Assessment of Power Core Parameters and Related Costs (Part-III)

L. El-Guebaly

Fusion Technology Institute
UW - Madison

Contributors:
L. Waganer (Boeing), J. Lyon (ORNL),
and X. Wang (UCSD)

ARIES-CS Project Meeting
April 27 - 28, 2006
UW

Contents

- Revised costing accounts (in 2004$):
  - **# 21: Structures & Site Facilities**
    - # 21.2: Reactor Building
  - **# 22: Reactor Plant Equipment**
    - # 22.1.5 Primary Structure
    - # 22.1.6: Vacuum System
- Shield vs NWL scaling law.
- Cryogenic heat load to magnet.
- Sensitivity of COE to availability and LSA.
- Radwaste volume comparison
- Future plan.

Account # 21.2
(Reactor Building)

ARIES-CS building volume V_{RB} (in m^3) = 1.3 x 10^5 x 1.3[#] , per Les and Xueren

<u>Old</u> costing algorithm (R. Miller):

Cost (2004 M$) = [77.1 ($V^{\#}_{RB}$ / 80,000)$^{0.62}$] x LSA Factor x 1.256[*]

<u>New</u> costing algorithm (L. Waganer):

Cost (2004 M$) = [33 + 0.00025 x V_{RB}] x LSA Factor

ARIES-	**RS**	**AT**	**CS**	
LSA	2	1	2	
21.2 Reactor Bldg (M$ - 2004$)	**~ 160** old	**~ 100** old	**~ 140** old	**~ 68** new

New costing algorithm results in factor of 2 lower building cost

Correction factor to account for unaccounted buildings.

* 2004$ = 1992$ x 1.256, per Les.

Account # 22.1.5
(Primary Structure)

Cost (2004 M$) = [volume x steel density (7.8 gm/cm^3) x vol. fract. (0.95) x unit cost (~25 $/kg)] x LSA Factor x 1.256

Volume = 18.4% FPC volume

FPC volume* = **actual** volume of FW + blanket + divertor + shield + VV + winding pack + coil structure (including bucking structure)
≈ 400 m^3

ARIES-	**RS**	**AT**	**CS**	
			1/06	**3/06**
LSA	2	1	2	
21.1.5 Primary Str. (M$- 2004$)	**67**	**34**	**46**	**~ 90**

* Should not include primary structure, cryostat, bioshield, nor buildings.

Account # 22.1.6
(Vacuum System)

Includes cost of VV, cryostat, and pumping system

ARIES-	RS	AT	CS		
LSA	2	1	2		
			9/05	1/06	3/06
VV	62 (20-30 cm)	922 (25-40 cm)	53 (28 cm)	55 (28 cm)	? (~55) (28 cm)
Cryostat	100 (4.3 cm)	9 (0.4 cm)	0 (0 cm)	? (~75) (8 cm)	? (~50) (5 cm)
Pumping System*	38	23	81	?	?
21.1.6 Vacuum System (M$- 2004$)	200	124	134	96 (should be >130)	? (should be >100)

ARIES-CS pumping system is too expensive. Why?

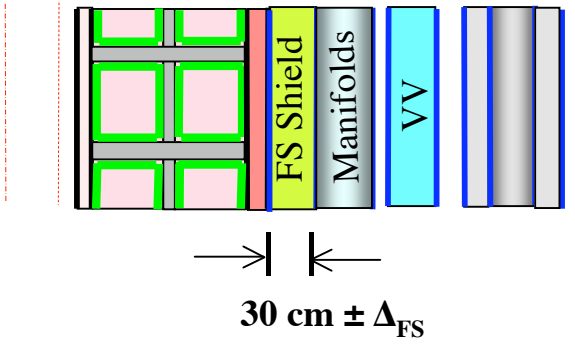
* Depends on plasma parameters.

