

INFORM

Reducing Office Paper Waste

An **INFORM** Special Report

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INFORM Special Reports cover the full range of environmental issues **INFORM** studies. This special report analyzes the mounting office paper waste problem and outlines possible solutions, using photocopying as the focus from which other strategies may be extrapolated. Prepared by Robert Graff, researcher in **INFORM's** Municipal Solid Waste Program, and Bette K. Fishbcin, Director of **INFORM's** Municipal Solid Waste Program, and edited by Sibyl R. Golden, Director of Research and Publications, it is being issued as part of **INFORM's** ongoing research and public education on the problems of municipal solid waste and ways that businesses can reduce at the source the amounts of waste they generate.

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I. Introduction

Despite the growing use of electronic office equipment that was widely expected to decrease the use of paper, the amount of office paper waste is increasing very rapidly - and much more rapidly than the waste stream in general. Some 65 million office workers in the United States threw out 7.3 million tons of office paper in 1988, or more than 225 pounds each. This 7.3 million tons equaled 4.1% of the total waste stream, up from only 1.5 million tons, or 1.7% of the total waste stream, in 1960. And the federal Environmental Protection Agency (EPA) projects that the amount of office paper waste will continue to grow, both in absolute terms and as a percentage of total waste, to 16.0 million tons and 6.4% in 2010.¹

The Garbage Crisis

While offices generate ever more paper waste, room for United States garbage is running out. Between 1978 and 1989, the number of landfills operating in the United States decreased from 20,000 to 6600; the EPA has predicted that 2000 more will close in the next five years. During the same time period, fast-paced construction of garbage-burning incinerators has taken place. In 1990, some 84,246 tons of garbage per day were burned in a total of 128 waste-to-energy (also called resource recovery) plants, up from 25,923 tons per day in 1987 and a mere 990 tons per day in 1970. However, concern about the environmental and health impacts of incinerators has also been growing. Both landfills and incinerators are becoming increasingly difficult and costly to site and construct.

As treatment and disposal options, both landfilling and incineration rank at the bottom of the EPA's hierarchy of policy options for dealing with our nation's solid waste problem. This hierarchy, now widely accepted by garbage experts in business and the environmental movement, as well as in government, relies on, first, reducing to the greatest extent possible the amount and toxicity of garbage generated (source reduction); second, recycling or

composting everything else feasible; and third, seeking treatment or disposal options only for what is left.

Generating less garbage not only decreases the amount of waste that must be managed, but also reduces pollution generated during manufacturing and preserves natural resources. Yet, despite source reduction's position atop the garbage management hierarchy, this strategy has generally received the least attention and effort.

Reducing Office Paper Waste

Office paper waste is a good candidate for source reduction because it is an important segment of the waste stream and because companies have a relatively high degree of control over its use and disposal. Additionally, companies and institutions can save substantial amounts of money by reducing office paper waste.

In this report, **INFORM** examines strategies for reducing office paper waste, with a particular focus on photocopying. It analyzes the source reduction and cost savings potential both of two-sided (duplex) photocopying and of reducing the number of photocopies made.

¹ US Environmental Protection Agency, *Characterization of Municipal Solid Waste in the United States: 1990 Update*, June, 1990.

Despite the fact that two-sided photocopying tops most lists of office source reduction options, no framework exists for evaluating its costs and benefits. In this report, INFORM aims to create such a framework by assessing the impact of a variety of scenarios - involving different duplex rates and different reductions in paper use - on the quantity of copy paper waste generated.

To do this, the report first profiles photocopy paper use in the United States today, analyzes the costs of photocopying, and establishes a baseline scenario that reflects 1990 photocopier use. Finally, it examines some of the constraints on reducing office paper waste through photocopying alone.

While this report highlights photocopy paper, the analysis can be extrapolated to all office paper. Almost every piece of office paper can be used on both sides, and opportunities abound for using paper more intensively in other ways (single-spacing documents, for example) and for eliminating some uses altogether (proofreading documents on the computer screen, for instance). Some of these opportunities are discussed in the final section of this report, "Paper Reduction."

