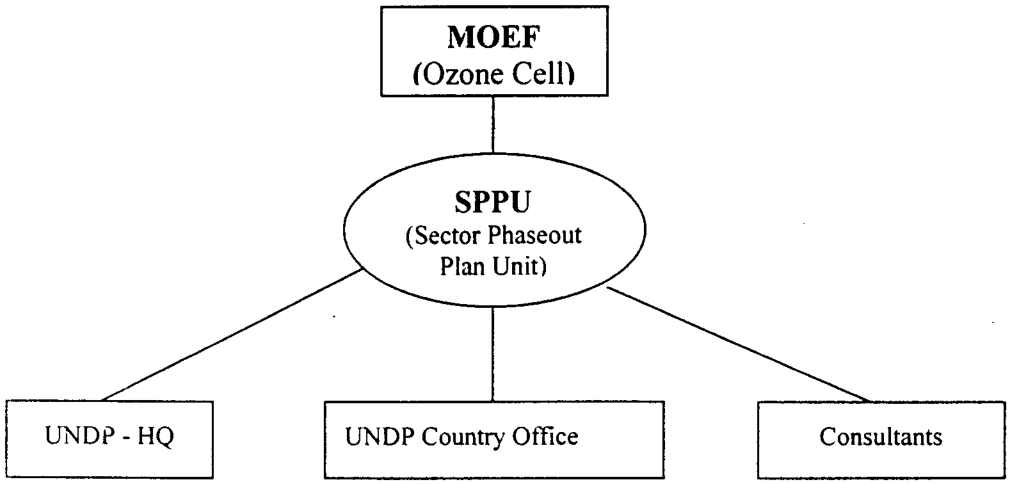
Sector Plan Phase-out Unit (SPPU), UNDP India Country Office and Montreal Protocol Unit will undertake all phase out activities at these four enterprises. As such, the programme will be implemented using the following structure:



The attached Operational Mechanism for Implementation (OMI) developed under IND/02/G66 – Foam Sector Phase-out Plan and IND/03/G62 – Refrigeration (Manufacturing) Sector Phase-out Plan that has been successfully applied to facilitate implementation of these two sector plans, will serve as a framework for implementation of UNDP activities under this project, to the extend relevant and applicable, generally in line with the role and responsibilities of various actors as described in the OMI.

8.4 Implementation Schedule

TASK	2004												2005											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
1.a) MLF approval & funding				X																				
b) Financial appraisal				X																				
c) sub-grant agreement						X																		
2. a) Equipment. Specification						X	X	X																
b) Equipment. Selection								X	X	X														
c) Equipment Procurement										X	X	X	X	X										
d) Installation														X	X	X								
3 a) Trial & start up																X	X	X						
b) Training/Certification																		X	X	X				
4.a) First disbursement														X	X	X								
b) Second disbursement																	X	X	X					
c) Final disbursement																				X	X	X		
5 Report submission																							X	X

8.5 Milestones for Project Monitoring

ACTIVITY	No later than
Grant Agreement submitted to beneficiary	June 2004
Grant Agreement signature	July 2004
Bids prepared and requested	July 2004
Contracts awarded	November 2004
Equipment delivered	April 2005
Commissioning and trial runs	June 2005
De-commissioning and/or destruction of redundant baseline equipment	August 2005
Submission of project completion report (needed to satisfy the requirements for project completion reports)	December 2005

Annex 1: Incremental Capital Cost Calculations

ANNEX 1a. Breakdown of Incremental Capital Cost –Bhilai Plant

Bhilai ICC					
	Description of cost item	Unit	Unit cost (US$)	Quantity	Total cost (US$)
1	**Technical Cleaning Process and Equipment Support**				
1.1	Material compatibility testing, Cleaning process standardization, Reliability testing, Equipment commissioning and user training	set	15,000	1	15,000
1.2	Alternative research, proposal and documentation, Equipment specifications, Environmental, Health and Safety training	set	30,000	1	30,000
	Sub-total				**45,000**
2	**Equipment to Purchase and Install**				
2.1	**Electrical Motor Repair Shop (ERMS)**				
2.1.1	1.0m x 1.0m x 1.5m basket Vapour Degreaser (VD) with integrated still	ea	90,000	1	90,000
2.1.2	1.0m x 1.5m x 2.5m basket VD with integrated still	ea	120,000	1	120,000
2.1.3	Hoist to load parts baskets	ea	5,000	2	10,000
2.1.4	Cold solvent cleaning station	ea	30,000	2	60,000
2.1.5	Safety shower & eyewash	ea	500	2	1,000
2.1.6	Shop modifications (civil work)	ea	20,000	2	40,000
2.2	**Stationary Motors**				
2.2.1	Exhaust fans	ea	500	12	6,000
2.2.2	Spray wands	ea	200	12	2,400
2.3	**Oxygen Plant**				
2.3.1	1.0m x 1.0m x 1.5m basket VD with integrated still	ea	90,000	2	180,000
2.3.2	Hoist to load parts baskets		5,000	2	10,000
2.3.3	Mobile spray apparatus	ea	10,000	1	10,000
2.3.4	Still and transfer pumps	ea	30,000	2	60,000
2.3.5	Safety shower & eyewash	ea	500	2	1,000
2.3.6	Shop modifications (civil work)	ea	10,000	2	20,000
2.4	Transportation (approximately 5%)				27,000
	Sub-total				**637,400**
	Total				**682,400**
	Contingency, 10%				**68,240**
	Total investment cost, US$				**750,640**

ANNEX 1b. Breakdown of Incremental Capital Cost-Bokaro Plant

Bokaro ICC					
	Description of cost item	**Unit**	**Unit cost (US$)**	**Quantity**	**Total cost (US$)**
1	**Technical Cleaning Process and Equipment Support**				
1.1	Material compatibility testing, Cleaning process standardization, Reliability testing, Equipment commissioning and user training	set	10,000	1	10,000
1.2	Alternative research, proposal and documentation, Equipment specifications, Environmental, Health and Safety training	set	20,000	1	20,000
	Sub-total				**30,000**
2	**Equipment to Purchase and Install**				
2.1	**Electrical Motor Repair Shop (ERMS)**				
2.1.1	1.0m x 1.0m x 1.5m basket Vapour Degreaser (VD) with integrated still	ea	90,000	1	90,000
2.1.2	1.0m x 1.5m x 2.5m basket VD with integrated still	ea	120,000	1	120,000
2.1.3	Hoist to load parts baskets	ea	5,000	2	10,000
2.1.4	Cold solvent cleaning station	ea	30,000	1	30,000
2.1.5	Safety shower & eyewash	ea	500	2	1,000
2.1.6	Shop modifications (civil work)	ea	20,000	1	20,000
2.2	**Stationary Motors**				
2.2.1	Exhaust fans	ea	500	8	4,000
2.2.2	Spray wands	ea	200	8	1,600
2.3	**Oxygen Plant**				
2.3.1	1.0m x 1.0m x 1.5m basket VD with integrated still	ea	90,000	1	90,000
2.3.2	Hoist to load parts baskets		5,000	1	5,000
2.3.3	Mobile spray apparatus	ea	10,000	1	10,000
2.3.4	Still and transfer pumps	ea	30,000	1	30,000
2.3.5	Safety shower & eyewash	ea	500	1	500
2.3.6	Shop modifications (civil work)	ea	10.000	1	10,000
2.4	Transportation (approximately 5%)				19,250
	Sub-total				**441,350**
	Total				**471,350**
	Contingency, 10%				**47,135**
	Total investment cost, US$				**518,485**

ANNEX 1c. Breakdown of Incremental Capital Cost-Durgapur Plant

Durgapur ICC					
	Description of cost item	**Unit**	**Unit cost (US$)**	**Quantity**	**Total cost (US$)**
1	**Technical Cleaning Process and Equipment Support**				
1.1	Material compatibility testing, Cleaning process standardization, Reliability testing, Equipment commissioning and user training	set	7,000	1	7,000
1.2	Alternative research, proposal and documentation; Equipment specifications, Environmental, Health and Safety training	set	13,000	1	13,000
	Sub-total				**20,000**
2	**Equipment to Purchase and Install**				
2.1	**Electrical Motor Repair Shop (ERMS)**				
2.1.1	1.0m x 1.0m x 1.5m basket Vapour Degreaser (VD) with integrated still	ea	90,000	0	0
2.1.2	1.0m x 1.5m x 2.5m basket VD with integrated still	ea	120,000	1	120,000
2.1.3	Hoist to load parts baskets	ea	5,000	1	5,000
2.1.4	Cold solvent cleaning station	ea	30,000	1	30,000
2.1.5	Safety shower & eyewash	ea	500	1	500
2.1.6	Shop modifications (civil work)	ea	20,000	1	20,000
2.2	**Stationary Motors**				
2.2.1	Exhaust fans	ea	500	8	4,000
2.2.2	Spray wands	ea	200	8	1,600
2.3	**Oxygen Plant**				
2.3.1	1.0m x 1.0m x 1.5m basket VD with integrated still	ea	90,000	1	90,000
2.3.2	Hoist to load parts baskets		5,000	1	5,000
2.3.3	Mobile spray apparatus	ea	10,000	1	10,000
2.3.4	Still and transfer pumps	ea	30,000	1	30,000
2.3.5	Safety shower & eyewash	ea	500	1	500
2.3.6	Shop modifications (civil work)	ea	10,000	1	10,000
2.4	Transportation (approximately 5%)				14,500
	Sub-total				**341,100**
	Total				**361,100**
	Contingency, 10%				**36,110**
	Total investment cost, US$				**397,210**

