TABLE 6-1a (METRIC). COSTS OF ESP REPLACEMENT TO CONTROL PM TO 0.10 G/DSCM FOR MODEL RECOVERY FURNACES (EXCLUDING PULP PRODUCTION LOSSES)<sup>a</sup>

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Pulp         Furnace         fiting rate,         Equivalent         ESP plate         New SCA,         Downime,         TCi,         Electricity,         A,1 A, T,           4a         Pip         Ype         Ype         Ype         Ype         Sy120,000         380         384,120,000         515,000         514,000	Model			Black liquor		Gas flowrate							Conital	
4a         BI         NDCE         700,000         380         93.4         9,806         105         300         \$4,120,000         \$19,400         \$165,000         \$165,000         \$19,400         \$165,000         \$165,000         \$19,400         \$165,000         \$165,000         \$237,000<	recovery furnaces	Pulp type	Furnace type	firing rate, kg BLS/d	Equivalent ADMP/d	ESP exit, m3/sec @8% 02	ESP plate area, m2	New SCA, m2/(m3/sec)	Downtime, d	TCI, \$	Electricity, \$/vr	A,I & T, \$/vr	capital recovery, \$/vr	ITAC, \$/vr
5a         BI         NDCE         1,200,000         680         168         17,638         105         30         \$7,430,000         \$35,000         \$297,000           6a         BI         NDCE         1,800,000         1,000         243         25,512         105         30         \$10,700,000         \$50,500         \$289,000         \$243,000         \$200,000         \$50,500         \$243,000         \$200,000         \$50,500         \$243,000         \$200,000         \$50,500         \$243,000         \$200,000         \$50,500         \$241,000         \$50,4100         \$50,500         \$50,400	RF-1a/4a	B	NDCE	700,000	380	93.4	9,806	105	30	\$4,120,000	\$19,400	\$165,000	\$482,000	\$666,000
6a         B1         NDCE         1,800,000         1,000         243         25,512         105         30         \$10,700,000         \$50,500         \$428,000         \$428,000         \$428,000         \$428,000         \$428,000         \$428,000         \$430,000         \$430,000         \$430,000         \$430,000         \$430,000         \$41,331         B5         30         \$2,010,000         \$49,400         \$134,000         \$41,331         B5         30         \$2,350,000         \$41,300         \$134,000         \$41,300         \$134,000         \$41,300         \$134,000         \$41,300         \$134,000         \$41,300         \$134,000         \$134,	RF-2a/5a	B	NDCE	1,200,000	680	168	17,638	105	30	\$7,430,000	\$35,000	\$297,000	\$869,000	\$1.200.000
BI         DCE         400,000         230         56.2         4,794         85         30         \$2,010,000         \$11,700         \$80,400           BI         DCE         700,000         380         93.4         7,967         85         30         \$33,350,000         \$134,000         \$134,000         \$134,000         \$134,000         \$134,000         \$134,000         \$134,000         \$134,000         \$134,000         \$134,000         \$134,000         \$134,000         \$134,000         \$134,000         \$134,000         \$134,000         \$134,000         \$156,000         \$134,000         \$156,000         \$154,000         \$156,000         \$154,000         \$156,000         \$154,000         \$154,000         \$154,000         \$156,000	RF-3a/6a	B	NDCE	1,800,000	1,000	243	25,512	105	30	\$10,700,000	\$50,500	\$428,000	\$1,250,000	\$1,730,000
BI         DCE         700,000         380         93.4         7,967         85         30         \$3,350,000         \$19,400         \$134,000           4B         DCE         1,200,000         680         168         14,331         85         30         \$5,030,000         \$35,000         \$241,000           4a         Unbi         NDCE         700,000         450         93.4         9,806         105         30         \$4,120,000         \$35,000         \$241,000           5a         Unbi         NDCE         7,00,000         450         93.4         9,806         105         30         \$4,120,000         \$29,700         \$243,000           5a         Unbi         NDCE         1,200,000         820         168         17,638         105         30         \$19,400         \$285,000         \$295,000         \$295,000         \$297,000         \$297,000         \$297,000         \$297,000         \$297,000         \$297,000         \$297,000         \$297,000         \$297,000         \$296,000         \$297,000         \$295,000         \$295,000         \$295,000         \$295,000         \$295,000         \$295,000         \$295,000         \$295,000         \$295,000         \$296,000         \$296,000         \$290,00	RF-7a	В	DCE	400,000	230	56.2	4,794	85	30	\$2,010,000	\$11,700	\$80,400	\$286,000	\$378,000
BI         DCE         1,200,000         680         168         14,331         85         30         \$6,030,000         \$35,000         \$241,000           4a         Unbi         NDCE         700,000         450         93.4         9,806         105         30         \$4,120,000         \$19,400         \$165,000         \$50,500         \$50,000         \$24,000         \$50,000         \$24,000         \$50,000         \$	RF-8a	В	DCE	700,000	380	93.4	7,967	85	30	\$3,350,000	\$19,400	\$134,000	\$477,000	\$630,000
4a         Unbl         NDCE         700,000         450         93.4         9,806         105         30         \$4,120,000         \$19,400         \$165,000         \$165,000         \$105         30         \$4,120,000         \$19,400         \$165,000         \$105         30         \$4,130,000         \$297,000         \$290,000         <	RF-9a	8	DCE	1,200,000	680	168	14,331	85	30	\$6,030,000	\$35,000	\$241,000	\$859,000	\$1,140. <b>625</b>
5aUnblNDCE1,200,00082016817,63810530\$7,430,000\$35,000\$297,0006aUnblNDCE1,800,0001,20024325,51210530\$10,700,000\$50,500\$428,000UnblDCE400,00027056.24,7948530\$2,010,000\$11,700\$80,400UnblDCE700,00045093.47,9678530\$3,350,000\$19,400\$134,000UnblDCE1,200,00082016814,3318530\$6,030,000\$35,000\$241,000	RF-1a/4a	Unbl	NDCE	700,000	450	93.4	9,806	105	30	\$4,120,000	\$19,400	\$165,000	\$482.000	\$666.0m
6a         Unbl         NDCE         1,800,000         1,200         243         25,512         105         30         \$10,700,000         \$50,500         \$428,000           Unbl         DCE         400,000         270         56.2         4,794         85         30         \$1,700,000         \$11,700         \$80,400           Unbl         DCE         700,000         450         93.4         7,967         85         30         \$3,350,000         \$11,700         \$80,400           Unbl         DCE         700,000         450         93.4         7,967         85         30         \$3,350,000         \$13,4,000         \$134,000           Unbl         DCE         1,200,000         820         168         14,331         85         30         \$6,030,000         \$21,000         \$241,000	RF-2a/5a	Unbl	NDCE	1,200,000	820	168	17,638	105	30	\$7,430,000	\$35,000	\$297,000	\$869,000	\$1.200.000
Unbl         DCE         400,000         270         56.2         4,794         85         30         \$2,010,000         \$11,700         \$80,400           Unbl         DCE         700,000         450         93.4         7,967         85         30         \$3,350,000         \$19,400         \$134,000           Unbl         DCE         700,000         820         168         14,331         85         30         \$3,350,000         \$19,400         \$134,000	RF-3a/6a	Unbl	NDCE	1,800,000	1,200	243	25,512	105	30	\$10,700,000	\$50,500	\$428,000	\$1,250,000	\$1,730,000
Unbl         DCE         700,000         450         93.4         7,967         85         30         \$3,350,000         \$19,400         \$134,000           Unbl         DCE         1,200,000         820         168         14,331         85         30         \$6,030,000         \$35,000         \$241,000	RF-7a	Unbl	DCE	400,000	270	56.2	4,794	85	30	\$2,010,000	\$11,700	\$80,400	\$286,000	\$378,000
Unbl         DCE         1,200,000         820         168         14,331         85         30         \$6,030,000         \$35,000         \$241,000	RF-8a	Unbl	DCE	700,000	450	93.4	7,967	85	30	\$3,350,000	\$19,400	\$134,000	\$477,000	\$630,000
	RF-9a	Idnbl	DCE	1,200,000	820	168	14,331	85	30	\$6,030,000	\$35,000	\$241,000	\$859,000	\$1,140,000

(a) Metric equivalents in this table were converted from the calculated English unit values given in Table 6-1b. Refer to Table 6-1b for footnotes, which include calculations.

