ILC BDS Kickoff Meeting
Basis for Magnet, Power System
and
Cooling Facility Optimization Discussion

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Topics

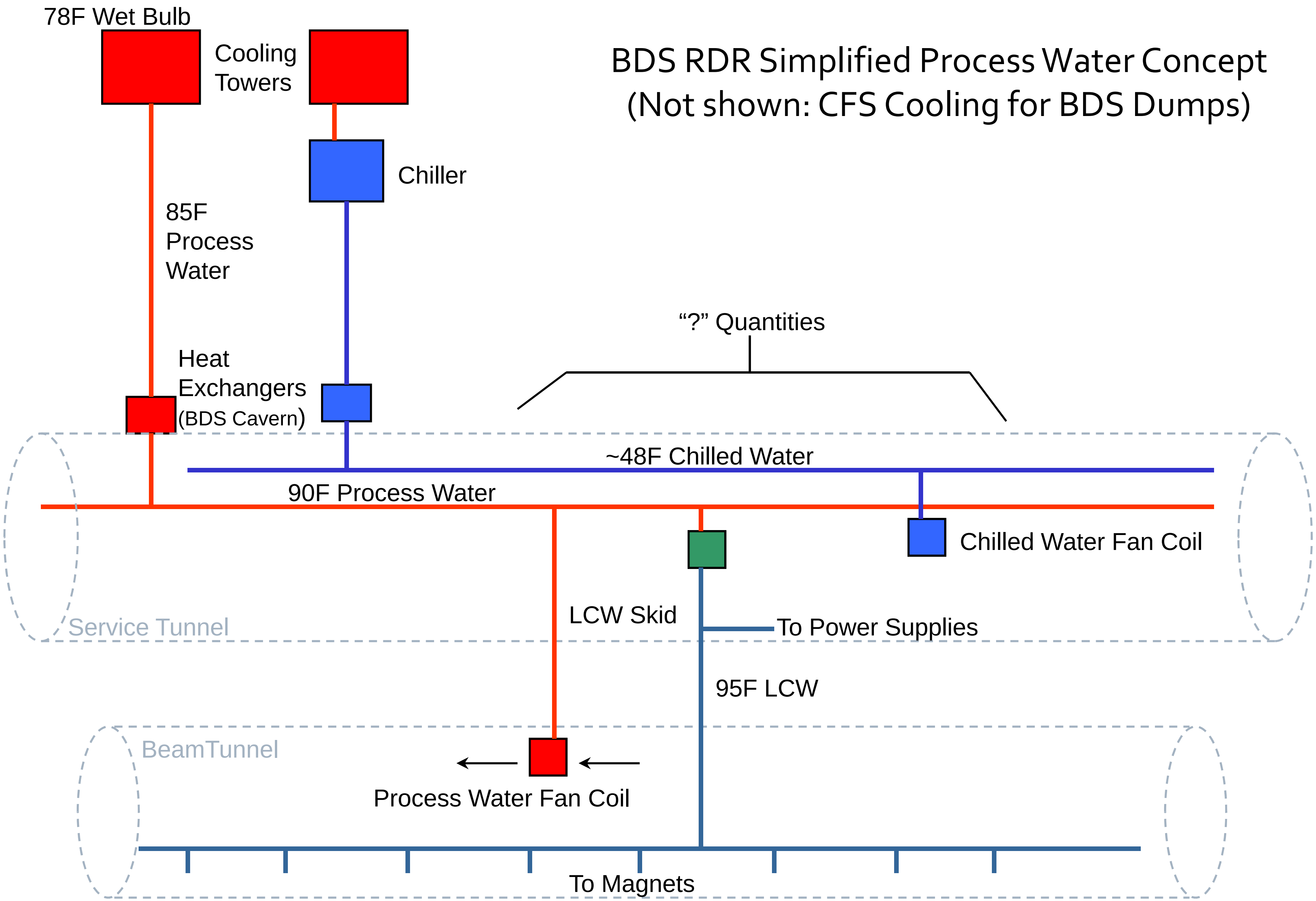
- Scope is cooling infrastructure, magnets, and magnet PS operating at 1TeV as conceived for the RDR
- Overview cooling infrastructure and assumptions
- Overview of magnet quantity and power systems
- Overview of magnet and power system losses
- Discuss RDR completeness regarding losses
- EDR areas for potential loss reductions, tradeoffs and cost optimization
- SLAC PCD EDR Expression of Interest pertaining to magnet power system design and optimization