Shield vs NWL Scaling Law

(Near-final radial build; average □ ~ 3 MW/m^2)

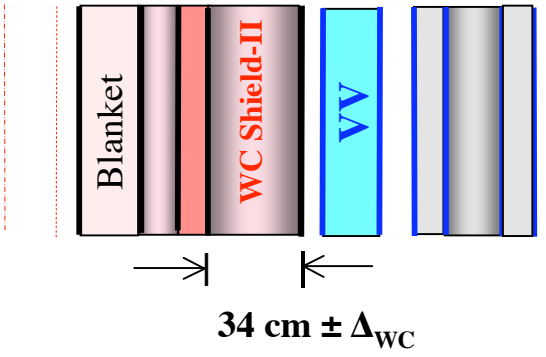
- **Incremental change to nominal 30 cm FS shield:**

$$\Delta_{\text{FS-shield}} = 7.3 \ln(\bar{\square} / 3)$$



- **Incremental change to 34 cm WC shield-II @ Δ_{min}:**

$$\Delta_{\text{WC-shield-I}} = 5.9 \ln(\bar{\square} / 3)$$



* Δ in cm and average □ in MW/m^2.

Cryogenic Heat Load to Magnet

(Near-final radial build; average □ ~ 3 MW/m^2)

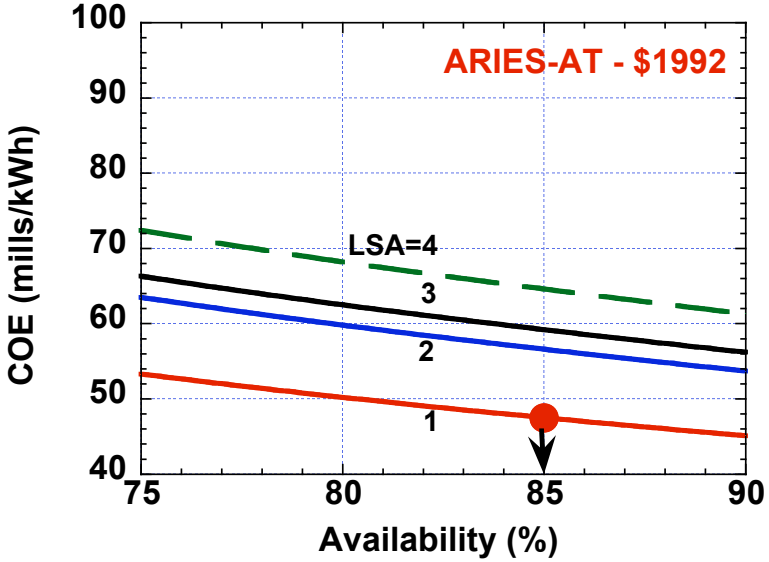
Assumptions:

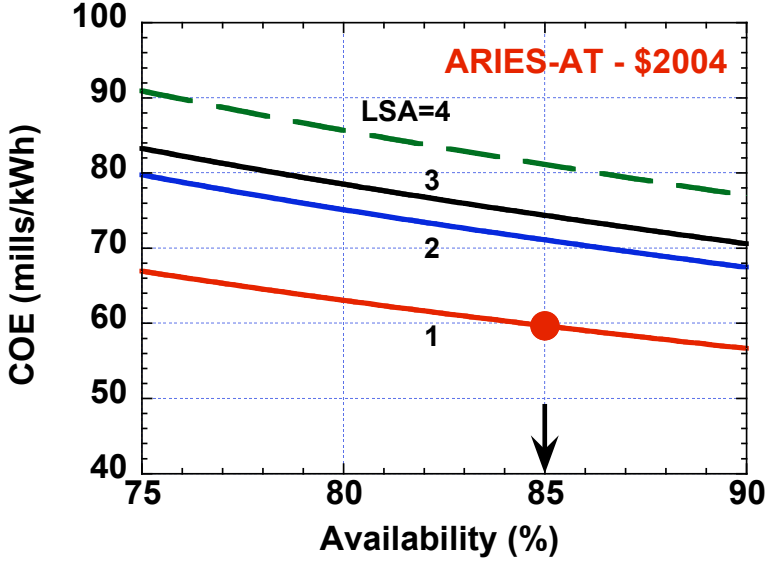
- Winding packs (WP) cover 32% of area.
- Inter-coil structure covers 68% of area.
- WP and structure @ 4K.
- 300 W_e to remove 1 W of nuclear heating.