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TABLE 6-1b (ENGLISH). COSTS OF ESP REPLACEMENT TO CONTROL PM TO 0.044 GR/DSCF FOR MODEL RECOVERY FURNACES (EXCLUDING PULP PRODUCTION LOSSES)<sup>a</sup>

Model		Furnacia	Black liquor firing rate	Equivalent	Gas flowrate ECD evit actim	ESD alate	New SCA	Downtime	IJ	Electricity	A   8. T	Capital	UT N
furnaces	type	type	Ib BLS/d	ADTP/d	02 @8% 02	area, ft2 (b)	Ð	d	; c) \$ (c)	\$/yr (d)	\$/yr (e)	s/yr (f)	\$/yr (g)
RF-1a/4a	BI	NDCE	1,500,000	420	198,000	105,600	533	30	\$4,120,000	\$19,400	\$165,000	\$482,000	\$666,000
RF-2a/5a	B	NDCE	2,700,000	750	357,000	190,400	533	30	\$7,430,000	\$35,000	\$297,000	\$869,000	\$1,200,000
RF-3a/6a	81	NDCE	3,900,000	1,100	515,000	274,667	533	30	\$10,700,000	\$50,500	\$428,000	\$1,250,000	\$1,730,000
RF-7a	B	DCE	900,000	250	119,000	51,567	433	30	\$2,010,000	\$11,700	\$80,400	\$286,000	\$378,000
RF-8a	В	DCE	1,500,000	420	198,000	85,800	433	30	\$3,350,000	\$19,400	\$134,000	\$477,000	\$630,000
RF-9a	æ	DCE	2,700,000	750	357,000	154,700	433	30	\$6,030,000	\$35,000	\$241,000	\$859,000	\$1,140,000
RF-1a/4a	Unbl	NDCE	1,500,000	500	198,000	105,600	533	30	\$4,120,000	\$19,400	\$165,000	\$482,000	\$666,000
RF-2a/5a	Unbl	NDCE	2,700,000	006	357,000	190,400	533	30	\$7,430,000	\$35,000	\$297,000	\$869,000	\$1,200,000
RF-3a/6a	IdnU	NDCE	3,900,000	1,300	515,000	274,667	533	30	\$10,700,000	\$50,500	\$428,000	\$1,250,000	\$1,730,000
RF-7a	Unbl	DCE	900,000	300	119,000	51,567	433	30	\$2,010,000	\$11,700	\$80,400	\$286,000	\$378,000
RF-8a	Unbl	DCE	1,500,000	500	198,000	85,800	433	30	\$3,350,000	\$19,400	\$134,000	\$477,000	\$630,000
RF-9a	Unbl	DCE	2,700,000	006	357,000	154,700	433	30	\$6,030,000	\$35,000	\$241,000	\$859,000	\$1,140,000

(a) All costs in \$1991
(b) ESP plate area = model gas flowrate x new SCA
(c) TCI = ESP plate area x (\$39/ff2 plate area)
(d) For NDCE furnaces, electricity = 0.00194 x model gas flowrate x (533 - 433 ff2)/1,000 acfm x 8,424 hr/yr x \$0.06/kWh

For DCE furnaces, electricity = 0.00194 x model gas flowrate x (433 - 333 ft2)/1,000 acfm x 8,424 hr/yr x \$0.06/kWh

(e) Administrative, insurance, and taxes (Å,I & T) = 0.04 x TCI
(f) For NDCE furnaces, capital recovery = 0.1169 CRF x TCI (based on 13.5-yr ESP life and 7% interest) For DCE furnaces, capital recovery = 0.1424 CRF x TCI (based on 10-yr ESP life and 7% interest)

(g) Incremental total annual cost (ITAC) = Electricity + A,I & T + capital recovery

TABLE 6-2a (METRIC). COSTS OF ESP REPLACEMENT TO CONTROL PM TO 0.10 G/DSCM FOR MODEL RECOVERY FURNACES (INCLUDING PULP PRODUCTION LOSSES)<sup>a</sup>

ບູ່ະ	000	000 0	000'C	000	000'C	000'0	000	000'C	000'C	000	000	000'C
ITAC, \$/yr	\$805,000	\$1,450,000	\$2,090,000	\$764,000	\$1,380,000	\$1,990,000	\$764,000	\$1,380,000	\$1,990,000	\$451,000	\$750,000	\$1,360,000
Capital recovery, \$/yr	\$621,000	\$1,120,000	\$1,610,000	\$580,000	\$1,050,000	\$1,510,000	\$580,000	\$1,050,000	\$1,510,000	\$359,000	\$597,000	\$1,080,000
A,I&T, \$/yr	\$165,000	\$297,000	\$428,000	\$165,000	\$297,000	\$428,000	\$165,000	\$297,000	\$428,000	\$80,400	\$134,000	\$241,000
Electricity, \$/yr	\$19,400	\$35,000	\$50,500	\$19,400	\$35,000	\$50,500	\$19,400	\$35,000	\$50,500	\$11,700	\$19,400	\$35.000
TCI+ production losses, \$	\$5,310,000	\$9,560,000	\$13,800,000	\$4,960,000	\$8,950,000	\$12,900,000	\$4,960,000	\$8,950,000	\$12,900,000	\$2,520,000	\$4,190,000	\$7.550.000
Pulp production losses, \$	\$1,190,000	\$2,130,000	\$3,120,000	\$844,000	\$1,520,000	\$2,190,000	\$844,000	\$1,520,000	\$2,190,000	\$506,000	\$844,000	\$1.520.000
TCI, \$	\$4,120,000	\$7,430,000	\$10,700,000	\$2,010,000	\$3,350,000	\$6,030,000	\$4,120,000	\$7,430,000	\$10,700,000	\$2,010,000	\$3,350,000	\$6 030 000
Downtime, d	30	90	30	30	30	30	30	90	30	30	30	30
New SCA, m2/(m3/sec)	105	105	105	85	85	85	105	105	105	85	85	85
ESP plate area, m2	9,806	17,638	25,512	4,794	7,967	14,331	9,806	17,638	25,512	4,794	7,967	14 331
Gas flowrate ESP exit, m3/sec @8% O2	93.4	168	243	56.2	93.4	168	93.4	168	243	56.2	93.4	168
Equivalent ADMP/d	380	680	1,000	230	380	680	450	820	1,200	270	450	N2R
Black liquor firing rate, kg BLS/d	700,000	1,200,000	1,800,000	400,000	700,000	1,200,000	700,000	1,200,000	1,800,000	400,000	700,000	1 200 000
Furnace type	NDCE	NDCE	NDCE	DCE	DCE	DCE	NDCE	NDCE	NDCE	DCE	DCE	DCF
Pulp type	Ē	B	B	BI	B	Ē	Unbl	Unbl	Unbl	Unbl	ldnU	441
Model recovery furnaces	RF-1a/4a	RF-2a/5a	RF-3a/6a	RF-7a	RF-8a	RF-9a	RF-1a/4a	RF-2a/5a	RF-3a/6a	RF-7a	AF-8a	RF-9a

(a) Metric equivalents in this table were converted from the calculated English unit values given in Table 6-2b. Refer to Table 6-2b for footnotes, which include calculations.

TABLE 6-2b, (ENGLISH). COSTS OF ESP REPLACEMENT TO CONTROL PM TO 0.044 GR/DSCF FOR MODEL RECOVERY FURNACES (INCLUDING PULP PRODUCTION LOSSES)<sup>a</sup>

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Model			Black liquor		Gas flowrate					and	10+			Canital	
recovery furnaces	Pulp type	Furnace type	firing rate, Ib BLS/d	Equivalent ADTP/d	ESP exit, acfm @8% O2	ESP plate area, ft2 (b)	New SCA, ft2/1,000 acfm	Downtime, d	TCI, \$ (c)	production losses, \$ (d)	production losses, \$	Electricity, \$/yr (e)	A,I&T, \$/yr(f)	S/yr (g)	ITAC, \$/yr (h)
RF-1a/4a	В	NDCE	1,500,000	420	198,000	105,600	533	30	\$4,120,000	\$1,190,000	\$5,310,000	\$19,400	\$165,000	\$621,000	\$805,000
RF-2a/5a	ā	NDCE	2,700,000	750	357,000	190,400	533	30	\$7,430,000	\$2,130,000	\$9,560,000	\$35.000	\$297.000	\$1120,000	\$1.450.000
RF-3a/6a	ā	NDCE	3,900,000	1,100	515,000	274,667	533	30	\$10,700,000	\$3,120,000	\$13,800,000	\$50,500	\$428,000	\$1.610.000	\$2.090.000
RF-7a	В	DCE	900,000	250	119,000	51,567	433	30	\$2,010,000	\$710,000	\$2,720,000	\$11,700	\$80,400	\$387.000	\$479.000
RF-8a	B	DOE	1,500,000	420	198,000	85,800	433	90	\$3,350,000	\$1,190,000	\$4,540,000	\$19,400	\$134,000	\$646,000	\$799.000
RF-9a	B	DCE	2,700,000	750	357,000	154,700	433	30	\$6,030,000	\$2,130,000	\$8,160,000	\$35,000	\$241.000	\$1.160.000	\$1,440,000
RF-1a/4a	Unbl	NDCE	1,500,000	500	198,000	105,600	533	зо	\$4,120,000	\$844.000	\$4.960.000	\$19 400	\$165,000	\$580.000	¢764 000
RF-2a/5a	Unbl	NDCE	2,700,000	006	357,000	190,400	533	ю	\$7,430,000	\$1,520,000	\$8,950,000	\$35,000	\$297,000	\$1.050.000	\$1,380,000
RF-3a/6a	Unbl	NDCE	3,900,000	1,300	515,000	274,667	533	30	\$10,700,000	\$2,190,000	\$12,900,000	\$50,500	\$428,000	\$1,510,000	\$1.990.000
RF-7a	Unbl	DCE	000'006	300	119,000	51,567	433	30	\$2,010,000	\$506,000	\$2,520,000	\$11,700	\$80,400	\$359,000	\$451.000
RF-8a	Unbi	DCE	1,500,000	500	198,000	85,800	433	g	\$3,350,000	\$844,000	\$4,190,000	\$19,400	\$134,000	\$597,000	\$750,000
RF-9a	Unbl	DCE	2,700,000	006	357,000	154,700	433	30	\$6,030,000	\$1,520,000	\$7,550,000	\$35,000	\$241,000	\$1,080,000	\$1.360.000
(a) All criete in \$1001	in \$100	-													