ANNEX 1d. Breakdown of Incremental Capital Cost- Rourkela Plant

Rourkela ICC					
	Description of cost item	**Unit**	**Unit cost (US$)**	**Quantity**	**Total cost (US$)**
1	**Technical Cleaning Process and Equipment Support**				
1.1	Material compatibility testing, Cleaning process standardization, Reliability testing, Equipment commissioning and user training	set	10,000	1	10,000
1.2	Alternative research, proposal and documentation, Equipment specifications, Environmental, Health and Safety training	set	20,000	1	20,000
	Sub-total				**30,000**
2	**Equipment to Purchase and Install**				
2.1	**Electrical Motor Repair Shop (ERMS)**				
2.1.1	1.0m x 1.0m x 1.5m basket Vapour Degreaser (VD) with integrated still	ea	90,000	1	90,000
2.1.2	1.0m x 1.5m x 2.5m basket VD with integrated still	ea	120,000	1	120,000
2.1.3	Hoist to load parts baskets	ea	5,000	2	10,000
2.1.4	Cold solvent cleaning station	ea	30,000	1	30,000
2.1.5	Safety shower & eyewash	ea	500	1	500
2.1.6	Shop modifications (civil work)	ea	20,000	1	20,000
2.2	**Stationary Motors**				
2.2.1	Exhaust fans	ea	500	12	6,000
2.2.2	Spray wands	ea	200	12	2,400
2.3	**Oxygen Plant**				
2.3.1	1.0m x 1.0m x 1.5m basket VD with integrated still	ea	90,000	2	180,000
2.3.2	Hoist to load parts baskets		5,000	2	10,000
2.3.3	Mobile spray apparatus	ea	10,000	1	10,000
2.3.4	Still and transfer pumps	ea	30,000	2	60,000
2.3.5	Safety shower & eyewash	ea	500	2	1,000
2.3.6	Shop modifications (civil work)	ea	10,000	2	20,000
2.4	Transportation (approximately 5%)				25,500
	Sub-total				**585,400**
	Total				**615,400**
	Contingency, 10%				**61,540**
	Total investment cost, US$				**676,940**

ANNEX 1e. Breakdown of Incremental Capital Cost-Indian Iron & Steel Company Plant

IISCO ICC					
	Description of cost item	**Unit**	**Unit cost (US$)**	**Quantity**	**Total cost (US$)**
1	**Technical Cleaning Process and Equipment Support**				
1.1	Material compatibility testing, Cleaning process standardization, Reliability testing, Equipment commissioning and user training	set	7,000	1	7,000
1.2	Alternative research, proposal and documentation, Equipment specifications, Environmental, Health and Safety training	set	13,000	1	13,000
	Sub-total				**20,000**
2	**Equipment to Purchase and Install**				
2.1	**Electrical Motor Repair Shop (ERMS)**				
2.1.1	1.0m x 1.0m x 1.5m basket Vapour Degreaser (VD) with integrated still	ea	90,000	0	0
2.1.2	1.0m x 1.5m x 2.5m basket VD with integrated still	ea	120,000	1	120,000
2.1.3	Hoist to load parts baskets	ea	5,000	1	5,000
2.1.4	Cold solvent cleaning station	ea	30,000	1	30,000
2.1.5	Safety shower & eyewash	ea	500	1	500
2.1.6	Shop modifications (civil work)	ea	20,000	1	20,000
2.2	**Stationary Motors**				
2.2.1	Exhaust fans	ea	500	8	4,000
2.2.2	Spray wands	ea	200	8	1,600
2.3	**Oxygen Plant**				
2.3.1	1.0m x 1.0m x 1.5m basket VD with integrated still	ea	90,000	1	90,000
2.3.2	Hoist to load parts baskets		5,000	1	5,000
2.3.3	Mobile spray apparatus	ea	10,000	1	10,000
2.3.4	Still and transfer pumps	ea	30,000	1	30,000
2.3.5	Safety shower & eyewash	ea	500	1	500
2.3.6	Shop modifications (civil work)	ea	10,000	1	10,000
2.4	Transportation (approximately 5%)				14,500
	Sub-total				**341,100**
	Total				**361,100**
	Contingency, 10%				**36,110**
	Total investment cost, US$				**397,210**

ANNEX 1f. **Breakdown of Incremental Capital Cost- Salem Plant**

Salem ICC					
	Description of cost item	**Unit**	**Unit cost (US$)**	**Quantity**	**Total cost (US$)**
1	**Technical Cleaning Process and Equipment Support**				
1.1	Material compatibility testing, Cleaning process standardization, Reliability testing, Equipment commissioning and user training	set	4,000	1	4,000
1.2	Alternative research, proposal and documentation, Equipment specifications, Environmental, Health and Safety training	set	6,000	1	6,000
	Sub-total				**10,000**
2	**Equipment to Purchase and Install**				
2.1	**Electrical Motor Repair Shop (ERMS)**				
2.1.1	1.0m x 1.0m x 1.5m basket Vapour Degreaser (VD) with integrated still	ea	90,000	1	90,000
2.1.2	1.0m x 1.5m x 2.5m basket VD with integrated still	ea	120,000	0	0
2.1.3	Hoist to load parts baskets	ea	5,000	1	5,000
2.1.4	Cold solvent cleaning station	ea	30,000	0	0
2.1.5	Safety shower & eyewash	ea	500	1	500
2.1.6	Shop modifications (civil work)	ea	20,000	1	20,000
2.2	**Stationary Motors**				
2.2.1	Exhaust fans	ea	500	2	1,000
2.2.2	Spray wands	ea	200	2	400
2.3	**Oxygen Plant**				
2.3.1	1.0m x 1.0m x 1.5m basket VD with integrated still	ea	90,000	0	0
2.3.2	Hoist to load parts baskets		5,000	0	0
2.3.3	Mobile spray apparatus	ea	10,000	0	0
2.3.4	Still and transfer pumps	ea	30,000	0	0
2.3.5	Safety shower & eyewash	ea	500	0	0
2.3.6	Shop modifications (civil work)	ea	10,000	0	0
2.4	Transportation (approximately 5%)				4,750
	Sub-total				**121,650**
	Total				**131,650**
	Contingency, 10%				**13,165**
	Total investment cost, US$				**144,815**

Annex 2: Incremental Operating Cost Calculations

ANNEX 2a. Breakdown of Incremental Operating Cost-Bhlai Plant

Bhilai IOC						
	Description of cost item	Unit	Unit cost, (US$)	Quantity	Pre-project total cost (US$)	Post-project total cost (US$)
1.0	Chemicals					
1.1	CTC	kg	0.94	113,000	106,220	
1.2	Trichloroethylene, stabilised	kg	1.50	39,000		58,500
1.3	Stabiliser replenishment estimated at 0.5% of total solvent use.		40	195		7,800
1.4	Dräger tubes for workplace solvent exposure measurements (4/mo.)	ea	1	48		48
	Sub-total				106,220	66,348
2.0	Electricity					
2.1	1.0m x 1.0m x 1.5m basket Vapour Degreaser (VD) with integrated still, (3VD x 30kw x 0.66 run hr/hr x 16hrs/day x 300days)	kWh	0.104	285,120		29,652
2.2	1.0m x 1.5m x 2.5m basket VD with integrated still, (1VD x 40kw x 0.66 run hr/hr x 16hrs/day x 300days)	kWh	0.104	126,720		13,179
2.3	Hoist to load parts baskets, (5kw x 4 hoists x 1.5hrs/day x 300days)	kWh	0.104	9,000		936
2.4	Cold solvent cleaning station, (3kw x 2 units x 8hrs/day x 300days)	kWh	0.104	14,400		1,498
2.5	Distillation unit and transfer pumps, (10kw x 2 units x 16hrs/day x 300days)	kWh	0.104	96,000		9,984
	Sub-total					55,249
3.0	Labour					
3.1	Operator, CTC; 8 employees/shift, 2 shift/day, = 16 annual workers	annual worker	1,400	16	22,400	
3.2	Operator, TCE; 8 employees/shift, 2 shift/day, = 16 annual workers	annual worker	1,400	16		22,400
	Sub-total				22,400	22,400
4.0	Personal Protection Equipment					
4.1	Gloves ($5x50/mo), apron ($10x10/mo), safety glasses ($3x100/mo), and half mask respirator or cartridges ($20x 10/mo), $250 + $100 + $300 + $200 = $850/mo	month	850	12		10,200
	Sub-total				0	10,200
TOTAL PRE- and POST-PROJECT COSTS/YEAR					128,620	154,197
TOTAL INCREMENTAL OPERATING COSTS/YEAR						25,577
NPV of 4 YEARS IOC at 10%						81,079