Further, reducing office paper use has environmental benefits in addition to the direct cost savings. According to figures gathered by the National Wildlife Federation, saving a ton of paper also saves 17 trees, 3 cubic yards of landfill space, 2 barrels of oil, 7000 gallons of water, and 4100 kilowatt-hours of electricity.²

II. Summary of Key INFORM Findings and Conclusions

INFORM has developed a series of findings and conclusions about strategies for reducing office paper waste. The findings fall into two categories. First, the scenarios we examined yielded estimates of the paper and cost savings that could be obtained through

a variety of combinations of increasing double-sided copying and reducing the number of copies made. (The scenarios are all based on 1990 photocopying rates and the current stock of machines.) Second, we identified several limitations and costs associated with increasing duplexing under current conditions.

The conclusions also fall into two categories. First, based on INFORM's evaluation of existing constraints on duplexing, we identified strategies that could be used to increase duplexing rates. Second, recognizing that there are finite limitations on the extent to which duplexing alone can reduce paper use, we have also looked at ways to reduce the use of other office paper, and even to eliminate some uses altogether.

Key Findings Benefits of Increasing Duplexing and Reducing Photocopy Paper Use

1. By increasing double-sided copying to the estimated maximum possible extent, offices in the United States could save 373,000 tons of paper annually, for a cost savings (in paper purchase and waste disposal) of \$414 million. (The estimated maximum differs for different classes of copiers - from 0% for the slowest personal copiers to 90% for the fastest copiers used in centralized duplicating facilities - due to both the availability of duplexing capability and the extent to which multipage, rather than single-page, documents are copied.) Even with a more limited duplexing rate increase of 50 percent from current levels, annual savings would reach 146,000 tons of paper and \$162 million.
2. Through a combination of increasing double-sided copying to the maximum possible extent and decreasing the number of copies made by 33 percent, United States offices could save 890,000 tons of paper annually, for a cost savings (in paper purchase and waste disposal) of \$987 million. Even with a more limited duplexing rate increase of 50 percent from current levels

² National Wildlife Federation, *Citizens Action Guide*.

and a decrease in copies made by only 20 percent, annual savings would reach 505,000 tons of paper and \$560 million.

3. Through a combination of increasing double-sided copying to the maximum possible extent and decreasing the number of copies made by 33 percent, New York City government offices could save 4131 tons of paper annually, for a cost savings (in paper purchase and waste disposal) of \$5,172,000. Even with a more limited duplexing rate increase of 50 percent from current levels and a decrease in copies made by only 20 percent, annual savings would reach 2342 tons of paper and \$2,169,000.
4. The first centralized copying facility within the American Telephone and Telegraph Company (AT&T) to implement a default duplexing strategy (as part of a corporate initiative to reduce office paper waste) increased its duplexing rate from 10 to 79 percent. AT&T estimates that, if it meets its company-wide goal of increasing the duplexing rate to 50 percent, it has the potential to reduce paper usage by 77 million sheets of paper annually, equating to approximately \$385,000 in reduced costs.

Limitations and Costs of Increased Duplexing

5. The lack of duplexing capability in many smaller copiers presents a significant obstacle to increasing duplexing beyond the theoretical maximum used in the scenarios above, to the extent that these machines are used to make multipage documents, as long as the existing stock of machines is in use. Currently, personal or convenience copiers (machine classes 1A to 3), make up 88.9 percent of machines and use approximately 40 percent of all copy paper, but have duplexing rates of 11 percent or less.
6. Existing photocopiers are less reliable in duplex mode than in single-sided mode and take longer to make double-sided, rather than single-sided, copies. The process used for making double-sided copies in almost all existing machines often leads to paper curling, which in turn leads to jams and breakdowns.

7. Current corporate and government photocopier procurement policies rarely specify duplexing performance as a purchasing criterion. Further, duplexing reliability is not routinely quantified (e.g., mean time between jams).
8. The major cost savings associated with increased duplexing (reducing paper purchase and waste disposal expenses) are partially offset by some potential cost increases (not analyzed in this report). Potential cost increases include increased service costs when fixed-cost maintenance contracts are not in place and increased labor costs since duplexing is slower than double-sided copying and there is more machine down-time. And, while an increase in duplexing may lead to the purchase of more expensive machines, the analyses presented in this report are based on using the current stock of machines. In the long run, however, technological improvements may eliminate such cost differentials for good duplex performance.
9. Since many documents are single pages and approximately half have an odd number of pages, it is impossible to ever reach a 100 percent duplexing rate; further, duplexing alone can never reduce paper usage beyond a finite point. That is, for every two images copied double-sided, only one piece of paper is saved.