(a) All costs in \$1991
(b) ESP plate area = model gas flowrate x new SCA
(c) TCl = ESP plate area x (\$39/FD plate area)
(c) TCl = ESP plate area x (\$39/FD plate area)
(d) Plate plate area x (\$39/FD plate area)
(e) TCl = ESP plate area x (\$39/FD plate area)
(e) TCl = ESP plate area x (\$39/FD plate area)
(f) Plate plate area x (\$39/FD plate area)
(g) Plate plate plate area x (\$39/FD plate area)
(g) Plate plate plate area x (\$39/FD plate area)
(g) Plate plate plate area x (\$39/FD plate area)
(g) Plate plate plate plate area x (\$39/FD plate area)
(g) Plate plate plate area x (\$39/FD plate area)
(g) Plate plate plate area x (\$39/FD plate area)
(g) Plate plate plate area x (\$39/FD plate area)
(g) Plate plate plate area x (\$30/FD plate area)
(g) Plate plate plate area x (\$16/FD plate area)
(h) Incemental total annual cost ([TCl = production losses) (based on 10-yr ESP life and 7% interest)
(h) Incemental total annual cost ([TCl) = Electricity + A, \$1, \$1, + capital recovery

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TABLE 6-3.	SUMMARY (	ΟF	ASSUMPTIONS	USED	IN	ESP	UPGRADE	COSTS
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NDCE Recovery Furnace ESP Characteristics:	
Existing ESP:	New ESP:
• The existing ESP is assumed to contain 46 lanes on 10-inch centers (weighted wire design).	• The ESP is rebuilt with 42 lanes on 11-inch centers (rigid electrode design).
• The existing ESP is 3 fields long, with each field 10 feet long and 30 feet tall.	• The size will be adequate for 99.4 percent PM removal, yielding an outlet PM residual of 0.044 gr/dscf at 8 percent oxygen.
• The existing ESP has a parallel drag scraper arrangement (dry-bottom).	• The ESP will be 3 fields long, with each field 10 feet long and 30 feet high.
DCE Recovery Furnace ESP Characteristics:	
Existing ESP:	New ESP:
• The existing ESP is assumed to contain 50 lanes on 10-inch centers (weighted wire design).	• The ESP is rebuilt with 46 lanes on 11-inch centers (rigid electrode design).
• The existing ESP is 3 fields long, with each field 10 feet long and 30 feet tall.	• The size will be adequate for 98.8 percent PM removal, yielding an outlet PM residual of 0.044 gr/dscf at 8 percent oxygen.
• The existing ESP has a steel shell design (wet- bottom).	• The ESP will be 3 fields long, with each field 10 feet long and 32 feet high.
Modifications:	
• There is single-chamber operation while the othe the internals gutted.	r chamber is washed down, the roof removed, and
• The recovery furnace is taken off line; work con	tinues on rebuild; one chamber is finished.
• The recovery furnace is at partial load through re-	ebuilt chamber; the other chamber is finished.
Other Assumptions:	
• The existing casing is in acceptable condition; on	ly minor replating is needed.
• Wet- and dry-bottoms are reused "as is," except inlet and outlet ductwork are also reused.	for minor repairs. Transformers, controls, and
• The roof insulation is replaced, but all other insu	lation is acceptable.
• The site location is in the southeast United States 1993 wage rates and work rules.	. As such, all field labor is based on merit shop,
• No removal of asbestos or polychlorinated bipher	nyls (PCB's) is required.
• The scrap is taken to a site within the plant gates	
• There are no perforated plates.	• The ESP is at grade.
• The ductwork and stack do not obstruct crane mobility.	• There is no low voltage.

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TABLE 6-4a (METRIC). COSTS OF SCHEDULE 1 ESP UPGRADE TO CONTROL PM TO 0.10 G/DSCM FOR MODEL RECOVERY FURNACES (EXCLUDING PULP PRODUCTION LOSSES)<sup>a</sup>

Summer .

RF-1a/4a Bl	Pulp Furnace type type	Black liquor firing rate, kg BLS/d	Equivalent ADMP/d	Gas flowrate ESP exit, m3/sec @ 8% O2	Downtime, d	TCI, \$	Electricity, \$/yr	А,I & T, \$/yr	Capital recovery, \$/yr	ITAC, \$/yr
	NDCE	700,000	380	93.4	17	\$1,200,000	\$19,400	\$48,000	\$140,000	\$207,000
RF-2a/5a BI	NDCE	1,200,000	680	168	17	\$1,700,000	\$35,000	\$68,000	\$199,000	\$302,000
RF-3a/6a Bl	NDCE	1,800,000	1,000	243	17	\$2,120,000	\$50,500	\$84,800	\$248,000	\$383,000
RF-7a Bl	DCE	400,000	230	56.2	17	\$811,000	\$11,700	\$32,400	\$115,000	\$159,000
RF-8a Bl	DCE	700,000	380	93.4	17	\$1,100,000	\$19,400	\$44,000	\$157,000	\$220,000
RF-9a BI	DCE	1,200,000	680	168	17	\$1,570,000	\$35,000	\$62,800	\$224,000	\$322,000
RF-1a/4a Unbl	NDCE	700,000	450	93.4	17	\$1,200,000	\$19,400	\$48,000	\$140,000	\$207,000
RF-2a/5a Unbl	NDCE	1,200,000	820	168	17	\$1,700,000	\$35,000	\$68,000	\$199,000	\$302,000
RF-3a/6a Unbl	NDCE	1,800,000	1,200	243	17	\$2,120,000	\$50,500	\$84,800	\$248,000	\$383,000
RF-7a Unbl	DCE	400,000	270	56.2	17	\$811,000	\$11,700	\$32,400	\$115,000	\$159,000
RF-8a Unbl	DCE	700,000	450	93.4	17	\$1,100,000	\$19,400	\$44,000	\$157,000	\$220,000
RF-9a Unbl	DCE	1,200,000	820	168	17	\$1,570,000	\$35,000	\$62,800	\$224,000	\$322,000

(a) Metric equivalents in this table were converted from the calculated English unit values given in Table 6-4b. Refer to Table 6-4b for footnotes, which include calculations.

TABLE 6-4b (ENGLISH). COSTS OF SCHEDULE 1 ESP UPGRADE TO CONTROL PM TO 0.044 GR/DSCF FOR MODEL RECOVERY FURNACES (EXCLUDING PULP PRODUCTION LOSSES)<sup>a</sup>

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Model			Black limitor								
recovery furnaces	Pulp type	Furnace type	firing rate, Ib BLS/d	Equivalent ADTP/d	uas nowrate ESP exit, acfm @ 8% 02	Downtime, d	TCI, \$ (b)	Electricity, \$/yr (c)	A,I & T, \$/yr (d)	Capital recovery, \$/vr (e)	ITAC, \$/vr (f)
RF-1a/4a	В	NDCE	1,500,000	420	198,000	17	\$1,200,000	\$19.400	\$48.000	\$140.000	000 202\$
RF-2a/5a	B	NDCE	2,700,000	750	357,000	17	\$1,700,000	\$35,000	\$68.000	\$199.000	\$302 000
RF-3a/6a	B	NDCE	3,900,000	1,100	515,000	17	\$2,120,000	\$50.500	\$84.800	\$248,000	¢383 000
RF-7a	В	DCE	900,000	250	119,000	17	\$811,000	\$11.700	\$32.400	\$115,000	\$159,000
RF-8a	B	DCE	1,500,000	420	198,000	17	\$1,100,000	\$19,400	\$44.000	\$157 000	\$220,000
RF-9a	В	DCE	2,700,000	750	357,000	17	\$1,570,000	\$35.000	\$62,800	\$224,000	\$322 DOD
RF-1a/4a	Unbl	NDCE	1,500,000	500	198,000	17	\$1,200,000	\$19.400		6140 000	\$001 000
RF-2a/5a	Unbl	NDCE	2,700,000	900	357,000	17	\$1.700.000	\$35,000	\$68 000	\$199,000	\$200,000 \$200,000
RF-3a/6a	Unbl	NDCE	3,900,000	1,300	515,000	17	\$2.120.000	\$50.500	\$84 BOO	\$248 000	\$382 000
RF-7a	Unbl	DCE	900,000	300	119,000	17	\$811.000	\$11 700	\$32,400	¢115,000	#150,000
RF-8a	Unbl	DCE	1,500,000	500	198,000	17	\$1,100.000	\$19.400	\$44 000	\$157,000	000'eci¢
RF-9a	IdnU	DCE	2,700,000	900	357,000	17	\$1,570,000	\$35.000	\$62 800	\$224 000	\$322 000
(a) All costs in \$1991	s in \$199	Ŧ								444.7,000	400°2'000

(a) All costs in \$1991
 (b) For NDCE turnaces, TCI = (\$1,292,000)/[(230,000 acfm/model gas flowrate) ~ 0.6] x (361.3 \$1991/357 \$May 1993)

For NDCE furnaces, electricity = 0.00194 x model gas flowrate x (533 - 433 ft2)/1,000 acfm x 8,424 hr/yr x \$0.06/kWh For DCE furnaces, electricity = 0.00194 x model gas flowrate x (433 - 333 ft2)/1,000 acfm x 8,424 hr/yr x \$0.06/kWh For DCE furnaces, TCI = (\$1,504,750)/[(340,000 acfm/model gas flowrate) ∽ 0.6] x (361.3 \$1991/357 \$May 1993) (c) Electricity costs for ESP upgrade assumed to equal electricity costs for ESP replacement.