ANNEX 2b. Breakdown of Incremental Operating Cost - Bokaro Plant

Bokaro IOC						
	Description of cost item	**Unit**	**Unit cost, (US$)**	**Quantity**	**Pre-project total cost (US$)**	**Post-project total cost (US$)**
1.0	**Chemicals**					
1.1	CTC	kg	0.94	24,000	22,560	
1.2	Trichloroethylene, stabilised	kg	1.50	10,000		15,000
1.3	Stabiliser replenishment estimated at 0.5% of total solvent use.		40	50		2,000
1.4	Dräger tubes for workplace solvent exposure measurements (3/mo.)	ea	1	36		36
	Sub-total				**22,560**	**17,036**
2.0	**Electricity**					
2.1	1.0m x 1.0m x 1.5m basket Vapour Degreaser (VD) with integrated still, (2VD x 30kw x 0.66 run hr/hr x 16hrs/day x 300days)	kWh	0.104	190,080		19,768
2.2	1.0m x 1.5m x 2.5m basket VD with integrated still, (1VD x 40kw x 0.66 run hr/hr x 16hrs/day x 300days)	kWh	0.104	126,720		13,179
2.3	Hoist to load parts baskets. (5kw x 3 hoists x 1.5hrs/day x 300days)	kWh	0.104	6,750		702
2.4	Cold solvent cleaning station, (3kw x 1 units x 8hrs/day x 300days)	kWh	0.104	7,200		749
2.5	Distillation unit and transfer pumps. (10kw x 2 units x 16hrs/day x 300days)	kWh	0.104	48,000		4,992
	Sub-total					**39,390**
3.0	**Labour**					
3.1	Operator, CTC; 6 employees/shift. 2 shift/day, = 12 annual workers	annual worker	1,400	12	16,800	
3.2	Operator, TCE; 6 employees/shift. 2 shift/day, = 12 annual workers	annual worker	1,400	12		16,800
	Sub-total				**16,800**	**16,800**
4.0	**Personal Protection Equipment**					
4.1	Gloves ($5x35/mo), apron ($10x6 mo). safety glasses ($3x70/mo), and half mask respirator or cartridges ($20x 6/mo)	month	565	12		6,780
	Sub-total				**0**	**6,780**
TOTAL PRE- and POST-PROJECT COSTS/YEAR					**39,360**	**80,006**
TOTAL INCREMENTAL OPERATING COSTS/YEAR						**40,646**
NPV of 4 YEARS IOC at 10%						**128,848**

ANNEX 2c. Breakdown of Incremental Operating Cost-Durgapur Plant

Durgapur IOC						
	Description of cost item	**Unit**	**Unit cost, (US$)**	**Quantity**	**Pre-project total cost (US$)**	**Post-project total cost (US$)**
1.0	**Chemicals**					
1.1	CTC	kg	0.94	10,000	9,400	
1.2	Trichloroethylene, stabilised	kg	1.50	4,000		6,000
1.3	Stabiliser replenishment estimated at 0.5% of total solvent use.		40	20		800
1.4	Dräger tubes for workplace solvent exposure measurements (2/mo.)	ea	1	24		24
	Sub-total				**9,400**	**6,824**
2.0	**Electricity**					
2.1	1.0m x 1.0m x 1.5m basket Vapour Degreaser (VD) with integrated still, (1VD x 30kw x 0.66 run hr/hr x 16hrs/day x 300days)	kWh	0.104	95,040		9,884
2.2	1.0m x 1.5m x 2.5m basket VD with integrated still, (1VD x 40kw x 0.66 run hr/hr x 16hrs/day x 300days)	kWh	0.104	126,720		13,179
2.3	Hoist to load parts baskets, (5kw x 2 hoists x 1.5hrs/day x 300days)	kWh	0.104	4,500		468
2.4	Cold solvent cleaning station, (3kw x 1 units x 8hrs/day x 300days)	kWh	0.104	7,200		749
2.5	Distillation unit and transfer pumps, (10kw x 2 units x 16hrs/day x 300days)	kWh	0.104	48,000		4,992
	Sub-total					**29,272**
3.0	**Labour**					
3.1	Operator, CTC; 4 employees/shift, 2 shift/day, = 8 annual workers	annual worker	1,400	8	11,200	
3.2	Operator, TCE; 4 employees/shift, 2 shift/day, = 8 annual workers	annual worker	1,400	8		11,200
	Sub-total				**11,200**	**11,200**
4.0	**Personal Protection Equipment**					
4.1	Gloves ($5x25/mo), apron ($10x5/mo), safety glasses ($3x50/mo), and half mask respirator or cartridges ($20x 5/mo)	month	425	12		5,100
	Sub-total				**0**	**5,100**
TOTAL PRE- and POST-PROJECT COSTS/YEAR					**20,600**	**52,396**
TOTAL INCREMENTAL OPERATING COSTS/YEAR						**31,796**
NPV of 4 YEARS IOC at 10%						**100,793**

ANNEX 2d. Breakdown of Incremental Operating Cost-Rourkela Plant

Rourkela IOC						
	Description of cost item	**Unit**	**Unit cost, (US$)**	**Quantity**	**Pre-project total cost (US$)**	**Post-project total cost (US$)**
1.0	**Chemicals**					
1.1	CTC	kg	0.94	41,000	38,540	
1.2	Trichloroethylene, stabilised	kg	1.50	13,000		19,500
1.3	Stabiliser replenishment estimated at 0.5% of total solvent use.		40	65		2,600
1.4	Dräger tubes for workplace solvent exposure measurements (3/mo.)	ea	1	36		36
	Sub-total				**38,540**	**22,136**
2.0	**Electricity**					
2.1	1.0m x 1.0m x 1.5m basket Vapour Degreaser (VD) with integrated still, (3VD x 30kw x 0.66 run hr/hr x 16hrs/day x 300days)	kWh	0.104	285,120		29,652
2.2	1.0m x 1.5m x 2.5m basket VD with integrated still, (1VD x 40kw x 0.66 run hr/hr x 16hrs/day x 300days)	kWh	0.104	126,720		13,179
2.3	Hoist to load parts baskets, (5kw x 4 hoists x 1.5hrs/day x 300days)	kWh	0.104	9,000		936
2.4	Cold solvent cleaning station, (3kw x 1 units x 8hrs/day x 300days)	kWh	0.104	7,200		749
2.5	Distillation unit and transfer pumps, (10kw x 2 units x 16hrs/day x 300days)	kWh	0.104	96,000		9,984
	Sub-total					**54,500**
3.0	**Labour**					
3.1	Operator, CTC: 6 employees/shift, 2 shift/day, = 12 annual workers	annual worker	1,400	12	16,800	
3.2	Operator, TCE: 6 employees/shift, 2 shift/day, = 12 annual workers	annual worker	1,400	12		16,800
	Sub-total				**16,800**	**16,800**
4.0	**Personal Protection Equipment**					
4.1	Gloves ($5x35/mo), apron ($10x6/mo), safety glasses ($3x70/mo), and half mask respirator or cartridges ($20x 6/mo)	month	565	12		6,780
	Sub-total				**0**	**6,780**
TOTAL PRE- and POST-PROJECT COSTS/YEAR					**55,340**	**100,216**
TOTAL INCREMENTAL OPERATING COSTS/YEAR						**44,876**
NPV of 4 YEARS IOC at 10%						**142,257**

ANNEX 2e. Breakdown of Incremental Operating Cost-Indian Iron & Steel Company Plant

