Dear Mahmoud and Dave,

Hesham Khater forwarded to me a memo from Mahmoud with some comments from Dave related to the waste volume in liquid vs. solid wall concepts. I have several comments on the original memo by Mahmoud.

1- While, I agree that there will be reduction in waste volume, I disagree with the factor of 1200 reduction given.

2- There are some inconsistencies in the estimate. For example, the assumption is made that the wall load in conventional solid wall concepts is 1 MW/m2 and the solid wall concept is penalized for this due to factor of 10 in FW area. "Area of the FW in high power density reactors, Aw, (10 MW/m2 wall load) is a factor of 10 less than the area of the FW in conventional concepts, Awo (1 MW/m2 wall load)." With such a wall load, the FW will have about 10 dpa/FPY implying ~2 replacements. However, in section 3 of the memo the assumption is made that it will be replaced once a year with 30 replacements. "In solid wall concepts, FW/Blanket is anticipated to be replaced once every year. For plant lifetime of 40 years with 0.75 availability, the number of replacement is ~30 times."

3- I believe you are addressing the volume of FW/blanket only. Therefore, the comment about shield thickness in section 1 is not relevant. By the way if an order of magnitude attenuation corresponds to 15 cm increment in shield thickness, we should have ts=ts0+15 not "ts = 1.15 tso"

4- The structure is assumed to be all lifetime components in the liquid concept. This applies only to the back wall behind the thick liquid blanket. On the other hand, the structure closer to the plasma such as nozzles, baffles and other components required to hydrodynamically establish the thick liquid layer will need more frequent replacement. I believe the 4% structure content that you assumed for the thick liquid wall corresponds to the 2 cm back wall divided by a 50 cm thick liquid blanket. This implies that the volume of nozzles, baffles, etc was assumed to be negligible.

5- I agree with the comment that Dave made regarding impact of failure rate on waste volume. Even if we agree with Mahmoud’s assumption of factor of 3 lower failure rate in liquid concepts that does not translate into a factor of 3 less waste volume.

It is really simple to factor in all the differences. I will estimate the difference in waste volume for the FW/blanket using solid and liquid walls following the approach used in the memo with the conservative assumptions. I will assume 1 MW/m2 vs 10 MW/m2 as in the memo. I will assume 20% structure in the conventional blanket as in the memo. I will neglect the volume of the nozzles, baffles, etc in the liquid concept as in the memo.

Credit for high power density:
wall load (liq) / wall load (solid) = 10
Credit for liq wall:
structure % (solid) / structure % (liq) = 20/4 = 5
Frequency of FW/blanket replacement:
lifetime of back wall (liq) / lifetime of FW (solid) = 30 FPY/15 FPY = 2

The net effect is a factor of ~100. If we use the more realistic 10% structure in conventional blanket the net effect will be only a factor of ~50. Even if we assume (as in memo) that replacement rate will be different by another factor of 3 due to expected lower failure rate, the net effect is still much lower than estimated in the memo.

If we repeat the same estimate using ARIES-RS parameters for the solid FW/blanket (4 MW/m2 wall load, 2.5 FPY FW lifetime) we get

Credit for high power density:
wall load (liq) / wall load (solid) = 2.5
Credit for liq wall:
structure % (solid) / structure % (liq) = 20/4 = 5
Frequency of FW/blanket replacement:
lifetime of back wall (liq) / lifetime of FW (solid) = 30 FPY/2.5 FPY = 12

The net effect is a factor of ~150. If we use the more realistic 10% structure in conventional blanket the net effect will be only a factor of ~70.

If we are concerned about the total radwaste volume (FW, blanket, shield, VV, magnet, divertor, limiter, stabilizing shells, etc) as we should, the reduction in total volume will be much much smaller (~2-3) than the factor of ~100 reduction in FW/blanket waste volume estimated above.

I believe that should use a factor of ~100 instead of the more than three orders of magnitude number when we talk about advantage of liquid wall concepts with respect to reduction of "FW/blanket waste volume". Two orders of magnitude reduction is still very significant. Even when we talk about a factor of ~2 reduction in "total radwaste volume" that is still significant improvement.

Best regards,

Mohamed