(d) Administrative, insurance, and taxes (A,I & T) = 0.04 x TCI
(e) For NDCE furnaces, capital recovery = 0.1169 CRF x TCI (based on 13.5-yr ESP life and 7% interest) For DCE furnaces, capital recovery = 0.1424 CRF x TCI (based on 10-yr ESP life and 7% interest)
(f) Incremental total annual cost (ITAC) = Electricity + A,I & T + capital recovery

TABLE 6-5a (METRIC). COSTS OF SCHEDULE 2 ESP UPGRADE TO CONTROL PM TO 0.10 G/DSCM FOR MODEL RECOVERY FURNACES (EXCLUDING PULP PRODUCTION LOSSES)<sup>a</sup>

Model recovery furnaces	Pulp type	Furnace type	Black liquor firing rate, kg BLS/d	Equivalent ADMP/d	Gas flowrate ESP exit, m3/sec @ 8% 02	Downtime, d	TCI, \$ (b)	Electricity, \$/yr (c)	A,I & T, \$/yr (d)	Capital recovery, \$/yr (e)	ITAC, \$/yr (f)
RF-1a/4a	m	NDCE	700,000	380	93.4	30	\$1,160,000	\$19,400	\$46,400	\$136,000	\$202,000
RF-2a/5a	B	NDCE	1,200,000	680	168	30	\$1,660,000	\$35,000	\$66,400	\$194,000	\$295,000
RF-3a/6a	B	NDCE	1,800,000	1,000	243	30	\$2,070,000	\$50,500	\$82,800	\$242,000	\$375,000
RF-7a	B	DCE	400,000	230	56.2	30	\$791,000	\$11,700	\$31,600	\$113,000	\$156,000
RF-8a	В	DCE	700,000	380	93.4	30	\$1,070,000	\$19,400	\$42,800	\$152,000	\$214,000
RF-9a	B	DCE	1,200,000	680	168	30	\$1,530,000	\$35,000	\$61,200	\$218,000	\$314,000
RF-1a/4a	Unbl	ESP	700,000	450	93.4	30	\$1,160,000	\$19,400	\$46,400	\$136,000	\$202,000
RF-2a/5a	ldnU	ESP	1,200,000	820	168	30	\$1,660,000	\$35,000	\$66,400	\$194,000	\$295,000
RF-3a/6a	Unbl	ESP	1,800,000	1,200	243	30	\$2,070,000	\$50,500	\$82,800	\$242,000	\$375,000
RF-7a	ldnU	DCE	400,000	270	56.2	30	\$791,000	\$11,700	\$31,600	\$113,000	\$156,000
RF-8a	Unbl	DCE	700,000	450	93.4	30	\$1,070,000	\$19,400	\$42,800	\$152,000	\$214,000
RF-9a	Unbl	DCE	1,200,000	820	168	30	\$1,530,000	\$35,000	\$61,200	\$218,000	\$314,000

(a) Metric equivalents in this table were converted from the calculated English unit values given in Table 6-5b. Refer to Table 6-5b for footnotes, which include calculations.

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TABLE 6-5b (ENGLISH). COSTS OF SCHEDULE 2 ESP UPGRADE TO CONTROL PM TO 0.044 GR/DSCF FOR MODEL RECOVERY FURNACES (EXCLUDING PULP PRODUCTION LOSSES)<sup>a</sup>

	Model recovery furnaces	Pulp type	Furnace type	Black liquor firing rate, Ib BLS/d	Equivalent ADTP/d	Gas flowrate ESP exit, acfm @ 8% 02	Downtime, - d	TCI, \$ (b)	Electricity, \$/yr (c)	A,I & T, \$/yr (d)	Capital recovery, \$/yr (e)	ITAC, \$/yr (f)
(5a         BI         NDCE         2.700,000         750         357,000         30         \$1,660,000         \$35,000         \$66,400         \$194,000         \$194,000         \$100.000         \$1,000.000         \$1,000.000         \$1,000.000         \$194,000         \$13,000         \$222,000         \$212,000	RF-1a/4a	В	NDCE	1,500,000	420	198,000	30	\$1,160,000	\$19,400	\$46,400	\$136,000	\$202.000
(a)         NDCE         3.900,000         1,100         515,000         30         \$2,070,000         \$50,500         \$82,800         \$242,000         \$242,000         \$242,000         \$113,000	RF-2a/5a	BI	NDCE	2,700,000	750	357,000	30	\$1,660,000	\$35,000	\$66,400	\$194,000	\$295,000
BI         DCE         900,000         250         119,000         30         \$791,000         \$11,700         \$31,600         \$113,000         \$13,600         \$13,000         \$13,600         \$13,000         \$13,600         \$13,000	RF-3a/6a	B	NDCE	3,900,000	1,100	515,000	30	\$2,070,000	\$50,500	\$82,800	\$242,000	\$375.000
BI         DCE         1,500,000         420         198,000         30         \$1,070,000         \$19,400         \$42,800         \$152,000           4a         Unbl         DCE         2,700,000         750         357,000         30         \$1,530,000         \$51,500         \$51,800         \$152,000         \$152,000         \$152,000         \$152,000         \$152,000         \$152,000         \$152,000         \$150,000         \$113,000         \$113,000         \$113,000         \$113,000         \$113,000         \$113,000         \$113,000         \$113,000         \$113,000         \$113,000         \$113,000         \$113,000         \$113,000         \$113,000         \$113,000         \$113,000         \$113,000         \$113,000         \$113,000 <t< td=""><td>RF-7a</td><td>В</td><td>DCE</td><td>900,000</td><td>250</td><td>119,000</td><td>30</td><td>\$791,000</td><td>\$11,700</td><td>\$31,600</td><td>\$113,000</td><td>\$156,000</td></t<>	RF-7a	В	DCE	900,000	250	119,000	30	\$791,000	\$11,700	\$31,600	\$113,000	\$156,000
BI         DCE         2,700,000         750         357,000         30         \$1,530,000         \$51,200         \$218,000         \$213,000	RF-8a	В	DCE	1,500,000	420	198,000	30	\$1,070,000	\$19,400	\$42,800	\$152,000	\$214,000
4a         Unbl         NDCE         1,500,000         500         198,000         30         \$1,160,000         \$19,400         \$46,400         \$136,000         \$136,000         \$516,000         \$56,400         \$136,000         \$519,000         \$50,000         \$56,400         \$519,000         \$519,000         \$50,000         \$50,000         \$50,000         \$50,000         \$519,000         \$519,000         \$519,000         \$519,000         \$519,000         \$519,000         \$52,000         \$56,400         \$519,000         \$519,000         \$519,000         \$519,000         \$519,000         \$519,000         \$519,000         \$519,000         \$519,000         \$519,000         \$519,000         \$519,000         \$519,000         \$519,000         \$519,000         \$513,000         \$513,000         \$513,000         \$513,000         \$512,000         \$51	RF-9a	B	DCE	2,700,000	750	357,000	30	\$1,530,000	\$35,000	\$61,200	\$218,000	\$314,000
5a         Unbl         NDCE         2,700,000         900         357,000         30         \$1,660,000         \$35,000         \$66,400         \$194,000           6a         Unbl         NDCE         3,900,000         1,300         515,000         30         \$2,070,000         \$50,500         \$66,400         \$194,000           6a         Unbl         NDCE         3,900,000         1,300         515,000         30         \$2,070,000         \$50,500         \$82,800         \$242,000           1         DCE         900,000         300         119,000         30         \$71,000         \$11,700         \$31,600         \$113,000           Unbl         DCE         1,500,000         500         198,000         30         \$1,070,000         \$19,400         \$42,800         \$152,000           Unbl         DCE         2,700,000         900         357,000         361,530,000         \$512,000         \$242,000	RF-1a/4a	Unbl	NDCE	1,500,000	500	198,000	30	\$1,160,000	\$19,400	\$46,400	\$136.000	\$202.000
Ga         Unbi         NDCE         3.900,000         1,300         515,000         30         \$2.070,000         \$82,800         \$2.42,000           Unbi         DCE         900,000         300         119,000         30         \$791,000         \$11,700         \$31,600         \$113,000           Unbi         DCE         1,500,000         500         198,000         30         \$13,070,000         \$11,700         \$31,600         \$113,000           Unbi         DCE         1,500,000         500         198,000         30         \$1,070,000         \$19,400         \$42,800         \$152,000           Unbi         DCE         2,700,000         500         357,000         30         \$1,530,000         \$351,600         \$218,000	RF-2a/5a	Unbl	NDCE	2,700,000	006	357,000	30	\$1,660,000	\$35,000	\$66.400	\$194.000	\$295,000
Unbl         DCE         900,000         300         119,000         30         \$791,000         \$11,700         \$31,600         \$113,000           Unbl         DCE         1,500,000         500         198,000         30         \$1,070,000         \$19,400         \$152,000           Unbl         DCE         2,700,000         900         357,000         30         \$1,530,000         \$61,200         \$218,000	RF-3a/6a	Unbl	NDCE	3,900,000	1,300	515,000	30	\$2,070,000	\$50,500	\$82,800	\$242,000	\$375,000
Unbl         DCE         1,500,000         500         198,000         30         \$1,070,000         \$42,800         \$152,000           Unbl         DCE         2,700,000         900         357,000         30         \$1,530,000         \$61,200         \$218,000	RF-7a	Unbl	DCE	900,000	300	119,000	30	\$791,000	\$11,700	\$31,600	\$113,000	\$156,000
Unbl DCE 2,700,000 900 357,000 30 \$1,530,000 \$61,200 \$218,000	RF-8a	Unbl	DCE	1,500,000	500	198,000	30	\$1,070,000	\$19,400	\$42,800	\$152,000	\$214.000
	RF-9a	Unbl	DCE	2,700,000	006	357,000	30	\$1,530,000	\$35,000	\$61,200	\$218,000	\$314.000