IISCO IOC (estimated)						
	Description of cost item	**Unit**	**Unit cost, (US$)**	**Quantity**	**Pre-project total cost (US$)**	**Post-project total cost (US$)**
1.0	**Chemicals**					
1.1	CTC	kg	0.94	10,000	9,400	
1.2	Trichloroethylene, stabilised	kg	1.50	4,000		6,000
1.3	Stabiliser replenishment estimated at 0.5% of total solvent use.		40	20		800
1.4	Dräger tubes for workplace solvent exposure measurements (2/mo.)	ea	1	24		24
	Sub-total				**9,400**	**6,824**
2.0	**Electricity**					
2.1	1.0m x 1.0m x 1.5m basket Vapour Degreaser (VD) with integrated still, (1VD x 30kw x 0.66 run hr/hr x 16hrs/day x 300days)	kWh	0.104	95,040		9,884
2.2	1.0m x 1.5m x 2.5m basket VD with integrated still, (1VD x 40kw x 0.66 run hr/hr x 16hrs/day x 300days)	kWh	0.104	126,720		13,179
2.3	Hoist to load parts baskets, (5kw x 2 hoists x 1.5hrs/day x 300days)	kWh	0.104	4,500		468
2.4	Cold solvent cleaning station, (3kw x 1 units x 8hrs/day x 300days)	kWh	0.104	7,200		749
2.5	Distillation unit and transfer pumps, (10kw x 2 units x 16hrs/day x 300days)	kWh	0.104	48,000		4,992
	Sub-total					**29,272**
3.0	**Labour**					
3.1	Operator, CTC; 4 employees/shift, 2 shift/day, = 8 annual workers	annual worker	1,400	8	11,200	
3.2	Operator, TCE: 4 employees/shift, 2 shift/day, = 8 annual workers	annual worker	1,400	8		11,200
	Sub-total				**11,200**	**11,200**
4.0	**Personal Protection Equipment**					
4.1	Gloves ($5x25/mo), apron ($10x5 mo), safety glasses ($3x50 mo), and half mask respirator or cartridges ($20x 5/mo)	month	425	12		5,100
	Sub-total				**0**	**5,100**
TOTAL PRE- and POST-PROJECT COSTS/YEAR					**20,600**	**52,396**
TOTAL INCREMENTAL OPERATING COSTS/YEAR						**31,796**
NPV of 4 YEARS IOC at 10%						**100,793**

ANNEX 2f. Breakdown of Incremental Operating Cost-Salem Plant

Salem IOC						
	Description of cost item	**Unit**	**Unit cost, (US$)**	**Quantity**	**Pre-project total cost (US$)**	**Post-project total cost (US$)**
1.0	**Chemicals**					
1.1	CTC	kg	0.94	3,000	2,820	
1.2	Trichloroethylene, stabilised	kg	1.50	1,000		1,500
1.3	Stabiliser replenishment estimated at 0.5% of total solvent use.		40	5		200
1.4	Dräger tubes for workplace solvent exposure measurements (3/mo.)	ea	1	36		36
	Sub-total				**2,820**	**1,736**
2.0	**Electricity**					
2.1	1.0m x 1.0m x 1.5m basket Vapour Degreaser (VD) with integrated still, (1VD x 30kw x 0.22 run hr/hr x 16hrs/day x 300days)	kWh	0.104	31,680		3,295
2.2	1.0m x 1.5m x 2.5m basket VD with integrated still, (0VD x 40kw x 0.66 run hr/hr x 16hrs day x 300days)	kWh	0.104	0		0
2.3	Hoist to load parts baskets, (5kw x 1 hoists x 1.5hrs/day x 300days)	kWh	0.104	2,250		234
2.4	Cold solvent cleaning station, (3kw x 0 units x 8hrs/day x 300days)	kWh	0.104	0		0
2.5	Distillation unit and transfer pumps, (10kw x 0 units x 16hrs/day x 300days)	kWh	0.104	0		0
	Sub-total					**3,529**
3.0	**Labour**					
3.1	Operator, CTC; 1 employees/shift, 2 shift day, = 2 annual workers	annual worker	1,400	2	2,800	
3.2	Operator, TCE: 1 employees/shift, 2 shift day, = 2 annual workers	annual worker	1,400	2		2,800
	Sub-total				**2,800**	**2,800**
4.0	**Personal Protection Equipment**					
4.1	Gloves ($5x6/mo), apron ($10x1/mo), safety glasses ($3x5/mo), and half mask respirator or cartridges ($20x 1/mo)	month	75	12		900
	Sub-total				**0**	**900**
TOTAL PRE- and POST-PROJECT COSTS/YEAR					**5,620**	**8,965**
TOTAL INCREMENTAL OPERATING COSTS/YEAR						**3,345**
NPV of 4 YEARS IOC at 10%						**10,603**

Annex 3: List of Equipment to be Destroyed for Project Completion

None

PROJECT COVER SHEET

COUNTRY: INDIA **IMPLEMENTING AGENCY:** UNDP

PROJECT TITLE: Conversion of Carbon Tetrachloride (CTC) as Cleaning Solvent to Trichloroethylene at Western Engineering Co., New Delhi and Srinagar Plant

PROJECT IN CURRENT BUSINESS PLAN:	Yes	
SECTOR:	Solvent	
SUB-SECTOR:	Cleaning /CTC	
ODS USE IN SECTOR:		
Baseline (average 1998 - 2000)	11,505	ODP tonnes - Consumption
Current (2001))	6,662	ODP tonnes - Consumption
ODS USE AT ENTERPRISE (Average of 2000-02)	38.5	ODP tonnes
PROJECT IMPACT:	38.5	ODP tonnes
PROJECT DURATION:	18	months
PROJECT COSTS:		
Incremental Capital Cost:	US$	371,500
Contingency (10%):	US$	37,150
Incremental Operating Costs:	US$	53,612
Total Project Cost:	US$	462,262
LOCAL OWNERSHIP:	100%	
EXPORT COMPONENT:	0	
REQUESTED GRANT:	US$	462,262
REQUESTED AGENCY FUNDING:	US$	50,848
TOTAL COST OF PROJECT TO MULTILATERAL FUND:	US$	513,110
COST EFFECTIVENESS (GRANT/KG ODP):	US$/kg	12.00
STATUS OF COUNTERPART FUNDING:	Committed	
PROJECT MONITORING MILESTONES INCLUDED:	Yes	
NATIONAL COORDINATING AGENCY:	Ozone Cell, Ministry of Environment and Forests	

Project summary:

The project will phase out the use of 35.00 MT (38.50 ODP tonnes) of carbon tetrachloride (CTC) at Western Engineering Co., New Delhi and Srinagar plants. CTC is used as cleaning solvent in the manufacture of components such as copper tubes/coils, evaporators, and air conditioners. The major cost items are two vapour degreasers and two cold solvent cleaning stations amounting to US$ 300,000 with trichloroethylene (TCE) as solvent. Incremental operating costs are US$ 53.612.

Country studies and the country program prepared during 1993 have identified the sector as a high priority area.

Impact of the project on country's Montreal Protocol obligations:

The project will eliminate 38.5 ODP tonnes of CTC consumption from the solvent sector.

Revised by: D. Staley, UNDP Solvent Sector Expert Date: June 2004

1.0 PROJECT OBJECTIVE

This project represents the Government of Japan's bilateral contribution, through the Multilateral Fund, towards India's commitment to phase-out consumption and production of the Montreal Protocol controlled substance carbon tetrachloride (CTC) prior to 1 January 2010, in compliance with Protocol schedules. The implementation of phase-out activities at four enterprises and its subsidiaries, Steel Authority of India Limited (SAIL), Western Engineering Co. (WEC), Nissan Copper Pvt. Ltd. (NCPL) and Hind Metal and Tubes (HMT), will eliminate an aggregate consumption of up to 533 metric tons of CTC and form an integral effort towards phase-out of consumption in the metal cleaning sub-sector.

The objective of this project is to phase out the use of 35 metric tonnes of carbon tetrachloride (CTC) (38.5 ODP tonnes) as cleaning solvent in the manufacture of copper tubes & pipes required for the refrigeration and air conditioning industry at Western Engineering Co, New Delhi and Srinagar plants (WEC). CTC will be replaced by trichloroethylene (TCE) in vapour degreasers and cold solvent cleaning stations.

2.0 SECTOR BACKGROUND

The Government of India ratified the Montreal Protocol (MP) on Substances that Deplete the Ozone Layer on September 17, 1992. India has been classified as a country operating under Article 5, paragraph 1 of the Protocol. The Ministry of Environment and Forests (MoEF) has been empowered by the Government of India to have overall responsibility for implementation of Montreal Protocol related activities in India. The MoEF has established an Ozone Cell with operational responsibility for implementation of the Protocol-related activities in India.

The Country Program for the Phase-out of Ozone Depleting Substances was submitted for the Executive Committee's consideration in 1993. The 1993 Country Program reported net CTC production and consumption of 1,958 ODP tons and 5,097 ODP tons in 1992, respectively. These figures do not include production and consumption for feedstock applications.

Table 1: India CTC Consumption and Production Data as per Article 7 of the Montreal Protocol
(ODP tonnes)

	1989	1992	1993	1994	1995	1996	1997	1998	1999	2000
Consumption	4,758	5,097	10,600	8,790	3,112	8,776	7,876	6,270	16,099	12,147
Production	4,758	1,958	(1,036)	8,433	(21,788)	(19,787)	7,876	6,614	15,897	12,147

As a Party to the Montreal Protocol, India is required to submit its annual production and consumption data for all controlled substances under the Montreal Protocol to the Ozone Secretariat of UNEP in Nairobi (Article 7 of the Montreal Protocol). The data reported by the Ozone Cell on behalf of the Government of India, as required by Article 7 of the Protocol, particularly the data for 1998 – 2000, was used for establishing the baseline levels for production and consumption of CTC during the compliance period. The official baseline consumption and production levels for India are 11,505 ODP tons and 11,553 ODP tons, respectively.