Conclusions

Strategies for Increasing Duplexing

1. The largest increases in number of pages duplexed could be achieved by focusing efforts on high-capacity machines, typically found in centralized copying facilities. The three fastest classes (4-6) of photocopiers, while accounting for only 11.1 percent of all machines, use 59.4 percent of the paper. Further, while almost all copiers from class 3 up have automatic duplexing capabilities, not all smaller, slower machines do.
2. Corporate and government procurement policies that include defined duplexing reliability standards would provide an incentive to manufacturers to improve duplexing reliability, which

in turn would stimulate greater office use of the duplexing mode. For example, AT&T is using its influence as a buyer of large numbers of photocopiers to encourage copier manufacturers to improve duplexing performance by reducing jams and increasing speed. The company is also working with its major copier suppliers to retrofit machines so that they automatically copy in duplex mode unless the user instructs otherwise, and is making duplexing a key issue in future copier contracts.

3. Targeting efforts to encourage increased duplexing by government offices would have a particularly significant impact, since federal, state, and local governments employ many office workers and use large amounts of paper. Nationally, one in six workers, a total of 19 million people, is a government employee, and government purchases account for 20% of the gross national product. The New York City government alone employs one in fifteen workers in the city and uses some 9000 tons of paper a year.

Strategies for Reducing Office Paper Use

4. Extrapolating the analysis of photocopy paper, almost every piece of paper used in an office - from pads to computer paper to file folders - can be used on both sides. If one-half of the 7.3 million tons of office paper in the United States waste stream in 1988 were used on both sides, 1.8 million tons of paper would be saved. Total cost savings would depend on the costs of the individual types of paper saved, but would be in the range of \$2 billion if all paper cost approximately the same amount as photocopy paper.
5. Further reductions in office paper waste can be achieved by eliminating some uses of paper. Strategies include electronic communication, proofreading documents on the computer screen before printing, using central bulletin boards

and circulating memos instead of distributing multiple copies, avoiding fax cover sheets, and using central rather than individual filing.

6. Increasing the intensity of paper use can also reduce office paper waste beyond the finite level achievable through double-sided paper use alone. For example, documents can be printed single-spaced rather than double-spaced, using narrower margins and smaller typefaces, and formatted to avoid largely blank pages. A document that is double-spaced and printed on one side uses four times as much paper as one that is single-spaced and printed on both sides.

III. Office Paper Use Today

Paper is the single largest component of the municipal solid waste stream, amounting to 71.8 million tons, or 40% of the nation's waste in 1988.³ And office paper is the third largest category of paper waste after corrugated cardboard and newspapers - 7.3 million tons in 1988.

Furthermore, office paper use is growing rapidly, at over twice the rate of the GNP.⁴ As mentioned in the introduction, this 1988 total of 7.3 million tons, or 4.1% of total waste, has risen from only 1.5 million tons of office paper, or 1.7% of total waste, in 1960, according to the American Paper Institute. The EPA estimates that office paper waste will more than double by 2010, rising to 16 million tons, or 6.4% of total waste. (See Table 1.)

The leading category of office paper is bond and writing paper, which includes photocopy and laser printing paper, according to the American Paper Institute's estimates of office paper consumption shown in Table 2. Together, these two types of paper accounted for more than 40% of the office paper used in the United States in 1988.

³ US Environmental Protection Agency, *Characterization of Municipal Solid Waste in the United States: 1990 Update*, June 1990.

⁴ John Ackerman, International Paper Product Line Division, Memphis, Tennessee.