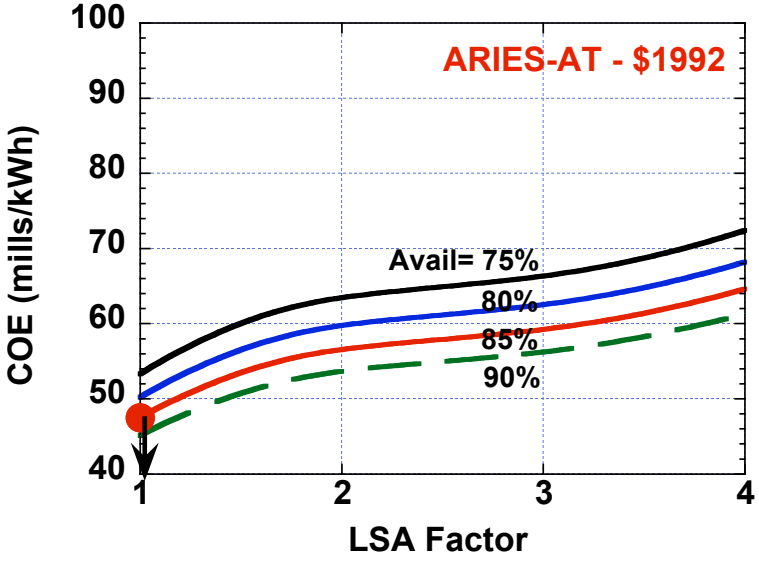
	Nuclear Heating (kW)	Cryogenic Load (MW_e)
2 cm Coil Case	2.0	0.6
18 cm Winding Pack	2.9	0.7
66 cm External Structure*	0.07	0.02
subtotal	**5**	**1.5**
35 cm Inter-coil Structure	**10.7**	**3.2**
Total	**16 kW**	**~ 5 MW_e**

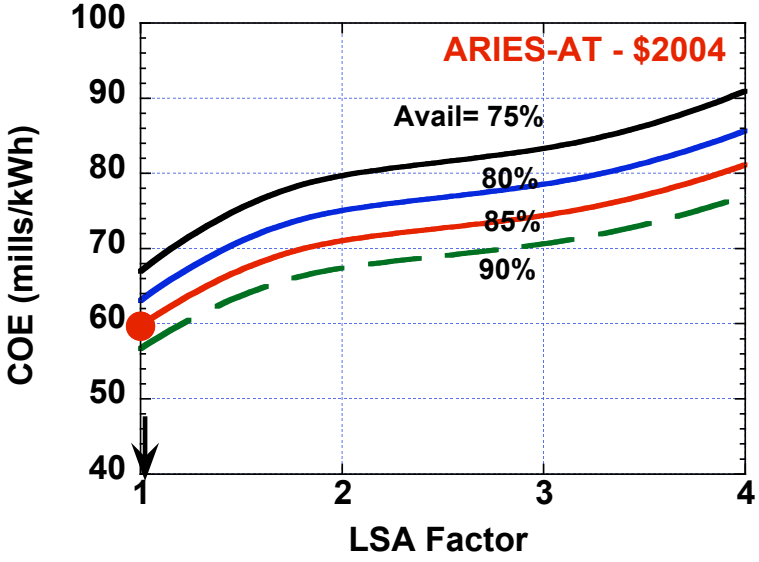
* Behind WP only.