Table 2: Average CTC Consumption and Production (per Article 7) During 1998 – 2000

Reported Data (Article 7)	1998	1999	2000	Baseline
Consumption (ODP tonnes)	6.270	16,099	12,147	11,505
Production (ODP tonnes)	6.614	15,897	12,147	11,553

CTC is an ozone depleting substance listed in Annex B, Group II, of the Montreal Protocol. The phase-out schedule of this chemical, that is applicable to Article 5 countries, is as follow:

Consumption

85% reduction of CTC consumption by 1 January 2005;
100% reduction of CTC consumption by 1 January 2010;

Production

85% reduction of CTC production by 1 January 2005[1];
100% reduction of CTC production by 1 January 2010[2].

The latest CTC consumption and production levels (2001)[3] are 42,639 ODP tons and 18,105 ODP tons, respectively. To be in compliance with the Montreal Protocol, India must reduce its consumption and production levels for non-feedstock applications to 1,725.75 ODP tons and 1,733 ODP tons, by 1 January 2005.

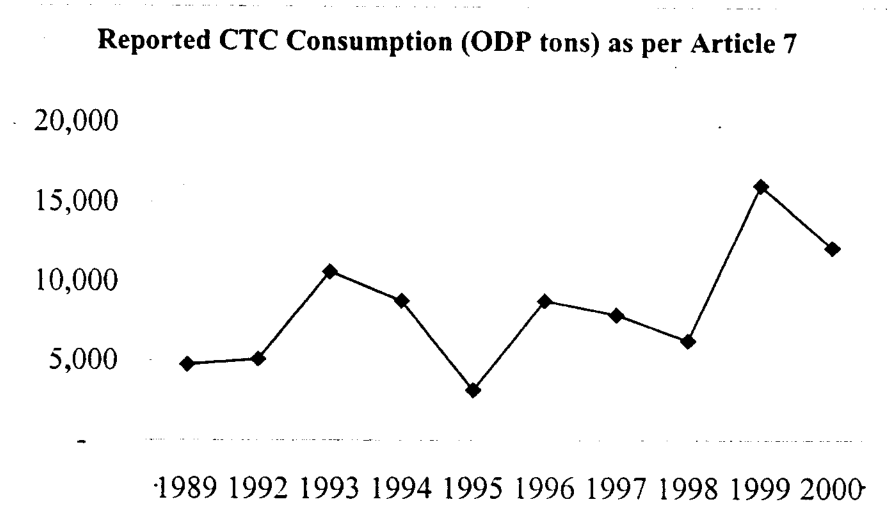


Figure 1 CTC consumption for non-feedstock applications reported by the Government of India as per Article 7 of the Montreal Protocol

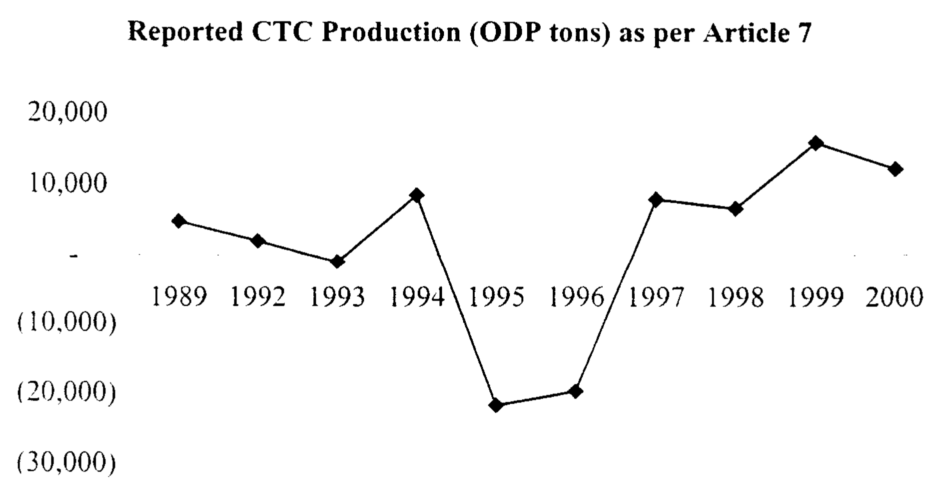


Figure 2 CTC production for non-feedstock applications reported by the Government of India as per Article 7 of the Montreal Protocol

[1] Allowance for production to meet the basic domestic needs of Article 5 parties: 10 percent of base level production.
[2] With possible essential use exemptions.
[3] Production and consumption figures include demand for feedstock and non-feedstock applications.

The definition of production as per Article 1 of the Montreal Protocol is the total production level minus the total tonnage destroyed by technologies approved by the Parties and minus the total tonnage consumed as feedstock. Based on this definition, the reported figures could vary significantly depending on the level of CTC imported for feedstock applications. However, for the purpose of this study and for the purpose of establishing a production and consumption baseline, the reported figures for 1998 to 2000 are used for the development of this CTC phase-out plan.

2.1 CTC Consumption and Production in India

The demand for CTC in India for feedstock and non-feedstock applications is more than 40,200 MT per year (average demand during the period from 1998 to 2000). CTC is used as a feedstock as well as a process agent and solvent. The demand is met by both the local production of CTC and imported CTC. The average production level of CTC during 1998 – 2000 is about 19,000 MT, which is supplemented by additional imports of 21,300 MT per year (as per survey results).

In average, about 33,800 MT of the total supply of 40,200 MT was used in the applications considered as feedstock[4] by the Montreal Protocol. Major feedstock applications in India include the use of CTC for the production of CFCs, and the use of CTC for the production of DV acid chloride, an intermediate material for the production of cypermethrin and other synthetic pytheroids. A small amount of CTC was exported in 1998 and 1999. However, export of CTC has stopped since 2000. In addition, small consumption of CTC as laboratory reagents was also identified. The average feedstock use for the production of CFC during the period from 1998 to 2000 is 27,000 MT, and 6,800 for the production of DV acid chloride[5].

The remaining amount of CTC (40,200 MT less 33,800 MT used as feedstock, laboratory reagents and export) is consumed by the process agents industry and the solvent sector in India. The average consumption of CTC in the process agents industry, between 1998 and 2000, is approximately 2,600 MT. A balance of 3,800 MT of CTC is believed to be used in the solvent sector.

In 2001, the total quantity of CTC locally produced was 16,459 MT. This quantity was supplemented by imports of another 24,661 MT. On the demand side, the total CTC requirement for feedstock applications was 32,649 MT. About 6,056 MT was consumed in the applications considered as consumption by the Montreal Protocol. There were about 2,415 MT of CTC unaccounted for by the survey. This could represent the level of inventory maintained by distributors and dealers. About 1,740 MT of the total identifiable consumption of 6,056 MT was for meeting the demand in the process agents industry. The total consumption of CTC in the solvent sector in 2001 was 4,314 MT.

Table 3: Estimated CTC Consumption and Production in 2001

	MT	Total MT
Supply		41,120
Domestic Production	16,459	
Import	24,661	
Demand		38,705
Feedstock Applications	32,649	
Consumption*	6,056	

*An estimate based on identifiable consumption

[4] Feedstock is defined as the use of controlled substances as raw materials for manufacturing of other chemicals.
[5] DV acid chloride is an intermediate chemical for production of cypermethrin and other synthetic pytheroids.

3.0 ENTERPRISE BACKGROUND

Western Engineering Co, New Delhi and Srinagar plants, (WEC) has been supplying heating, ventilation, air conditioning (HVAC) and refrigeration plants and parts for the last 35 years. It is a 100% Indian entity. WEC has two production units at Delhi and Srinagar, (Jammu & Kashmir). Operations take place in Plot No 8, Friends Colony, Industrial Area, G.T. Road, Shahdara, Delhi and 270, Nursingarh, Srinagar, J & K. The company was incorporated in 1964 with its head quarters at 3785, Subhash Marg, Darya Ganj, New Delhi-110002. The total manpower of these two plants is 150 and there is one shift worked per day for most of the operations in the plants.