(a) All costs in \$1991
 (b) For NDCE furnaces, TCI = (\$1,259,000)/[(230,000 acfm/model gas flowrate) ^ 0.6] × (361.3 \$1991/357 \$May 1993)

For DCE furnaces, TCI = (\$1,466,500)/[[340,000 acfm/model gas flowrate) ~0.6] x (361.3 \$1991/357 \$May 1993) (c) Electricity costs for ESP upgrade assumed to equal electricity costs for ESP replacement.

For NDCE furnaces, electricity = 0.00194 x model gas flowrate x (533 - 433 ft2)/1,000 acfm x 8,424 hr/yr x \$0.06/kWh For DCE furnaces, electricity = 0.00194 x model gas flowrate x (433 - 333 ft2)/1,000 acfm x 8,424 hr/yr x \$0.06/kWh

(d) Administrative, insurance, and taxes (A,I & T) = 0.04 x TCI
(e) For NDCE furnaces, capital recovery = 0.1169 CRF x TCI (based on 13.5-yr ESP life and 7% interest) For DCE furnaces, capital recovery = 0.1424 CRF x TCI (based on 10-yr ESP life and 7% interest)
(f) Incremental total annual cost (ITAC) = Electricity + A,I & T + capital recovery

TABLE 6-6a (METRIC). COSTS OF SCHEDULE 1 ESP UPGRADE TO CONTROL PM TO 0.10 G/DSCM FOR MODEL RECOVERY FURNACES (INCLUDING PULP PRODUCTION LOSSES)<sup>a</sup>

		······			<del></del> ,							
ITAC, \$/yr	\$233,000	\$348,000	\$452,000	\$178,000	\$251,000	\$379,000	\$226,000	\$336,000	\$431,000	\$173,000	\$242,000	\$363,000
Capital recovery, \$/yr	\$166,000	\$245,000	\$317,000	\$134,000	\$188,000	\$281,000	\$159,000	\$233,000	\$296,000	\$129,000	\$179,000	\$265,000
A,I & T, \$/yr	\$48,000	\$68,000	\$84,800	\$32,400	\$44,000	\$62,800	\$48,000	\$68,000	\$84,800	\$32,400	\$44,000	\$62,800
Electricity, \$/yr	\$19,400	\$35,000	\$50,500	\$11,700	\$19,400	\$35,000	\$19,400	\$35,000	\$50,500	\$11,700	\$19,400	\$35,000
TCI+ production losses, \$	\$1,420,000	\$2,100,000	\$2,710,000	\$944,000	\$1,320,000	\$1,970,000	\$1,360,000	\$1,990,000	\$2,530,000	\$906,000	\$1,260,000	\$1,860,000
Pulp production losses, \$	\$224,000	\$399,000	\$585,000	\$133,000	\$224,000	\$399,000	\$158,000	\$285,000	\$411,000	\$94,900	\$158,000	\$285,000
¢ ,	\$1,200,000	\$1,700,000	\$2,120,000	\$811,000	\$1,100,000	\$1,570,000	\$1,200,000	\$1,700,000	\$2,120,000	\$811,000	\$1,100,000	\$1,570,000
Downtime, d	17	17	17	17	17	17	17	17	17	17	17	17
Gas flowrate ESP exit, m3/sec @8% O2	93.4	168	243	56.2	93.4	168	93.4	168	243	56.2	93.4	168
Equivalent ADMP/d	380	680	1,000	230	380	680	450	820	1,200	270	450	820
Black liquor firing rate, kg BLS/d	700,000	1,200,000	1,800,000	400,000	700,000	1,200,000	700,000	1,200,000	1,800,000	400,000	700,000	1,200,000
Furnace type	NDCE	NDCE	NDCE	DCE	DCE	DCE	NDCE	NDCE	NDCE	DCE	DCE	DCE
Pulp type	В	B	B	В	В	В	Unbl	Unbl	Unbl	Unbl	Unbl	IdnU
Model recovery furnaces	RF-1a/4a	RF-2a/5a	RF-3a/6a	RF-7a	RF-8a	RF-9a	RF-1a/4a	RF-2a/5a	RF-3a/6a	RF-7a	RF-8a	RF-9a

(a) Metric equivalents in this table were converted from the calculated English unit values given in Table 6-6b. Refer to Table 6-6b for footnotes, which include calculations.

PRODUCTION LOSSES)<sup>a</sup> TABLE 6-6b (ENGLISH). COSTS OF SCHEDULE 1 ESP UPGRADE TO CONTROL PM TO 0.044 GR/DSCF FOR MODEL RECOVERY FURNACES (INCLUDING PULP PRODUCTION LOSSES

Model recovery furnaces	Pulp type	Furnace type	Black liquor firing rate, Ib BLS/d	Equivalent ADTP/d	Gas flowrate ESP exit, acfm @8% 02	Downtime, d	TCI, \$ (b)	Pulp production losses, \$ (c)	TCI+ production losses, \$	Electricity, \$/yr (d)	A,I & T, \$/yr (e)	Capital recovery, \$/yr (f)	ITAC, \$/yr (g)
RF-1a/4a	B	NDCE	1,500,000	420	198,000	17	\$1,200,000	\$224,000	\$1,420,000	\$19,400	\$48,000	\$166,000	\$233,000
RF-2a/5a	B	NDCE	2,700,000	750	357,000	17	\$1,700,000	\$399,000	\$2,100,000	\$35,000	\$68,000	\$245,000	\$348,000
RF-3a/6a	B	NDCE	3,900,000	1,100	515,000	17	\$2,120,000	\$585,000	\$2,710,000	\$50,500	\$84,800	\$317,000	\$452,000
RF-7a	B	DCE	900'006	250	119,000	17	\$811,000	\$133,000	\$944,000	\$11,700	\$32,400	\$134,000	\$178,000
RF-8a	BI	DCE	1,500,000	420	198,000	17	\$1,100,000	\$224,000	\$1,320,000	\$19,400	\$44,000	\$188,000	\$251,000
RF-9a	B	DCE	2,700,000	750	357,000	17	\$1,570,000	\$399,000	\$1,970,000	\$35,000	\$62,800	\$281,000	\$379,000
RF-1a/4a	Unbl	NDCE	1,500,000	500	198,000	17	\$1,200,000	\$158,000	\$1,360,000	\$19,400	\$48,000	\$159,000	\$226,000
RF-2a/5a	Unbl	NDCE	2,700,000	006	357,000	17	\$1,700,000	\$285,000	\$1,990,000	\$35,000	\$68,000	\$233,000	\$336,000
RF-3a/6a	Unbl	NDCE	3,900,000	1,300	515,000	17	\$2,120,000	\$411,000	\$2,530,000	\$50,500	\$84,800	\$296,000	\$431,000
RF-7a	Unbl	DCE	900,000	300	119,000	17	\$811,000	\$94,900	\$906,000	\$11,700	\$32,400	\$129,000	\$173,000
RF-8a	Unbl	DCE	1,500,000	500	198,000	17	\$1,100,000	\$158,000	\$1,260,000	\$19,400	\$44,000	\$179,000	\$242,000
RF-9a	Unbl	DCE	2,700,000	006	357,000	17	\$1,570,000	\$285,000	\$1,860,000	\$35,000	\$62,800	\$265,000	\$363,000

(a) All costs in \$1991
 (b) For NDCE furnaces, TCI = (\$1,292,000)/[(230,000 acfm/model gas flowrate) ^ 0.6] × (361.3 \$1991/357 \$May 1993)

For DCE furnaces, TCI = (\$1,504,750)/[(340,000 acfm/model gas flowrate) ^ 0.6] x (361.3 \$1991/357 \$May 1993)

(c) Pulp production losses = (25% gross profit margin) x (\$646/ton bleached pulp or \$384/ton unbleached pulp) x (136.2 \$1991/124 \$1989) x (17 d downtime-14 d scheduled downtime) x ADTP/d (d) Electricity costs for ESP upgrade assumed to equal electricity costs for ESP replacement.