Cooling System Overview

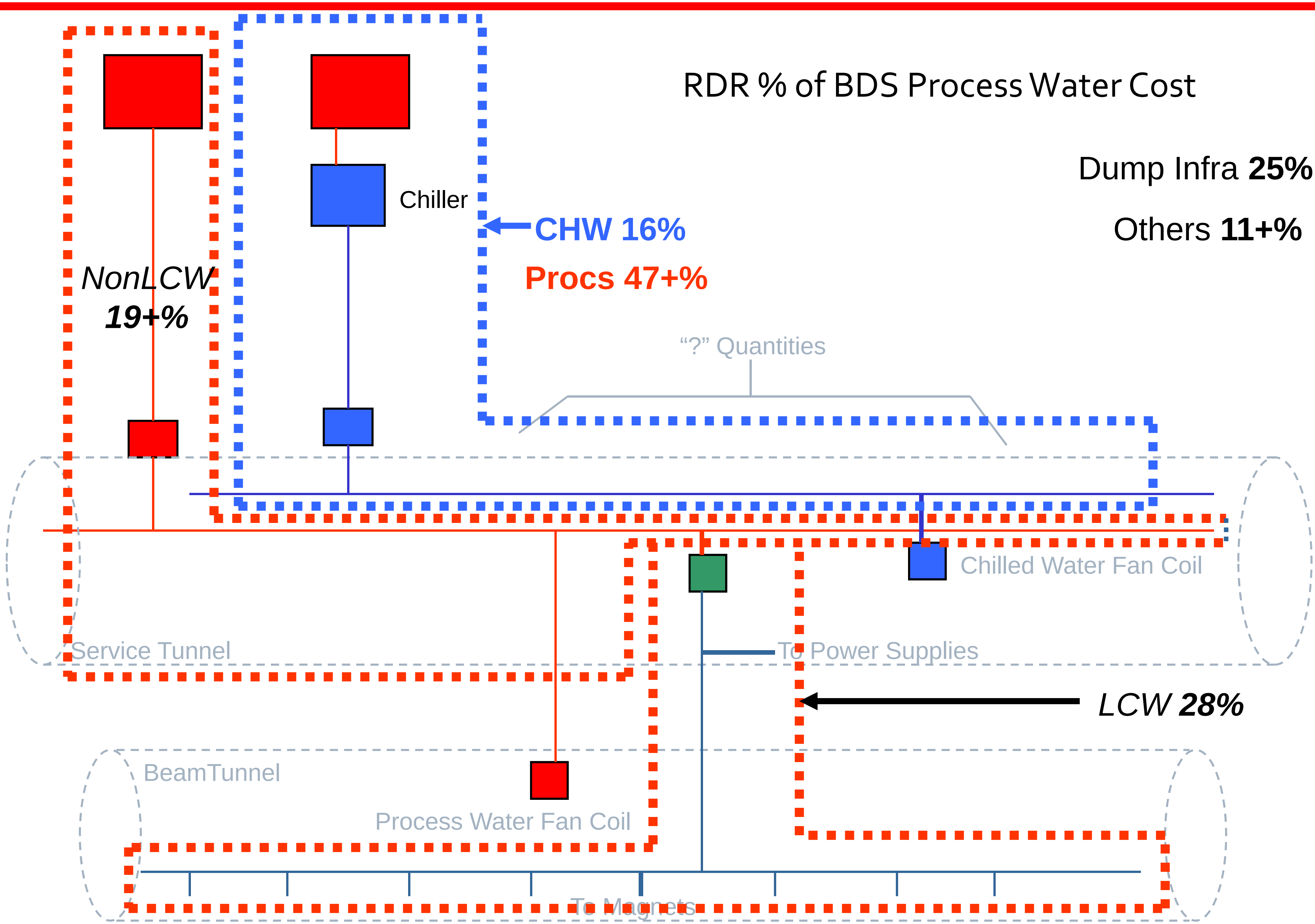
- BDS Cooling infrastructure concept and cost scaled from Main Linac Plant, except the BDS Dump near surface distribution, which was cost estimated separately. Main Linac process water uses 20F temp rise. The same is assumed for the BDS.
- There are two basic water cooling infrastructure system, the chilled water and the process water (which includes LCW). The LCW supply temperature is 95F.
- The air system used same as ML. No details, - didn't consider multiple tunnels in BDS/KAS area.
- Still need to layout/conceptualize LCW?, establish other heat load components in service tunnel, get updated loads, firm up environmental criteria.
- See next diagram for more description