The product mix manufactured by the company is as follows:

Components:

- Shell and tube type condensers
- Shell and tube type chillier
- Air cooled condenser coils
- Dryers
- Strainers
- Accumulators
- Headers & copper fittings

Sub- Assemblies:

- Packed Air conditioners
- Water Cooled ductable air conditioners with cooling and heating system
- Air cooled & water cooled condensing units
- Window/ Split air conditioners with cooling and heating system

Products:

- Fan coil units
- Chilled water coils
- Copper tubes and pipes
- Water cooled chillers
- Bent condenser coils
- Chiller Coils
- Air Cooled chillers
- Heat convectors
- Hot water coils

Table 4: Manufacture of Products, Sub-Assemblies and Components

Year	Air conditioning, central heating system, cold storage units		Package units		Large Chillers		Components/ products*	
	Delhi	Srinagar	Delhi	Srinagar	Delhi	Srinagar	Delhi	Srinagar
2000	125	60	25	20	6	-	20,000	15,000
2001	110	50	20	15	4	-	19,000	10.000
2002	130	75	25	18	5	-	25,000	16,000
Average	122	62	23	18	5	-	21,000	14,000
Capacity	200	100	50	50	25	-	30,000	20,000

* This component figure does not include components used by WEC in-house in the manufacture and assembly of finished product indicated above. The average requirement of components for these products would be similar in numbers of components indicated in the table. Hence the total components manufactured by WEC would be double, 50,000 pieces and 32, 000 pieces at Delhi and Srinagar respectively, in the year 2002.

There are no exports at present. The company is exploring possibilities to export its products to Middle East and Far East African countries.

4.0 PROJECT DESCRIPTION

As shown, WEC produces a large variety of cooling and heating systems. CTC is relied upon as the industrial solvent in support of their production processes. Specific uses include the cleaning of tubes between various steps of the manufacturing process and final cleaning of both components and final products. For these purposes CTC has several very useful characteristics including being non-flammable, strong cleaning power, fast evaporation rate, no post-evaporation residue, and low cost. Unfortunately, it is very toxic, believed to be carcinogenic and known to deplete the ozone layer with a high ODP.

4.1 Existing Cleaning Process

The primary manufacturing process at WEC is the production of components and assembly of final products. The basic cleaning steps within the manufacturing process are listed below.

- ***Components cleaning:*** Smaller components are dip cleaned in crude metal tanks of CTC for approximately 30 minutes. Small hydraulic pumps are attached to these rectangular metal tanks to provide solvent circulation: increasing mechanical action and facilitating CTC cleaning. Roughly half of these small components are sold as final products. The remainder are integrated into larger products to build final assemblies.
- ***Final assembly primary cleaning - external:*** After components are assembled into final products an initial cleaning is performed by submersion in CTC. Primary cleaning removes forming oils and brazing soils. CTC is left in this container with a water cap to inhibit evaporation.
- ***Final assembly primary cleaning - internal:*** After components are assembled and exterior cleaning is complete, the inlet and outlet of the product is connected to a small hydraulic pump and CTC is flushed through the system.
- ***Final assembly final cleaning - external and internal:*** After nitrogen is used to perform leak testing, repairs are made and virgin solvent is used in the same manner as the primary cleaning step to complete final cleaning.
- ***Standard drying - external and internal:*** After final cleaning, residual CTC simply evaporates from the outside of the product. Compressed air is used to purge the inside of the products.
- ***Special drying:*** If ambient temperature is less than 30°C then a diesel oven is used to facilitate drying. This same process is used for special products such as low temperature compressors (-80°C) and critical hospital products.
- ***Large products:*** A small number of large products (primarily chillers and condensers) are cleaned using a combination of dip and manual wiping or brushing.
- ***Surface preparation cleaning:*** Manual wipe cleaning with CTC is also performed on certain products prior to painting.

4.2 Solvent Consumption

CTC consumption can be seen in Table 5.

Table 5: CTC Consumption in Metric Tonnes/Year

Year	CTC consumption (metric tonnes/year)		
	Delhi	Srinagar	Total
2000	20	15	35
2001	19	10	29
2002	25	16	41

The baseline for CTC use is therefore the average of the three years, that is, 35 metric tonnes/yr (38.5 ODP tonnes/yr).

4.3 Existing Cleaning Equipment

No major dedicated CTC cleaning equipment exists for this application. Overhead cranes, ovens and compressed air all serve other maintenance or production functions as well as their cleaning support role. Minor low value assets such as metal solvent containers and small hydraulic pumps are utilized in a variety of ways to facilitate solvent application and removal as previously described.

5.0 Alternatives, Proposed Cleaning Processes, and Requirements

5.1 Alternatives

Many alternatives exist for most solvent cleaning applications. The ultimate selection requires careful consideration of the various advantages and disadvantages between possible options. Table 6 compares the most likely alternatives by assigning each a score for the various considerations. The analysis can be more sophisticated if weighting factors are assigned to each consideration. For this discussion each consideration column is weighted evenly.

Table 6: Alternative Comparison

Considerations	ODP	Ability to clean [a]	Simple cleaning process	Cost	Safety [b]	Worker chronic health	Other environmental [c]	Total	Usability [d]
Current Process (carbon tetrachloride)	0	3	4	4	4	0	0	15	0
Alternative Process									
Chlorinated	3	4	3	3	3	2	2	20	20
Aqueous	4	3	0	2	2	3	2	16	0
Aliphatic & Aromatic hydrocarbons	4	2	1	3	2	3	2	17	17
Petroleum distillate speciality blends	4	3	2	1	3	3	2	18	18
HCFC 225cb	2	2	3	0	4	3	1	15	0
HCFC 141b	1	2	3	2	3	3	1	15	15
HFCs and HFE	4	2	3	0	4	4	1	18	0
n-propyl bromide	2	4	3	2	2	1	2	16	16
PFCs	4	1	1	0	4	4	1	15	0

0 = Worst, 1 = Poor, 2 = Average, 3 = Good, 4 = Best
a - Ability to clean forming oils and brazing soils and other soils from copper and other non-ferrous metals
b - Safety considers workers during cleaning (acute exposure & flammability)
c - Other environmental = VOC, GWP, and Groundwater
d - Usability = This column reflects 0 if there are any zeros in the row

5.1.1 Carbon Tetrachloride

The current cleaning processes generally speaking are very simple. In addition CTC is inexpensive. However, CTC has many critical disadvantages including high ODP, high toxicity, and high global warming potential. Like other chlorinated solvents CTC is heavier than water so if released onto the ground it can quickly cause significant environmental impact.

5.1.2 Non-Ozone Depleting Chlorinated

Some chlorinated solvents have more cleaning power than CTC. Also, there are many alternative chlorinated solvent-cleaning processes that would significantly reduce solvent emissions and increase recycling. New processes are more complicated than existing cold solvent cleaning manual methods. Worker safety and health concerns are also reduced with lower exposure to a less toxic solvent. Although VOC and GWP for the chlorinated solvents are low, there is still a concern for groundwater contamination.

5.1.3 Aqueous

Aqueous cleaning advantages include non-ozone depleting and a relatively low worker health risk. Disadvantages include the significantly complicated aqueous cleaning process. Challenges with detergent make up, mechanical agitation (e.g., ultrasonics or spray) pure rinse water, wastewater treatment, and drying all contribute.

5.1.4 Aliphatic & Aromatic Hydrocarbons

Although non-ozone depleting, the choice of which non-halogenated hydrocarbon to use is a compromise. Faster evaporation means higher flammability. To increase safety by using a solvent that is non-flammable but only combustible will increase drying time. When making a solvent decision inside this group of alternatives it is also necessary to consider possible residue issues.

5.1.5 Petroleum Distillate Speciality Blends

Non-halogenated hydrocarbons can be blended to emphasise the advantages and minimize most disadvantages found in pure solvents. The prime disadvantage in this case becomes the high cost of these speciality blends.

5.1.6 HCFCs

Although relatively safe and acceptable for worker health; ODP, GWP, lower cleaning power and high cost make HCFCs an unattractive alternative.

5.1.7 HFCs and HFE

Cost and poor cleaning ability (even after blending) rule out this alternative. No ODP, relative safety and low toxicity are the advantages.

5.1.8 n-Propyl Bromide

Strong cleaning ability and low cost are attractive features of nPB. ODP and expected high toxicity are disadvantages. Potential for future regulation under the Montreal Protocol also deserves consideration.

5.1.9 PFCs

Expensive, high GWP, slow drying and poor cleaning ability but safety is good and health risk very low.

5.2 Further Consideration of Chlorinated Solvent Alternatives

After reviewing the considerations for the various possible options it is clear that non-ozone depleting chlorinated solvents will provide the best overall solution. Table 7 provides more detailed information to assist with the final selection of the optimal chlorinated solvent for cleaning at WEC.