For NDCE furnaces, electricity = 0.00194 x model gas flowrate x (533 - 433 ft2)/1,000 acfm x 8,424 hr/yr x \$0.06/kWh For DCE furnaces, electricity = 0.00194 x model gas flowrate x (433 - 333 ft2)/1,000 acfm x 8,424 hr/yr x \$0.06/kWh

(e) Administrative, insurance, and taxes (A,I & T) = 0.04 x TCI (f) For NDCE furnaces, capital recovery = 0.1169 CRF x (TCI  $\rightarrow$ 

For NDCE furnaces, capital recovery = 0.1169 CRF x (TCI + production losses) (based on 13.5-yr ESP life and 7% interest)

For DCE furmaces, capital recovery = 0.1424 CRF x (TCI + production losses) (based on 10-yr ESP life and 7% interest)

(g) Incremental total annual cost (ITAC) = Electricity + A,I & T + capital recovery

TABLE 6-7a+(METRIC). COSTS OF SCHEDULE 2 ESP UPGRADE TO CONTROL PM TO 0.10 G/DSCM FOR MODEL RECOVERY FURNACES (INCLUDING PULP PRODUCTION LOSSES)<sup>a</sup>

6 -	00 00	00	00	80	80	000	80	00	000	00	00	000
ITAC, \$/yr	\$341,000	\$544,000	\$740,000	\$257,000	\$384,000	\$617,000	\$300,000	\$473,000	\$631,000	\$228,000	\$334,000	\$530,000
Capital recovery, \$/yr	\$275,000	\$443,000	\$607,000	\$214,000	\$322,000	\$521,000	\$234,000	\$372,000	\$498,000	\$185,000	\$272,000	\$434,000
A,I & T, \$/yr	\$46,400	\$66,400	\$82,800	\$31,600	\$42,800	\$61,200	\$46,400	\$66,400	\$82,800	\$31,600	\$42,800	\$61,200
Electricity, \$/yr	\$19,400	\$35,000	\$50,500	\$11,700	\$19,400	\$35,000	\$19,400	\$35,000	\$50,500	\$11,700	\$19,400	\$35,000
TCI+ production losses, \$	\$2,350,000	\$3,790,000	\$5,190,000	\$1,500,000	\$2,260,000	\$3,660,000	\$2,000,000	\$3,180,000	\$4,260,000	\$1,300,000	\$1,910,000	\$3,050,000
Pulp production losses, \$	\$1,190,000	\$2,130,000	\$3,120,000	\$710,000	\$1,190,000	\$2,130,000	\$844,000	\$1,520,000	\$2,190,000	\$506,000	\$844,000	\$1,520,000
TCI, \$	\$1,160,000	\$1,660,000	\$2,070,000	\$791,000	\$1,070,000	\$1,530,000	\$1,160,000	\$1,660,000	\$2,070,000	\$791,000	\$1,070,000	\$1,530,000
Downtime, d	30	30	30	30	30	30	30	30	30	30	30	30
Gas flowrate ESP exit, m3/sec @8% O2	93.4	168	243	56.2	93.4	168	93.4	168	243	56.2	93.4	168
Equivalent ADMP/d	380	680	1,000	230	380	680	450	820	1,200	270	450	820
Black liquor firing rate, kg BLS/d	700,000	1,200,000	1,800,000	400,000	700,000	1,200,000	700,000	1,200,000	1,800,000	400,000	700,000	1,200,000
Furnace type	NDCE	NDCE	NDCE	DCE	DCE	DCE	NDCE	NDCE	NDCE	DCE	DCE	DCE
Pulp type	B	B	B	B	В	В	Unbl	ldnb	Unbl	Unbl	Unbi	Unbl
Model recovery furnaces	RF-1a/4a	RF-2a/5a	RF-3a/6a	RF-7a	RF-8a	RF-9a	RF-1a/4a	RF-2a/5a	RF-3a/6a	RF-7a	RF-8a	RF-9a

(a) Metric equivalents in this table were converted from the calculated English unit values given in Table 6-7b. Refer to Table 6-7b for footnotes, which include calculations.

TABLE 6-7b (ENGLISH). COSTS OF SCHEDULE 2 ESP UPGRADE TO CONTROL PM TO 0.044 GR/DSCF FOR MODEL RECOVERY FURNACES (INCLUDING PULP PRODUCTION LOSSES)<sup>a</sup>

Model recovery furnaces	Pulp type	Furnace type	Black liquor firing rate, Ib BLS/d	Equivalent ADTP/d	Gas flowrate ESP exit, acfm @8% 02	Downtime, d	TCI, \$ (b)	Pulp production losses, \$ (c)	TCI+ production losses, \$	Electricity, \$/yr (d)	A,I & T, \$/yr (e)	Capital recovery, \$/yr (f)	ITAC, \$/yr (g)
RF-1a/4a	8	NDCE	1,500,000	420	198,000	30	\$1,160,000	\$1,190,000	\$2,350,000	\$19,400	\$46,400	\$275,000	\$341,000
RF-2a/5a	B	NDCE	2,700,000	750	357,000	30	\$1,660,000	\$2,130,000	\$3,790,000	\$35,000	\$66,400	\$443,000	\$544,000
RF-3a/6a	В	NDCE	3,900,000	1,100	515,000	30	\$2,070,000	\$3,120,000	\$5,190,000	\$50,500	\$82,800	\$607,000	\$740,000
RF-7a	В	DCE	900,000	250	119,000	30	\$791,000	\$710,000	\$1,500,000	\$11,700	\$31,600	\$214,000	\$257,000
RF-8a	В	DCE	1,500,000	420	198,000	30	\$1,070,000	\$1,190,000	\$2,260,000	\$19,400	\$42,800	\$322,000	\$384,000
RF-9a	BI	DCE	2,700,000	750	357,000	30	\$1,530,000	\$2,130,000	\$3,660,000	\$35,000	\$61,200	\$521,000	\$617,000
RF-1a/4a	Unbl	NDCE	1,500,000	500	198,000	30	\$1,160,000	\$844,000	\$2,000,000	\$19,400	\$46,400	\$234,000	\$300,000
RF-2a/5a	IdnU	NDCE	2,700,000	006	357,000	30	\$1,660,000	\$1,520,000	\$3,180,000	\$35,000	\$66,400	\$372,000	\$473,000
RF-3a/6a	Inbl	NDCE	3,900,000	1,300	515,000	30	\$2,070,000	\$2,190,000	\$4,260,000	\$50,500	\$82,800	\$498,000	\$631,000
RF-7a	IdnU	DCE	900,000	300	119,000	30	\$791,000	\$506,000	\$1,300,000	\$11,700	\$31,600	\$185,000	\$228,000
RF-8a	Unbl	DCE	1,500,000	500	198,000	30	\$1,070,000	\$844,000	\$1,910,000	\$19,400	\$42,800	\$272,000	\$334,000
RF-9a	ldnU	DCE	2,700,000	006	357,000	30	\$1,530,000	\$1,520,000	\$3,050,000	\$35,000	\$61,200	\$434,000	\$530,000

(a) All costs in \$1991
 (b) For NDCE furnaces, TCI = (\$1,259,000)/[(230,000 acfm/model gas flowrate) ^ 0.6] x (361.3 \$1991/357 \$May 1993)

For DCE furnaces, TCI = (\$1,466,500)/[(340,000 acfm/model gas flowrate) ~ 0.6] x (361.3 \$1991/357 \$May 1993)

(c) Pulp production losses = (25% gross profit margin) x (\$646/ton bleached pulp or \$384/ton unbleached pulp) x (136.2 \$1991/124 \$1989) x (30 d downtime-14 d scheduled downtime) x ADTP/d (d) Electricity costs for ESP upgrade assumed to equal electricity costs for ESP replacement.

For NDCE furnaces, electricity = 0.00194 x model gas flowrate x (533 - 433 ft2)/1,000 acfm x 8,424 hr/yr x \$0.06/kWh For DCE furnaces, electricity = 0.00194 x model gas flowrate x (433 - 333 ft2)/1,000 acfm x 8,424 hr/yr x \$0.06/kWh

(e) Administrative, insurance, and taxes (A,I & T) = 0.04 x TCI
(f) For NDCE furnaces, capital recovery = 0.1169 CRF x (TCI + production losses) (based on 13.5-yr ESP life and 7% interest) For DCE furnaces, capital recovery = 0.1424 CRF x (TCI + production losses) (based on 10-yr ESP life and 7% interest)
(g) Incremental total annual cost (ITAC) = Electricity + A,I & T + capital recovery

TABLE 6-8a (METRIC). COSTS OF ESP UPGRADE TO CONTROL PM FROM 0.10 G/DSCM TO 0.034 G/DSCM FOR MODEL RECOVERY FURNACES (EXCLUDING PULP PRODUCTION LOSSES)<sup>a</sup>