Table 1. Office Paper Waste 1960 - 2010 (projection)

	1960	1970	1980	1988	2000	2010
Tons (millions)	1.5	2.7	4.0	7.3	11.8	16.0
Percent total MSW	1.7%	2.2%	2.7%	4.1%	5.5%	6.4%

Source: US EPA, *Characterization of Municipal Solid Waste in the United States: 1990 Update*, June 1990.

Table 2. Annual Consumption of Office Paper

Paper Category	Weight (tons/year)	Percent of Total Paper Waste
Bond and writing paper (including xerography and laser printing)	3,000,000	41.1%
Form bond (computer paper)	2,000,000	27.4%
Envelope paper	500,000	6.8%
Tablets	400,000	5.5%
Other (including ledger, file folders, index cards, cotton bond)	1,400,000	19.2%
Total	7,300,000	100.0%

Source: American Paper Institute

Current Photocopying Practices

Photocopying alone accounts for more than one-quarter of all office paper use. In 1990, 1,939,170 tons of paper went through photocopiers in the United States.⁵ This is equivalent to-almost 400 billion sheets of paper,⁶ or about 6000 sheets per office worker.⁷ In fact, photocopy paper alone makes up almost 3% (by weight) of all the paper used in this country, and just over 1% of the total waste.⁸

While 1% may not seem large, this 1.9 million tons is more than all the paper plates and cups, more than all the aluminum cans, and slightly less than all the rubber tires discarded in a year. And it is more than half of the disposable diapers in the waste stream. Table 3 shows how office paper and photocopy paper compare with some other familiar items in the nation's waste stream.

An understanding of current photocopying practices

⁵ Banking Information Systems (BIS CAP), Norwell, MA (a consultant to the office machine industry).

⁶ 387,830,000,000 sheets, according to BIS CAP.

⁷ In 1988 there were 64,722,000 managerial, professional, technical, sales, and administrative support workers in United States. This approximates the number of office workers. US Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States*, 1990, table 645, pp. 389-391.

⁸ This assumes that essentially all of the paper ultimately is disposed of as waste. That which is filed, for example, will eventually be discarded, or will cause an equal amount of old paper to be discarded. While this is not strictly accurate, it provides a reasonable estimate.

Table 3. Selected Materials in the US Waste Stream (1988)

Material	Consumption (million tons)	Percent of Total
Total office paper	7.3	4.1%
Photocopier paper	1.9	1.0%
Paper plates and cups	0.7	0.2%
Aluminum cans and packaging	1.8	1.0%
Tires	2.2	1.2%
Disposable diapers	2.7	1.5%
Milk cartons	0.9	0.5%

Source: US EPA, Characterization of Municipal Solid Waste in the United States: 1990 Update, June 1990.

Table 4. Industry Classification of Photocopiers

Copier Type	Class	Speed (copies per minute)
Personal	1AA	under 10
Convenience	1	10-19
	2	20-30
	3	31-45
Copy center duplicating	4	46-69
	5	70-90
Centralized xero-graphic duplicating	6	91 and over

Source: Banking Information Systems (BIS CAP), Norwell, MA (a consultant to the office machine industry).

is necessary for a determination of the possibilities for decreasing photocopy paper use. Banking Information Systems (BIS CAP), a consultant to the office machine industry, has gathered basic data on photocopier usage in the United States today. The photocopier industry divides the market into several classes of machines, based on the number of copies the machine can make per minute, as shown in Table 4.

Paper demand differs for each class of machine. Although there are more small, slower machines than fast machines, the faster machines are the largest users of paper, as shown in Table 5. The fastest three classes (4-6) use almost 60% of the paper, although they make up only 11.1% of the machines.

Automatic duplexing (two-sided copying) is not available on all copiers. This feature is more likely to be found on machines in the higher classes. Almost all machines from class 3 up have it, while the smaller machines rarely do.

BIS CAP has estimated the duplexing rate or prevalence of usage of the duplex feature, on machines in the different classes (Table 6). The duplex rate is the percentage of copies made using the duplex feature.

$$\text{Duplexing rate} = \frac{\# \text{ of copies made duplex}}{\# \text{ of copies}}$$

For example, if two of ten originals are copied with the duplex feature, the duplexing rate is 0.20, or 20%.