Table 7: Non-ozone Depleting Chlorinated Solvent Comparison

Properties	Formula	ODP	GWP	Boiling Point	Evaporate Rate (nBA=1)	Latent Heat (cal/gm)	Flash Point C	Flammable limits (vol % @ 25 C)	Kauri-Butanol Value *	Toxicity
Current Process (carbon tetrachloride)	CCl_4	1.1	1,400	77	7.5	46.4	None	None	113	High
Alternatives										
Methylene chloride	CH_2Cl_2	0	9	40	14.5	78.9	None	14-22	136	Med
Perchloroethylene	CCl_2CCl_2	0	~9	121	2.1	50.1	None	None	90	Med
Trichloroethylene	$CHClCCl_2$	0	< 9	87	6.4	56.4	None	8-9	129	Med

* Solvent cleaning power is expressed in terms of the Kauri Butanol value (higher number = higher power)

5.2.1 Methylene Chloride

Methylene chloride (MC) has the lowest boiling point, fastest evaporation rate and highest cleaning power of the three non-ozone depleting chlorinated solvents. Fast evaporation makes it a poor choice for cold solvent (ambient temperature) manual cleaning. Heightened awareness of solvent conservation is required when using MC for this type of cleaning. A final concern is worth noting about small mass parts manually cleaned with MC. In humid locations it is possible to reduce the temperature of parts enough to cause water moisture to condense on them. This results from the high latent heat of vaporization for MC. For many applications this is not desirable.

As a vapour degreasing solvent the low boiling point means less energy consumption. Because the solvent boils near ambient room temperature it is a good option for temperature sensitive cleaning applications or when parts must be handled soon after leaving the vapour degreaser. Both of these potential benefits are of little value to WEC cleaning applications. Lower boiling point also means reduced cleaning time in the vapour zone because the part being cleaned will reach temperature equilibrium faster and condensation cleaning will stop sooner. Stubborn soils that require a hotter solvent condensate will not be cleaned as effectively with MC. On the other hand, its higher solvent cleaning power may somewhat offset the cooler cleaning temperature.

The storage of MC at ambient temperatures in the pre-summer monsoon period may lead to drum rupture, because the pressure will increase as the boiling point is approached, especially if the drum is accidentally exposed to sunlight. Air-conditioned storage facilities with strict instructions for the use would be necessary.

In short, MC will lead to more emissive manual cleaning and has more complicated storage requirements. It also results in lower temperature and shorter duration vapour degreaser cleaning. The only applicable advantage is reduced energy consumption but this is not enough to outweigh the disadvantages. MC is not the best solvent choice for WEC.

5.2.2 Perchloroethylene

Perchloroethylene (PCE) is at the opposite end of the chlorinated solvent spectrum from MC. It has the highest boiling point, slowest evaporation rate and lowest cleaning power. Lower evaporation rate would seem to be an advantage for cold solvent manual cleaning. However, reduced emissions must be compared with the need for increased drying time.

As a vapour degreasing solvent, PCE consumes the most energy per kilogram of parts cleaned. With the highest vapour temperature, PCE cleaned parts experience the maximum condensation cleaning time before temperature equilibrium is reached and cleaning stops. Parts being cleaned in a PCE vapour degreaser must be able to withstand higher temperatures. Hotter condensate facilitates removal of many otherwise difficult soils but more time is required to let the hot parts cool after removal from the degreaser.

In short, PCE is more suitable than MC for manual cleaning applications if longer drying times are acceptable. Vapour degreasing with PCE is good for difficult soils but energy required and longer cooling time for hotter parts need to be considered.

5.2.3 Trichloroethylene

For many of the critical physical solvent properties Trichloroethylene (TCE) is a good middle of the road option. Boiling point, evaporation rate and solvent cleaning power are all between the other two non-ozone depleting chlorinated options. TCE has an evaporation rate very similar to CTC. It is likely that no difference would be noticed in emission amounts or drying time for cold solvent manual cleaning operations.

For vapour degreasing TCE again offers a centre point solution. Boiling point requires medium energy consumption and allows for medium duration dwell times. Parts emerge at double ambient temperature but not triple as for PCE. So again drying time is in the middle. Cleaning power is one property that is not in the middle. KB value for TCE is more than CTC and leans toward the high end with MC.

In short, TCE seems to offer a good compromise between MC and PCE. TCE is recommended for cleaning needs at WEC.

5.3 Proposed Cleaning Processes and Requirements

Significant change is required to replace CTC product cleaning processes in use today. The following items are required at WEC.

1) 1.0m x 1.5m x 3.0m batch vapour degreasers for components and exterior surfaces of final assemblies.
2) Integral solvent distillation unit for each degreaser.
3) Dedicated hoist for each degreaser to load and unload parts baskets.
4) 2.0m x 2.5m x 2.0m cold solvent cleaning station for flushing internal surfaces of final assemblies. Station will include cleaning bench, spray wand, solvent supply container, recirculation pump, integral still, and induced draft ducted ventilation.
5) Shop modifications that are required to provide a foundation with sealed containment under all equipment holding TCE, utilities, ventilation ducting, and existing equipment rearranges.
6) Safety shower and eyewash stations
7) Personal protection equipment (PPE) to include gloves, apron, safety glasses, and half mask respirator for spill conditions.

The process for cleaning large final products, currently cleaned by cold solvent manual wiping or brushing, will continue. Two process changes are required. First, is a simple switch of solvents from CTC to TCE. Second, all personnel performing manual cleaning will be required to limit exposure to acceptable levels by using the correct PPE.

Table 8: **Equipment Requirements**

Required Cleaning Equipment				
1.0m x 1.5m x 3.0m basket Vapour Degreaser (VD) with still	Hoist	Cold Solvent Cleaning Station	Safety shower & eyewash	Shop modifications (civil work)
2	2	2	2	2

5.4 Additional Considerations

5.4.1 Chemical Supply

Availability of the chosen solvent alternative requires verification. This includes both a primary and secondary source to meet requirements.

5.4.2 Single Solvent Solution

The most simplistic approach for choosing an alternative to CTC is to select a single solvent. As was previously discussed, some properties of other alternatives may be more optimal for a portion of the total cleaning requirement at WEC. However, with multiple solvents a disciplined material management system is required to ensure potentially dangerous mistakes do not occur by inadvertently using the wrong solvent. This same argument can be made when considering using stabiliser-free TCE as a cost cutting measure. Stabilised TCE is 50% more expensive and is not required for applications that are completely emissive (e.g., large product cold solvent manual cleaning). However, it is a must for vapour degreasing. Accidental use of the wrong solvent can cause serious problems so is not worth the risk. In addition, the use of non-stabilised TCE requires closer inventory monitoring as it has a shorter shelf life. Stabilised chlorinated solvents last two years or more if sealed and uncontaminated. Shelf life of non-stabilised solvent is closer to six months.

5.4.3 Cleaning Complexity

It is likely that WEC will have very positive experiences after implementation of the alternative cleaning processes. Less solvent will be required. Parts will likely be cleaner because of better processes with a stronger solvent and worker exposure will be dramatically decreased. As usual all of these benefits come with a cost. Cleaning at WEC will become more complex. Initial and maintenance training will be required. In addition to new cleaning equipment, maintenance of solvent chemistry will be required.

Correct Stabiliser

Only special metal-cleaning grades of TCE should be purchased; they will be specially stabilised for this application. The stabiliser systems for nonferrous metals, such as aluminum and copper can be different from those for ferrous metals.

Stabiliser Maintenance

TCE has a slight tendency to create hydrochloric acid when heated in the presence of water. It is therefore important to maintain an adequate level of stabiliser in order to prevent corrosion of metals. This includes both the parts being cleaned and the cleaning equipment itself. Periodic solvent sampling is required to monitor the solvent chemistry. Stabiliser concentrates are available which can be added as needed to maintain a correct chemistry. Under no circumstances should alkali be used to neutralise acids in TCE. Periodically over the course of a year the solvent contents of the vapour degreaser will need to be changed completely. Many variables affect the amount of time between changes. The manufacturer/supplier of TCE should be consulted for detailed discussion of surfaces to be cleaned and correct maintenance levels to ensure optimum results in terms of the stabiliser system. Cost of stabiliser was considered in Annex 1.

6.0 Safety, Health and Environment

Compliance with safety, health and environmental regulations are ultimately of course the responsibility of WEC. However, it should be noted that an effort was made to research applicable national regulations. The proposed implementation plan described in this project document provides guidance and suggests new processes that will meet all known regulations.

6.1 Safety

CTC is a safe solvent when used correctly. Due to carbon tetrachloride's volatility, inhalation is the principal hazard. However, like all chlorinated solvents it has a vapor density much greater than air so CTC (and MC, PCE, TCE) displaces air within confined low-lying spaces. This can easily result in asphyxiation (suffocation) because there is no oxygen available. The initial effects of an excessive inhalation exposure are dizziness, loss of coordination, and symptoms of anesthesia. These symptoms may be accompanied by nausea. Excessive exposure may also cause systemic injury (kidney and liver damage). Extremely high vapor levels may increase myocardial irritability (irregular heartbeats) and potentially death.