RDR BDS Cooling Infrastructure

BDS RDR Simplified Process Water Concept
(Not shown: CFS Cooling for BDS Dumps)



RDR BDS Cooling Cost Distribution



Overview of RDR Power System Quantities and Types

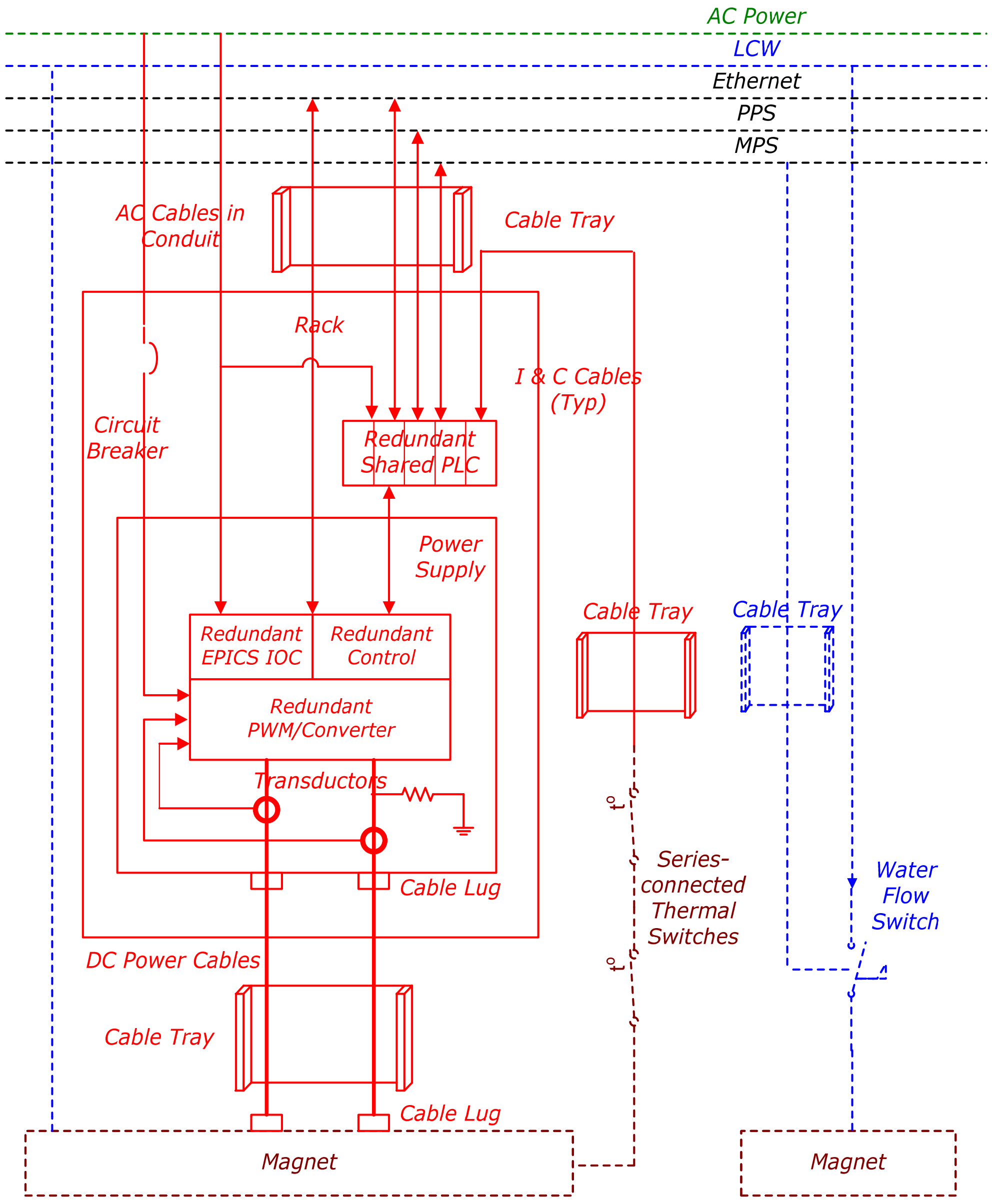
- Rollup as of December 2006
- 368 individually powered magnets, 276 magnets on strings