Model recovery furnaces	Pulp type	Furnace type	Black liquor firing rate, kg BLS/d	Equivalent ADMP/d	Gas flowrate ESP exit, m3/sec @8% 02	Increase in ESP plate area, m2	Increase in SCA, m2/(m3/sec)	Downtime, d	TCI, \$	Electricity, \$/yr	A,I & T, \$/yr	Capitał recovery, \$/yr	ITAC, \$/yr
RF-1b/4b	В	NDCE	700,000	380	93.4	1,532	16	17	\$644,000	\$16,200	\$25,800	\$75,300	\$117,000
RF-2b/5b	B	NDCE	1,200,000	680	168	2,756	16	17	\$1,160,000	\$29,200	\$46,400	\$136,000	\$212,000
RF-3b/6b	BI	NDCE	1,800,000	1,000	243	3,986	16	17	\$1,670,000	\$42,100	\$66,800	\$195,000	\$304,000
RF-7b	BI	DCE	400,000	230	56.2	922	16	17	\$387,000	\$9,720	\$15,500	\$55,100	\$80,300
RF-8b	BI	DCE	700,000	380	93.4	1,532	16	17	\$644,000	\$16,200	\$25,800	\$91,700	\$134,000
RF-9b	18	DCE	1,200,000	700	168	2,756	16	17	\$1,160,000	\$29,200	\$46,400	\$165,000	\$241,000
RF-1b/4b	Unbl	NDCE	700,000	450	93.4	1,532	16	17	\$644,000	\$16,200	\$25,800	\$75,300	\$117,000
RF-2b/5b	IdnU	NDCE	1,200,000	820	168	2,756	16	17	\$1,160,000	\$29,200	\$46,400	\$136,000	\$212,000
RF-3b/6b	Unbl	NDCE	1,800,000	1,200	243	3,986	16	17	\$1,670,000	\$42,100	\$66,800	\$195,000	\$304,000
RF-7b	Unbl	DCE	400,000	270	56.2	922	16	17	\$387,000	\$9,720	\$15,500	\$55,100	\$80,300
RF-8b	Unbl	DCE	700,000	450	93.4	1,532	16	17	\$644,000	\$16,200	\$25,800	\$91,700	\$134,000
RF-9b	Unbl	DCE	1,200,000	820	168	2,756	16	17	\$1,160,000	\$29,200	\$46,400	\$165,000	\$241,000

(a) Metric equivalents in this table were converted from the calculated English unit values given in Table 6-8b. Refer to Table 6-8b for footnotes, which include calculations.

ABLE 6-8th (ENGLISH). COSTS OF ESP UPGRADE TO CONTROL PM FROM 0.044 GR/DSCF TO 0.015 GR/DSCF FOR MODEL RECOVERY FURNACES (EXCLUDING PULP PRODUCTION LOSSES)<sup>a</sup> TABLE 6-81D (ENGLISH).

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Gas flowrate     Gas flowrate       Equivalent     ESP exit, acfm       ADTP/d     @8% 02       420     198,000			Increase in ESP plate area, ft2 (b) 16,500	Increase in SCA, ft2/1,000 acfm 83	Downtime, d 17	TCI, \$ (c) \$644,000	Electricity, \$/yr (d) \$16,200	A,I & T, \$/yr (e) \$25.800	Capital recovery, \$/yr (f) \$75.300	ITAC, \$/yr (g) \$117,000
750		357,000	29,750	83	17	\$1,160,000	\$29,200	\$46,400	\$136,000	\$212,000
1,100		515,000	42,917	83	17	\$1,670,000	\$42,100	\$66,800	\$195,000	\$304,000
250	-	119,000	9,917	83	17	\$387,000	\$9,720	\$15,500	\$55,100	\$80,300
420		198,000	16,500	83	17	\$644,000	\$16,200	\$25,800	\$91,700	\$134,000
750		357,000	29,750	83	17	\$1,160,000	\$29,200	\$46,400	\$165,000	\$241,000
500	-	198,000	16,500	83	17	\$644,000	\$16,200	\$25,800	\$75,300	\$117,000
006		357,000	29,750	83	17	\$1,160,000	\$29,200	\$46,400	\$136,000	\$212,000
1,300 5		515,000	42,917	83	17	\$1,670,000	\$42,100	\$66,800	\$195,000	\$304,000
300		119,000	9,917	83	17	\$387,000	\$9,720	\$15,500	\$55,100	\$80,300
200		198,000	16,500	83	17	\$644,000	\$16,200	\$25,800	\$91,700	\$134,000
900										

(a) All costs in \$1991
(b) Increase in ESP plate area = model gas flowrate x increase in SCA
(c) TCI = Increase in ESP plate area x (\$39/ft2 plate area)
(d) For NDCE furmaces, electricity = 0.00194 x model gas flowrate x (617 - 533 ft2)/1,000 acfm x 8,424 hr/yr x \$0.06/kWh

For DCE furnaces, electricity = 0.00194 x model gas flowrate x (517 - 433 ft2)/1,000 acfm x 8,424 hr/yr x \$0.06/kWh (e) Administrative, insurance, and taxes (A,I & T) = 0.04 x TCI (f) For NDCE furnaces, capital recovery = 0.1169 CRF x TCI (based on 13.5-yr ESP life and 7% interest)

For DCE furnaces, capital recovery = 0.1424 CRF x TCI (based on 10-yr ESP life and 7% interest) (g) Incremental total annual cost (ITAC) = Electricity + A,I & T + capital recovery

TABLE 6-49a (METRIC). COSTS OF ESP UPGRADE TO CONTROL PM FROM 0.10 G/DSCM TO 0.034 G/DSCM FOR MODEL RECOVERY FURNACES (INCLUDING PULP PRODUCTION LOSSES)<sup>a</sup>

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	g	g	g	。	g	g	g	g	g	0	g	''
iTAC, \$/yr	\$143,000	\$258,000	\$373,000	\$99,000	\$166,000	\$298,000	\$136,000	\$246,000	\$352,000	\$94,000	\$156,000	\$282,000
Capital recovery, \$/yr	\$101,000	\$182,000	\$264,000	\$74,000	\$124,000	\$222,000	\$93,800	\$170,000	\$243,000	\$68,600	\$114,000	\$206,000
A,I & T, \$/yr	\$25,800	\$46,400	\$66,800	\$15,500	\$25,800	\$46,400	\$25,800	\$46,400	\$66,800	\$15,500	\$25,800	\$46,400
Electricity, \$/yr	\$16,200	\$29,200	\$42,100	\$9,700	\$16,200	\$29,200	\$16,200	\$29,200	\$42,100	\$9,700	\$16,200	\$29,200
TCI+ production losses, \$	\$868,000	\$1,560,000	\$2,260,000	\$520,000	\$868,000	\$1,560,000	\$802,000	\$1,450,000	\$2,080,000	\$482,000	\$802,000	\$1,450,000
Pulp production losses, \$	\$224,000	\$399,000	\$585,000	\$133,000	\$224,000	\$399,000	\$158,000	\$285,000	\$411,000	\$94,900	\$158,000	\$285,000
tci, \$	\$644,000	\$1,160,000	\$1,670,000	\$387,000	\$644,000	\$1,160,000	\$644,000	\$1,160,000	\$1,670,000	\$387,000	\$644,000	\$1,160,000
Downtime, d	17	17	17	17	17	17	17	17	17	17	17	17
Increase in SCA, m2/(m3/sec)	16	16	<del>1</del> 6	16	16	16	16	16	16	16	16	16
Increase in ESP plate area, m2	1,532	2,756	3,986	922	1,532	2,756	1,532	2,756	3,986	922	1,532	2,756
Gas flowrate ESP exit, m3/sec @8% O2	93.4	168	243	56.2	93.4	168	93.4	168	243	56.2	93.4	168
Equivalent ADMP/d	380	680	1,000	230	380	680	230	820	1,200	270	450	820
Black liquor firing rate, kg BLS/d	700,000	1,200,000	1,800,000	400,000	700,000	1,200,000	700,000	1,200,000	1,800,000	400,000	700,000	1,200,000
Furnace type	NDCE	NDCE	NDCE	DCE	DCE	DCE	NDCE	NDCE	NDCE	DCE	DCE	DCE
Pulp type	₫	⊡	8	B	Ē	BI	Unbi	Unbl	Unbl	Unbl	Unbi	IdnU
Model recovery furnaces	RF-1b/4b	RF-2b/5b	RF-3b/6b	RF-7b	RF-8b	RF-9b	RF-1b/4b	RF-2b/5b	RF-3b/6b	RF-7b	RF-8b	RF-9b

(a) Metric equivalents in this table were converted from the calculated English unit values given in Table 6-9b. Refer to Table 6-9b for footnotes, which include calculations.