Note that "copy" refers to one image produced. Thus the two-sided copy in the example counts as two copies, even though it only uses one sheet of paper.

We can estimate the total number of copies made by each class of machine. First, we can calculate the number of sheets of paper used by class of machine since we know the distribution of paper usage by machine class (Table 5) and the total number of sheets of paper used (387,830,000,000). Then, using the estimated duplex rate for each class of machine (Table 6), we can calculate the number of copies using the following formula:

$$\text{Copies} = \frac{\text{Sheets}}{1 - \frac{\text{Duplex rate}}{2}}$$

(Copies refers to the number of images made, sheets refers to the number of sheets of paper, and duplex rate is the proportion of copies made double-sided.) The results of these calculations are presented in Table 7.

Overall, just over one-quarter (26.2%) of all photocopies are currently made in duplex mode. This estimate is based on the number of copies made and

Table 5. US Photocopier Paper Use, 1990

Machine Class	Number of Machines	Percent of Machines	Paper Demand (tons)	Percent of Demand	Average Demand per Machine (tons)
1AA	1,072,500	21.3%	21,880	1.1%	0.02
1	1,672,200	33.3%	175,970	9.1%	0.11
2	1,214,100	24.2%	327,650	16.9%	0.27
3	506,880	10.1%	262,970	13.6%	0.52
4	387,050	7.7%	406,810	21.0%	1.05
5	129,250	2.6%	389,460	20.1%	3.01
6	41,900	0.8%	354,440	18.3%	8.46

Source: BIS CAP. (Numbers may not add to expected totals due to rounding and truncation.)

Table 6. Duplex Usage by Machine Class (US1990)

Machine Class	Duplex Rate
1AA	Essentially none
1	1.8% *
2	4.6%
3	11.0%
4	18.0%
5	38.0%
6	55.4%

Source: BIS CAP.

*Class 1 is actually broken down into two subclasses, 1A and 1B, which have duplex rates of 1.2% and 2.4%, respectively. For simplicity, they are combined using a rate of 1.8%.

Table 7. Copies Made by Class of Machine (US,1990)

Machine Class	Copies Ma&	Percent of Total Copies
1AA	4,376,000,000	1.0%
1	35,513,622,603	8.0%
2	67,072,671,443	15.0%
3	55,655,026,455	12.5%
4	89,408,791,209	20.0%
5	96,162,962,963	21.5%
6	98,047,026,279	22.0%
Total	446,236,100,963	100.0%

number of sheets of paper used, as in the following formula:

$$\frac{2 \times (\text{\#of copies} - \text{\#of sheets of paper})}{\text{\# of copies}} = \text{Duplex rate}$$

or

$$\frac{2 \times (446,236,100,953 - 387,830,000,000)}{446,236,100,953} = 0.262 = 26.2\%$$

This duplexing rate means that of every 100 photocopy images made, 26 are duplex. Eighty-seven sheets of paper are used: 13 sheets for the 26 copies that are duplexed and 74 sheets for the remaining one-sided copies. Thus, there is a 13 percent savings in paper versus single-sided copying. That is, the paper savings from two-sided copying is half the duplex rate: if all copying were done duplex, the duplex rate would be 100% and the paper savings would be 50%.

Costs of Photocopying

The potential cost savings of two-sided copying examined in this paper focus on savings in purchasing and disposing of paper. Large savings can be realized, even though these are but a small portion of the total costs of photocopying. Expenditures on photocopying in the US are estimated at \$18.4 billion a year. Of this, 46% is spent on hardware (i.e., the machines themselves), 29% on service and maintenance, and 25% on supplies.⁹ About a third of the supply budget is for paper. Thus, just under 10% of

the nation's photocopy budget, or about \$1.9 billion per year, is spent on paper. Photocopy paper costs about \$0.005 per sheet when bought in large quantities (\$25 per lo-ream case), or approximately \$1000 per ton.

Paper waste disposal costs are not as easily quantified as purchasing costs because they are quite variable. The principal cost of paper waste disposal, for an office, is waste hauling charges. Hauling charges are generally based on volume, measured in cubic yards. They vary greatly from location to location, depending on local labor and transportation costs, as well as disposal tip fees charged to the waste hauler.