Area	Magnet Quantity	Power Systems								
BDS	644	432								
Section		Rack Mounted		Free Standing						
		Small < 2.5kW	Intermediate 2.5 < kw < 30	Large > 30kW	Septum Kickers (rating unknown)	Redundant	Normal temperature	Superconducting	Unipolar	Bipolar
e+Comm	126	6	38	30	0	74	74	0	74	0
e-e+14mr	518	166	66	62	64	358	260	98	226	132
Subtotals		172	104	92	64	432	334	98	300	132

Overview of RDR Power Systems

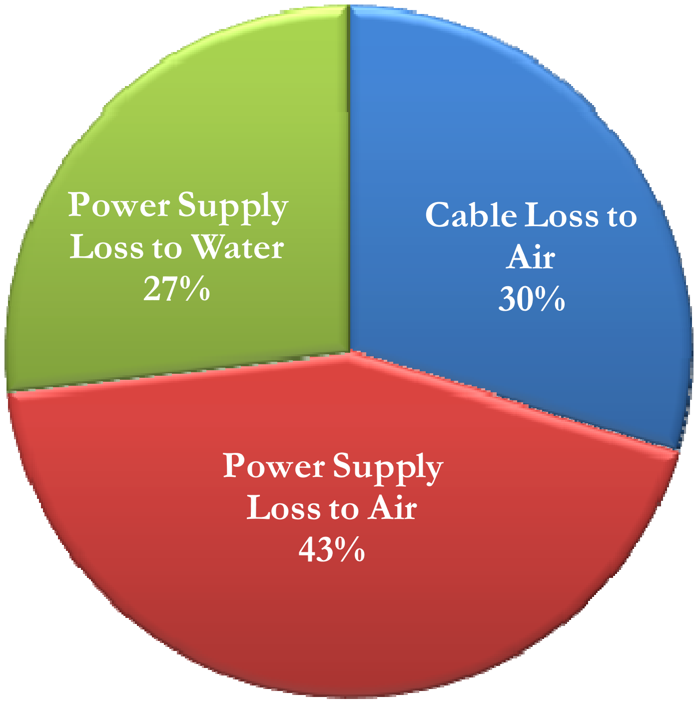
- Small or Intermediate, rack-mounted, unipolar or bipolar power supply, powers an individual, normal temperature magnet

- Power supplies are distributed in service tunnels adjacent to beamline. Cable runs are relatively short



Overview of RDR Power System Losses

Area	Magnet Power (kW) Ref Only	Cable Loss to Air (kW)	Power Supply Loss to Air (kW)	Power Supply Loss to Water (kW)	Required Water Flow (gpm)	Sum of All PS + Cable Losses (kW)
e-e+ Common	2,746	186	272	168	72	626
e-e+14mr	5,604	398	348	552	232	1,298
BDS	8,350	584	620	720	304	1,924



Water flow based on 1TeV losses and 18^{O}F rise in water

LCW water 95^{O}F in, 115^{O}F out, maximum

Beam tunnel ambient 100^{O}F to 105^{O}F

Service tunnel ambient 80^{O}F to 85^{O}F

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E- or e+ Common Service Tunnel	E- or e+ Common Beam Tunnel
• Length = 866m	• Length = 866m
• PS loss to air+50% cable loss=182.5kW	• 50% cable loss to air = 46.5kW
• Heat Loading = 212W/m	• Heat Loading = 53W/m
E- or e+ 14mr Service Tunnel	**E- or e+ 14mr Beam Tunnel**
• Length = 1,360m	• Length = 1,360m
• PS loss to air+50% cable loss=273.5kW	• 50% cable loss to air = 99.5kW
• Heat Loading = 201W/m	• Heat Loading = 73W/m

RDR Completeness Estimate

- BDS Cooling infrastructure concept and cost was scaled from Main Linac Plant, except for the BDS Dump near surface distribution, which was cost estimated separately. Main Linac process water use 20F temp rise. The same is assumed for the BDS.
- Cooling infrastructure is conceptual, and very little on paper. The only loads used for costing was the total kW load for 1 TeV dated Sep 06, adjusted for 1 IR. Cost was completed in November 2006
- Still need to layout/conceptualize LCW?, establish other heat load components in service tunnel, get updated loads, firm up environmental criteria.
- All power system designs conceptual, very little is on paper. Written specifications, building/equipment layouts, rack profiles, wiring diagrams, cable tray or raceway layouts do not exist
- Accurate estimate of losses and their distributions cannot be made until layouts and equipment profiles are made
- Environmental and facility Project specifications needed for design are not available