If at all possible, a system such as self-contained breathing apparatus (SCBA) should be employed with careful monitoring for any spill situations. SCBA means supplying oxygen from outside the oven. It is a dangerous mistake to believe half mask respirators can be used in this application. These mask only filter solvent vapour they do not supply oxygen. It is critical to understand the difference.

6.2 Health

TCE as an alternative to CTC will be a significant improvement from a worker exposure perspective. Not only is TCE less toxic than CTC but correct use of PPE and improved cleaning processes will drastically reduce worker exposure. This will make TCE much more acceptable from both an acute and chronic worker exposure point of view.

Training will be provided during implementation to explain the details on how to minimise TCE exposure using PPE. However, the following types of PPE should be employed as soon as feasible to limit CTC exposure in the interim.

Operators should be equipped with the following:

- Gloves: Viton fluoroelastomer, nitrile rubber, neoprene, or polyvinyl alcohol (PVA).
- Apron: Polyvinyl alcohol, neoprene, or nitrile.
- Eye Protection: Safety glasses or their equivalent. Goggles where liquid splash contact is likely.
- Half mask carbon filter respirator should be available for handling in case of spills
- Self-contained breathing apparatus must be provided where persons are exposed to oxygen deprived situations. TCE has heavy vapours that will collect in low poorly ventilated areas.

6.3 Environment

6.3.1 Air

The use of vapour degreasers, solvent recycling and solvent reclamation distillation units will greatly reduce air emissions from pre-conversion levels. However, manual cleaning of large products will remain to be a high emission cold solvent cleaning application. Efforts should continue to reduce solvent loss in these cleaning applications.

6.3.2 Water

It is never acceptable to introduce halogenated industrial solvents to sanitary or storm water sewer systems as a means of disposal.

6.3.3 Soil

Halogenated industrial solvent should never be allowed to spill onto bare earth, asphalted roads or unsealed concrete. Their relative density allows them to sink below groundwater. This causes toxic contamination of community drinking water drawn from wells and hinders removal efforts.

6.3.4 Disposal

Evaporation served as the primary means of disposal for CTC. In addition to the environmental impact, this method is very wasteful from a financial perspective. Recycling and the use of reclamation stills will dramatically reduce cleaning costs but it will also introduce a more concentrated waste stream known as still bottoms. The disposal of still bottoms should be well planned. In some cases the solvent vendor will provide disposal services for a nominal fee.

7.0 Project Costs

The project cost refers to all costs including incremental operating costs. As shown in Table 9, the total project cost of US$ 462,262 was calculated as the incremental capital cost of US$ 408,650 plus net incremental operating costs of US$ 53,612 for 4 years discounted at 10%.

7.1 Incremental Capital Cost

As given in Annex 1, the total incremental capital cost is US$ 408,650. The major components of this cost included technical cleaning process support, equipment support, and the purchase and installation of equipment to permit the conversion to TCE solvent and 10% contingency.

7.1.1 Cleaning Process and Equipment Support

WEC has two primary cleaning application, electrical motors and oxygen systems. As previously explained the change from CTC to TCE needs careful study and process standardisation. Material compatibility testing will be required to ensure TCE is not too aggressive for electrical components such as motor winding insulation. The ability to remove all traces of TCE from the different oxygen system components must be ensured. A standardised method must be developed and instituted to measure whether all TCE has been removed. If these conditions cannot be met then another solution will be required for large portions of the oxygen system that are cleaned in place. Standardised testing procedures need to be established and instituted to meet existing cleanliness standards.

Pre-commissioning of complex equipment should be carried out at the site of the Original Equipment Manufacturer (OEM) prior to shipment. Prior to shipment of equipment, batches of actual work-pieces from the factory should be sent to OEM to clean with the proposed alternative and returned to the factory to evaluate if it meets the cleanliness requirements. If the pieces are too heavy to transport, then the work pieces are to be simulated. An expert from the OEM should be present during the installation and start-up at the WEC plants. The existing engineers, operators and maintenance personnel will be trained in operating and maintaining the new equipment.

7.1.2 Technical Consultancy

Technical consultancy will be required to research, propose and document alternative selection. Equipment specifications will be required for the purchase of custom cleaning equipment described in Table 8. Also, staff training is required in safety, health and environmental aspects of TCE use.

7.1.3 Equipment to Purchase and Install

Equipment to be purchased is outlined in Table 8. The project includes funding to prepare the sites for equipment installation. Scope of this work includes providing a foundation with sealed containment, utilities, and existing equipment rearranges.

7.2 Incremental Operating Costs/Savings

If the project were not undertaken, the annual operating cost would be US$ 53,900. The annual operating cost of the implemented project will be US$ 70,812, resulting in annual operating costs of US$ 16,912. Given an equipment lifetime of 10 years and discount rate of 10%, the net value of the first 4 years of incremental operating cost is US$ 53,612. The details are provided in Annex 2.

7.3 Revenues

This project will create an annual incremental operating cost for WEC of US$ 16,912.

7.4 Local Ownership Ratio

WEC is 100% Indian owned therefore, the total proposed Multilateral Fund financing is equal to the total project cost of US$ 462,262.

7.5 Exports

Exports are nil.

7.6 Proposed MLF grant

The proposed MLF grant for this project is calculated as follows: To the total incremental capital cost (ICC) of US$ 408,650 was added the net present value of the incremental operating costs over the first 4 years of the project, which is US$ 53,612. The sum was then multiplied by the 100% Indian ownership ratio of WEC, to yield the resultant grant of US$ 462,262. There are no exports to non-Article 5 countries so the grant remains at US$ 462,262.

7.7 MLF Grant Calculation

Table 9: Total Project Grant

Cost / Plant	ICC	ICC contingency	ICC total	IOC	NPV of 4 years IOC	Total Project Cost
WEC	371,500	37,150	408,650	16,912	53,612	462,262

7.8 Financing Plan

MLF funding is a grant and is limited to the incremental capital and incremental operating costs as calculated above. Funding for this project will be financed from the bilateral contributions of the Government of Japan to the MLF.

8.0 Project Implementation

The project will be carried out at WEC.

8.1 Required Regulatory Action

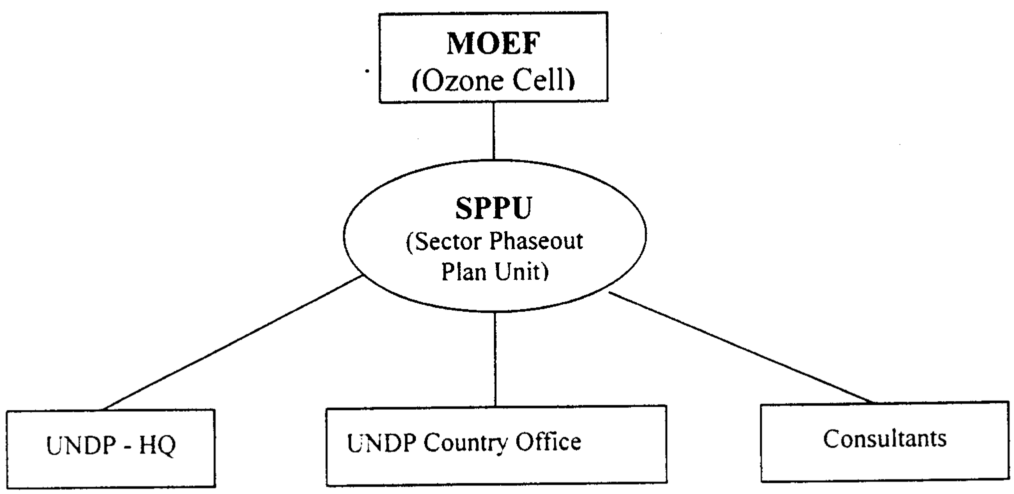
No regulatory action, other than routine permitting, will be required to implement this project.

8.2 Direct Project Impacts

The project will eliminate annually 35 metric tonnes or 38.5 OD tonnes from WEC.

8.3 Project Management and Implementation

Ozone Cell, Ministry of Environment and Forest will administer the Project, an allocation has been allocated to facilitate management coordination, monitoring and performance verification responsibilities of the MoEF. As designated by the Government of Japan, with the concurrence of the Government of India, UNDP will implement this project under Direct Execution (DEX) modality. In close coordination with the Ozone Cell and the Sector Plan Phase-out Unit (SPPU), UNDP India Country Office and Montreal Protocol Unit will undertake all phase out activities at these four enterprises. As such, the programme will be implemented using the following structure:



The attached Operational Mechanism for Implementation (OMI) developed under IND/02/G66 – Foam Sector Phase-out Plan and IND/03/G62 – Refrigeration (Manufacturing) Sector Phase-out Plan that has been successfully applied to facilitate implementation of these two sector plans, will serve as a framework for implementation of UNDP activities under this project, to the extend relevant and applicable, generally in line with the role and responsibilities of various actors as described in the OMI.