In addition, some copies enter the municipal waste stream shortly after being made, while others are mailed or filed and not disposed of until later. However, virtually all office paper waste enters the municipal solid waste stream at some point. In this analysis, we use an average disposal cost of \$25 per cubic yard.¹⁰

A cubic yard of waste office paper weighs about 460 pounds,¹¹ so a ton of paper has a volume of just over 4 1/3 cubic yards. At the cost of \$25 per cubic yard, disposing of one ton of paper costs about \$110. Note that this is relatively small in comparison to the cost of purchasing one ton of paper. Also, offices may be able to reduce their paper waste disposal costs, or even generate some revenue, by recycling paper.

The benefits of duplexing associated with paper distribution and storage are even less easily quantified. Since two-sided copies weigh less, mailing costs are reduced. For example, first-class postage for a 12-ounce document (approximately 75 single-sided pages) is \$2.90. If that document is copied on

⁹ Carl Lindquist, consultant to the photocopying industry.

¹⁰ This is essentially an educated estimate. The National Solid Waste Management Association, the trade group for the industry, does not release information on hauling charges. Tipping fees (the amount a landfill or transfer station charges for disposal) in 1988 ranged from under \$10 to well over \$100 per ton, with a national average of \$26.93 per ton (Waste Age, March 1989, p. 101). Adding labor and operating costs would bring this in the range of these estimates. In any case, the avoided hauling charges are less significant than the avoided purchases.

¹¹ From various sources, including AT&T's corporate recycling program publicity, and interviews with several recycled paper dealers.

both sides and the package (with envelope) is reduced in weight to 7 ounces, it would only cost \$1.67, a savings of over 42%.¹²

Two-sided copies take up less filing space, so files need to be expanded less often, saving both the purchase cost of filing cabinets and the floor space they occupy. If a foot of file drawers holds about 2500 sheets, then a four-drawer filing cabinet contains about 20,000 sheets of paper.¹³ If a four-drawer filing cabinet were in high-rent office space, where floor space costs \$30 per square foot per month, it would cost about \$52.50 to store 1000 pages of text for a year if these sheets were all single-sided. If they were double-sided, the storage cost per page of information would be halved.

Offsetting these cost savings are some potential cost increases. An increase in duplexing may lead to the purchase of more expensive machines. Such capital costs are not included in our analysis as our scenarios are based on an increase in duplexing with the current stock of machines. Other cost increases include increased service costs when fixed-cost service contracts are not in place and increased labor costs since duplexing is slower than single-sided copying and there is more machine down-time.

In the following analysis of the potential cost savings associated with increasing double-sided copying and reducing paper use, we focus on the most direct and quantifiable costs: the cost of paper purchase (\$1000 per cubic yard) and the cost of waste paper disposal (\$25 per cubic yard). In the long run, these may prove to be the most relevant costs as technological improvements may eliminate cost differentials for good duplex performance.

IV. Using Less Paper: The Impact of Several Scenarios

In the scenarios that follow, we examine the impact of reducing the use of office paper for photocopying (through both increased duplexing and decreased number of copies) to varying degrees. Each scenario identifies the net duplexing rate and the amount of paper and money saved compared to a base scenario. The base scenario used, shown in Table 8, represents photocopying in the United States in 1990; thus all scenarios are based on the equipment stock in use at that time.

Conducting the analysis by machine class makes it possible to evaluate the impact of policies in which the duplexing rate is increased a different amount for each class of machine, as would policies concentrating primarily on central duplicating facilities rather than smaller office copiers. (Note, however, that because of rounding and truncation during the analyses of the scenarios, figures for the different machine classes in the tables that follow do not always add up precisely to the totals shown.)

Several features of the base scenario merit comment. The fastest machines, which use the most paper, also have the highest duplexing rates. Classes 4-6 account for almost 60% of all photocopy paper use and have duplexing rates of 18-55.4%. Conversely, the slowest three classes of copiers (1 AA, 1 and 2) have duplex rates of 5% or less, but are responsible for less than 30% of all paper used (although they make up 80% of all machines). Thus, increasing the duplex rate on these slower machines would have a comparatively smaller impact on the overall usage of paper.