EDR Areas of Potential Optimization

- BDS has 53,700m of cable. This is the smallest amount of cable in all the ILC areas
- 23,000m of this cable is larger than 500kcmil in size. These are candidates for water cooled cable.
- Changing from air-cooled to water-cooled cable will have the following implications:
  - ❖Smaller diameter, and in the cases of paralleled cable, less cable is needed. Although this has the potential for a smaller, less expensive cable tray system, the cable itself will be more expensive on a per meter basis, but possibly less expensive overall.
  - ❖The replacement of larger, air-cooled, copper cable with smaller, water-cooled (possibly aluminum) cable will cause an increase in power losses. Detailed deigns are needed
  - ❖Even with the larger cable losses, the losses will be re-directed from the building cooling system to the cooling water system
  - ❖The next slide tabulates the loss transfer from air to water for the large cables.

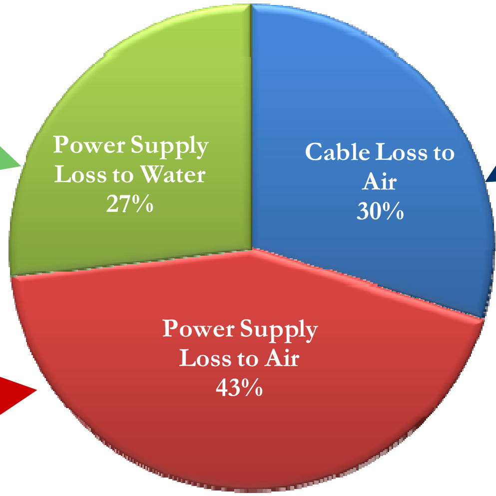
EDR Areas of Potential Future Optimization

Here are the cable losses that could be transferred from air to water. This table does not take into account the possible increase in cable loss from smaller water-cooled cables and thus underestimates the new water heat load

Area	Present Cable Loss to Air (kW)	New Water Losses from Air Cooled Cable (kW)	New Cable Loss to Air (kW)
E- Common	93	52	41
E+ Common	93	52	41
E- 14mr	199	146	53
E+ 14mr	199	146	53
Total	**584**	**397**	**188**

EDR Areas of Potential Optimization

Load to Process Water



Load to Chilled Water

Assumed 50% to service tunnel (Chilled Water), and 50% to beam tunnel (process water via fancoil)

Adjusted from Nov 2006 load assumptions

	Present Losses (all AC cables) - KW			Redistribution losses potential Water Cooled Cables		
CHW Load	912	KW	9%	714	KW	7%
Cables to service tunnel to Air (50%)	292	KW	32%	94	KW	13%
Power Supply to Air	620	KW	68%	620	KW	87%
Others (xmfr, equip) - <u>wag</u>	TBD	KW		TBD	KW	
Process/LCW Load	9362	KW	91%	9561	KW	93%
Magnets Water	8287	KW	89%	8287	KW	87%
Magnets Air	63	KW	1%	63	KW	1%
Cables to beam tunnel to water (50%)	292	KW	3%	94	KW	1%
Cables Directly to Water	0	KW	0%	397	KW	4%
Power Supply to Water	720	KW	8%	720	KW	8%

Reduction in CHW load by ~200kW, BUT how much reduction in net cost?

Increase in Process/LCW load by ~200kW, BUT how much increase in net cost?

EDR Areas of Potential Optimization

- The magnet – power supply/cable interface is another optimization area. If the magnet currents are lowered, since cable losses go as I^2, for a given cable size the cable losses are reduced. This would reduce heat loading and the facility plant.

- It might also be possible to reduce the size of the cable and reduce cable tray system costs.

- Stringing more magnets will reduce cable and raceway costs, cable loss heat loading and reduce power system (less power supplies and controls) costs

Last Slide – EDR EOI

- The SLAC Power Conversion Department (PCD) prepared an Expression of Interest (EOI) proposal for design and engineering of pulsed and DC magnet power systems. Expect design effort involving electrical engineer, control engineer (hardware) and layout designers to achieve the EDR goals. The EDR EOI includes an estimate of the interdisciplinary effort to optimize the tradeoffs between cable costs, raceway costs and facility costs.