TABLE 6-9b (ENGLISH). COSTS OF ESP UPGRADE TO CONTROL PM FROM 0.044 GR/DSCF TO 0.015 GR/DSCF FOR MODEL RECOVERY FURNACES (INCLUDING PULP PRODUCTION LOSSES)<sup>a</sup>

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Model			Black liquor		Gas flowrate	Increase in				<u>4</u>	Ţ				
recovery	Pulp .	Furnace	firing rate,	Equivalent	ESP exit, acfm	ESP plate	in SCA,	Downtime,	TCI	production	production	Electricity,	А, I & Т,	recovery,	ITAC,
rumaces	type	type	ID BLS/d	ADTP/d	@8% 02	area, ft2 (b)	ft2/1,000 acfm	σ	\$ (c)	losses, \$ (d)	losses, \$	\$/yr (e)	\$/yr (f)	\$/yr (g)	\$/yr (h)
RF-1b/4b	В	NDCE	1,500,000	420	198,000	16,500	83	17	\$644,000	\$224,000	\$868,000	\$16,200	\$25,800	\$101,000	\$143,000
RF-2b/5b	亩	NDCE	2,700,000	750	357,000	29,750	83	17	\$1,160,000	\$399,000	\$1,560,000	\$29,200	\$46,400	\$182,000	\$258.000
RF-3b/6b	⊡	NDCE	3,900,000	1,100	515,000	42,917	83	17	\$1,670,000	\$585,000	\$2,260,000	\$42,100	\$66,800	\$264,000	\$373.000
RF-7b	ā	DCE	900,000	250	119,000	9,917	83	17	\$387,000	\$133,000	\$520,000	\$9,700	\$15,500	\$74,000	000'66\$
RF-8b	Ē	DCE	1,500,000	420	198,000	16,500	83	17	\$644,000	\$224,000	\$868,000	\$16,200	\$25,800	\$124,000	\$166,000
RF-9b	8	DCE	2,700,000	750	357,000	29,750	83	17	\$1,160,000	\$399,000	\$1,560,000	\$29,200	\$46,400	\$222,000	\$298,000
RF-1b/4b	Unbl	NDCE	1,500,000	500	198,000	16,500	83	17	\$644,000	\$158,000	\$802,000	\$16,200	\$25,800	\$93,800	\$136.000
RF-2b/5b	Unbi	NDCE	2,700,000	006	357,000	29,750	83	17	\$1,160,000	\$285,000	\$1,450,000	\$29,200	\$46,400	\$170,000	\$246,000
RF-3b/6b	ldnU	NDCE	3,900,000	1,300	515,000	42,917	83	17	\$1,670,000	\$411,000	\$2,080,000	\$42,100	\$66,800	\$243,000	\$352,000
RF-7b	Unbl	DCE	900,000	300	119,000	9,917	83	17	\$387,000	\$94,900	\$482,000	002'6\$	\$15,500	\$68,600	\$94.000
RF-8b	Unbl	DCE	1,500,000	500	198,000	16,500	83	17	\$644,000	\$158,000	\$802,000	\$16,200	\$25,800	\$114,000	\$156,000
RF-9b	Unbl	DCE	2,700,000	006	357,000	29,750	83	17	\$1,160,000	\$285,000	\$1,450,000	\$29,200	\$46,400	\$206,000	\$282,000
(a) All costs in \$1001	1001¢ - 1001														

(a) All costs in \$1991
(b) Increase in ESP plate area = model gas flowrate x increase in SCA
(c) TCI = Increase in ESP plate area x (\$39/ft2 plate area)
(d) Pulp production losses = (25% gross profit margin) x (\$464(fton bleached pulp or \$384(fton unbleached pulp) x (136.2 \$1991/124 \$1989)x (17 d downtime-14 d scheduled downtime) x ADTP/d
(d) Pulp production losses = (25% gross profit margin) x (\$646(fton bleached pulp or \$384(fton unbleached pulp) x (136.2 \$1991/124 \$1989)x (17 d downtime-14 d scheduled downtime) x ADTP/d
(d) For NDCE furnaces, electricity = 0.00194 x model gas flowrate x (517 - 533 ft2)/1,000 acfm x 8,424 hr/yr x \$0.06/kWh
For DCE furnaces, electricity = 0.00194 x model gas flowrate x (517 - 433 ft2)/1,000 acfm x 8,424 hr/yr x \$0.06/kWh

(f) Administrative, insurance, and taxes (AI & T) = 0.04 × TCI
 (g) For NDCE furnaces, capital recovery = 0.1169 CRF × (TCI + production losses) (based on 13.5-yr ESP life and 7% interest)
 For DCE furnaces, capital recovery = 0.1424 CRF × (TCI + production losses) (based on 10-yr ESP life and 7% interest)
 (h) Incremental total annual cost (ITAC) = Electricity + A,I & T + capital recovery

TO DRY-BOTTOM ESP CONVERSION COSTS FOR MODEL NDCE RECOVERY FURNACES<sup>A</sup> WET -TABLE 6-10a (METRIC).

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\$133,000 \$166,000 \$133,000 \$166,000 \$93,500 \$93,500 ITAC, \$/yr recovery, \$124,000 \$124,000 \$69,700 \$99,200 \$69,700 \$99,200 Capital \$/yr A,I & T, \$23,800 \$34,000 \$42,400 \$23,800 \$34,000 \$42,400 \$/yr \$1,060,000 \$1,060,000 \$596,000 \$849,000 \$596,000 \$849,000 tCl, \$ ESP exit, m3/sec Gas flowrate--@8% 02 93.4 168 243 93.4 243 168 dry-bottom dry-bottom dry-bottom dry-bottom dry-bottom dry-bottom ESP type Control option wet-bottom wet-bottom wet-bottom wet-bottom wet-bottom wet-bottom ESP type Baseline Equivalent ADMP/d 1,200 1,000 380 680 450 820 Black liquor firing rate, kg BLS/d 1,200,000 1,800,000 1,800,000 1,200,000 700,000 700,000 Unbl ldnU Pulp Unbl type Ē m Ξ RF-4a/4b RF-5a/5b RF-4a/4b RF-5a/5b RF-6a/6b RF-6a/6b recovery furnaces Model

(a) Metric equivalents in this table were converted from the calculated English unit values given in Table 6-10b. Refer to Table 6-10 for footnotes, which include calculations. TO DRY-BOTTOM ESP CONVERSION COSTS FOR MODEL NDCE RECOVERY FURNACES<sup>a</sup> WET -TABLE 6-10b (ENGLISH).

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Model recovery furnaces	Pulp type	Black liquor firing rate, Ib BLS/d	Equivalent ADTP/d	Baseline ESP type	Control option ESP type	Gas flowrate ESP exit, acfm @8% O2	TCI, \$ (b)	A,I & T, \$/yr (c)	Capital recovery, \$/yr (d)	ITAC, \$/yr (e)
RF-4a/4b	В	1,500,000	420	wet-bottom	dry-bottom	198,000	\$596,000	\$23,800	\$69,700	\$93,500
RF-5a/5b	BI	2,700,000	750	wet-bottom dry-bottom	dry-bottom	357,000	\$849,000	\$34,000	\$99,200	\$133,000
RF-6a/6b	BI	3,900,000	1,100	wet-bottom	dry-bottom	515,000	\$1,060,000	\$42,400	\$124,000	\$166,000
RF-4a/4b	Unbl	1,500,000	500	wet-bottom dry-bottom	dry-bottom	198,000	\$596,000	\$23,800	\$69,700	\$93,500
RF-5a/5b	Unbl	2,700,000	006	wet-bottom	dry-bottom	357,000	\$849,000	\$34,000	\$99,200	\$133,000
RF-6a/6b	Unbl	3,900,000	1,300	wet-bottom dry-bottom	dry-bottom	515,000	\$1,060,000	\$42,400	\$42,400 \$124,000	\$166,000

(a) All costs in \$1991
(b) TCl = \$845,000/(357,000 acfm/model gas flowrate) ^ 0.6 x (361.3 \$1991/359.4 \$July 1993)
(c) Administrative, insurance, and taxes (A,I & T) = 0.04 x TCl
(d) Capital recovery = 0.1169 CRF x TCl (based on 13.5-yr ESP life and 7% interest)
(e) Incremental total annual cost (ITAC) = A,I & T + capital recovery

TABLE 6-11a (METRIC). CAPITAL COSTS OF LOW-ODOR CONVERSION (INCLUDING ESP UPGRADE TO CONTROL PM TO 0.10 G/DSCM) FOR MODEL DCE RECOVERY FURNACES (EXCLUDING PULP PRODUCTION LOSSES)<sup>a</sup>

Model recovery furnaces	Pulp type	Black liquor firing rate, kg BLS/d	Equivalent ADMP/d	Gas flowrate ESP exit, m3/sec @ 8% O2	Downtime, d	Economizer expansion, demolition, \$	Concentrator, \$	Low-odor conversion, \$	ESP upgrade, \$	Wet- to dry- bottom ESP conversion, \$	±Ci, \$
RF-7a/7b	B	400,000	230	56.2	25	\$4,780,000	\$3,310,000	\$8,090,000	\$881,000	\$439,000	\$9,410,000
RF-8a/8b	m	700,000	380	93.4	55	\$6,500,000	\$4,500,000	\$11,000,000	\$1,200,000	\$596,000	\$12,800,000
RF-9a/9b	m	1,200,000	680	168	25	\$9,250,000	\$6,400,000	\$15,700,000	\$1,700,000	\$849,000	\$18,200,000
RF-7a/7b	Unbl	400,000	270	56.2	55	\$4,780,000	\$3,310,000	\$8,090,000	\$881,000	\$439,000	\$9,410,000
RF-8a/8b	Unbl	700,000	450	93.4	25	\$6,500,000	\$4,500,000	\$11,000,000	\$1,200,000	\$596,000	\$12,800,000
RF-9a/9b	Unbl	1,200,000	820	168	25	\$9,250,000	\$6,400,000	\$15,700,000	\$1,700,000	\$849,000	\$18,200,000

(a) Metric equivalents in this table were converted from the calculated English unit values given in Table 6-11b. Refer to Table 6-11b for footnotes, which include calculations.