Sensitivity of ARIES-AT COE to Availability and LSA

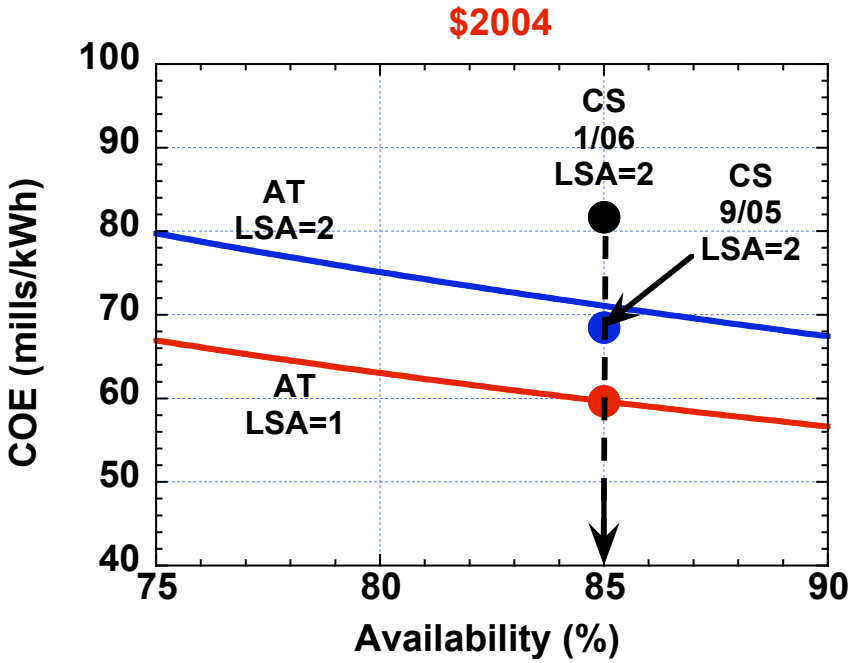


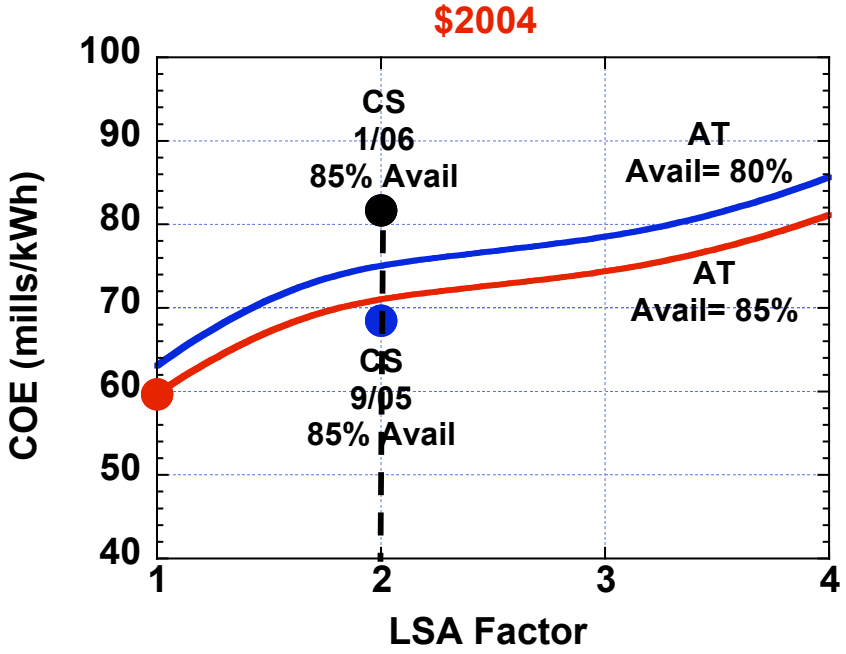






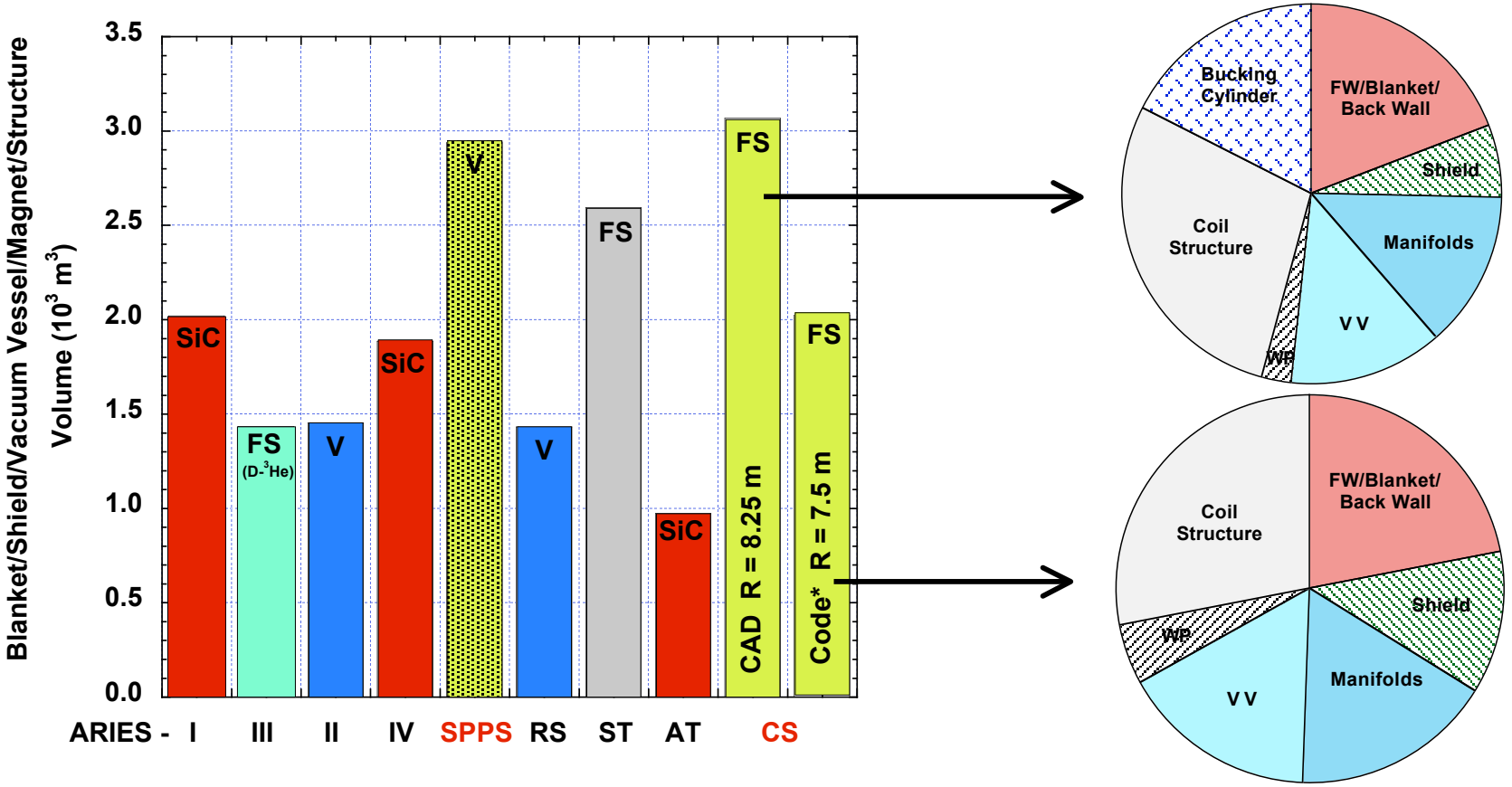
Sensitivity of COE to Availability and LSA





Radwaste Volume Comparison

(not compacted, no replacements)
(cryostat and bioshield excluded)



Compared to 8.25 m machine, more compact 7.5 m ARIES-CS **and** removal of bucking cylinder reduced waste volume by 30%

Future Plan

- Changes to Systems code:
  - 30 $/kg of WC, per Les
  - availability: 80 or 85% ? TBD.

- Provide radial build for LiPb/SiC design to systems code

- Provide radial build for 2 FP configuration to systems code