ITER- "International Thermonuclear Experimental Research Program" by L. J. Perkins

A GOAL-DIRECTED, INTERNATIONAL UMBERALLA ORGANIZATION TO DIRECT WORLD FUSION R&D TOWARDS AN ATTRACTIVE END PRODUCT.

Each of the following would be an international facility/program with an international team of scientists. Each party gets at least one facility (thus solving the ITER siting question!). The total program cost would be about that of ITER (~$10B single machine + base program) and, very importantly, is a flexible, goal-directed program towards an attractive end point. This end point must be a fusion device which is "economically"[1] competitive with passively-safe, advanced fission reactors, our major competitor in the mid 21st century . Note that this would delay the ETR/DEMO step (i.e the present ITER and beyond) until the reactor product has been identified. This is the only way that a credible DEMO can be defined.

(1) ***A DT ignition test facility***: one of CIT, BPX, IGNITOR, IGNITEX, etc, to provide information on bulk alpha effects, ignited plasmas and thermonuclear burn processes (cost ~$1.5-3B)[2].

(2) ***An expanded, more ambitious international TPX (steady-state advanced tokamak experiment):*** for testing long pulse & steady-state operation, divertors, conventional advanced current-drive, and especially advanced beta and confinement, etc (cost ~$1.5B)

(3) ***A high fluence, accelerator-based neutron source and an advanced materials program***: (cost ~$1B) To exploit the safety & environmental aspects of fusion, especially in the area of low activation, low afterheat materials

(4) ***A pilot plant*** (cost ~$2-3B) A machine for integrated testing of reactor relevant systems (blanket/shield, etc) together with tritium and neutrons (neutron wall loading~1MW/m^2). Non-reactor-relevant core, probably highly driven ($Q \leq 1$) and probably copper magnets[2].

(5) ***Advanced fusion program:*** (cost ~$1-2B): To pursue and objectively examine ideas for fusion concepts -- magnetic, inertial and others -- that offer the potential for a step change in cost and complexity over present, conventional reactor approaches. This will necessitate investigation of new or relatively unexplored physics areas as distinct from refining the engineering for the present approach

Total cost ~$7-10B, i.e ~same cost as ITER EDA single machine

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[1] By "economic" here, we mean under all contingencies: capital costs, operating costs, availability, fuel costs, fuel reserves, safety, environment, waste disposal and decommissioning. Thus, the cost and complexity of the fusion power core may be offset to some extent by the other factors, but the overall economic envelope must be competitive.

[2] These facilities (Ignition Test Facility and Pilot Plant) could, conceivably, be based on the ST rather than the conventional tokamak

NORMAL-CONDUCTING COPPER OPTIONS FOR THE ITER "PROGRAM"

STRATEGY	RESULT
NORMAL-CONDUCTING ITER Normal-conducting copper machines with same physics margins as super-conducting ITER: • Steady-state magnets and PFCs • Ignition @ H = 2.0 • τ_{pulse} = 200 — 1000 sec • Fluence = 0.1 — 3 MWy/m^2	• R = 4.6 — 5.3 m • I_p = 14 — 16 MA • A = 3.3 — 3.9 (for min. cost) • Magnet power = 650 — 820 MW • Cost rel. to ITER CDA = 0.8 — 0.95
LONG PULSE "BPX" Normal-conducting copper machine with same physics margins as BPX but long pulse: • Steady-state magnets and PFCs • Q ~ 10 @ H = 1.85 (ignition at +1σ) • τ_{pulse} ≥200 sec • Fluence: very low (≤0.01MWy/m^2)	• R = 3.8 — 4.0 m • I_p = 12 — 15 MA • A = 3.2 — 3.6 (for min. cost) • Magnet power = 405 — 490 MW • Cost rel. to ITER CDA ~0.60
SHORT PULSE BPX Normal-conducting copper machine with same physics margins as BPX and short pulse: • Inertial magnets and PFCs • Q ~ 10 @ H = 1.85 (ignition at +1σ) • τ_{pulse} ~ 5 — 10 sec • Fluence: very low (≤0.01MWy/m^2)	• BPX!, i.e: • R ~ 2.6 m • I_p ~ 10.6 MA • A ~ 3.26 • Magnet power ~300 MW (short pulse) • Cost rel. to ITER CDA = 0.25 — 0.3

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