	5.49	5.67	0
Plasma current [MA]	19.26	19.60	0
Fusion power [MW]	2037	2037	DT ≈ 2000
Radiation power [MW]	304.2	305.5	0
Additional heating power [MW]	50	50	DT ≈ 50
Transport loss across the separatrix [MW]	154.1	154.2	0
TBR (HCPB/WCLL) [-]	1.20/1.14	n.a.	$DT \geq 1.05$
Total thermal power (HCPB/WCLL) [MW]	2624/2371	2436	0
Net electric power (HCPB/WCLL) [MW]	365/350	500	$\text{DT} \sim 300\text{-}500$
Plasma Burn time [hr]	1.81	2.00	$DT \ge 2 hr$

Design Improvement



Conclusion

- ☐ Advanced reactor systems analyses highlight non-trivial interdependencies between different reactor systems.
- ☐ Refined 2D/3D reactor design codes like MIRA are beneficial to the conceptual design of DEMO and of FPPs.