¹² While postage costs generally increase with the weight of the package, the relationship is not completely linear. First-class postage for any package weighing between 11 ounces and 2 pounds, for example, is \$2.90.

¹³ A standard filing cabinet covers a floor area of approximately 420 square inches, or 2.92 square feet (15 inches wide by 28 inches deep). The drawers are approximately 2 feet deep. If the drawers are not full, the cost of storage per 1000 pages is even greater, although the savings for two-sided copying are not as great.

Table 8. Base Scenario: Photocopying in the US, 1990

Machine Class	Copies Made	Duplex Rate	Annual Paper Demand (tons)	Percentage of Demand
IAA	4,376,000,000	0.0%	21,880	1.1%
1	35,513,622,603	1.8%	175,970	9.1%
2	67,072,671,443	4.6%	327,650	16.9%
3	55,655,026,455	11.0%	262,970	13.6%
4	89,408,791,209	18.0%	406,810	21.0%
5	96,162,962,963	38.0%	389,460	20.1%
6	98,047,026,279	55.4%	354,440	18.3%
Total	446,236,100,953		1,939,160	100.0%

Sheets of paper used: 387,836,000,000
Net duplex rate: 26.2%

Source: See Tables 5 and 7

Table 9. Duplexing Rate Increased 50%

Machine Class	Copies Made	Duplex Rate	Annual Paper Demand (tons)	Percentage of Demand
IAA	4,376,000,000	0.0%	21,880	1.2%
1	35,513,622,603	2.7%	175,171	9.8%
2	67,072,671,443	6.9%	323,793	18.1%
3	55,655,026,455	16.5%	255,317	14.2%
4	89,408,791,209	27.0%	386,693	21.6%
5	96,162,962,963	57.0%	343,783	19.2%
6	98,047,026,279	83.1%	286,542	16.0%
Total	446,236,100,953		1,793,160	100.0%

Sheets of paper used: **358,635,949,524**
Net duplex rate: **39.3%**
Paper saved vs. base scenario: 146,000 tons
7.5%
Savings in purchase of paper (\$1000/ton): \$146,000,000
Avoided disposal costs (\$25/cubit yard): \$15,869,593
Total cost savings \$161,869,593

Table 10. Duplexing Rate Doubled*

Machine Class	Copies Made	Duplex Rate	Annual Paper Demand (tons)	Percentage of Demand
1AA	4,376,000,000	0.0%	21,880	1.3%
1	35,513,622,603	3.6%	174,372	10.3%
2	67,072,671,443	9.2%	319,937	18.8%
3	55,655,026,455	22.0%	247,665	14.6%
4	89,408,791,209	36.0%	366,576	21.6%
5	96,162,962,963	76.0%	298,105	17.6%
6	98,047,026,279	90.0%	269,629	15.9%
Total	446,236,100,953		1,698,164	100.0%
Sheets of paper used:			339,632,789,780	
Net duplex rate:			47.8%	
Paper saved vs. base scenario:			241,016 tons	
			12.4%	
Savings in purchase of paper (\$1000/ton):			\$241,016,000	
Avoided disposal costs (\$25/cubit yard)			\$26,197,397	
Total cost savings			\$267,213,397	

*Except for class 6, where it is raised to 90%

Increasing Duplex Copying

The first set of three scenarios examines the effects of increasing duplex copying without any reduction in overall photocopy use. The scenarios involve increasing duplexing by 50%, doubling duplexing, and increasing duplexing to a theoretical maximum.

Table 9 illustrates the impact of increasing the duplexing rate for every class of machine by 50%, compared to the 1990 base scenario. While the total number of copies made is unchanged, some 29.2 billion fewer sheets of paper are used. This corre-

sponds to a net duplex rate of 39.3%, and a reduction of paper use by 146,000 tons, or 7.5% of that used in the base scenario. The resultant savings in the purchase of paper is \$146 million, and almost \$16 million of disposal costs are avoided, for a total cost savings of over \$160 million.

Table 10 shows the effects of doubling the duplexing rate in all classes except class 6, where it is raised to 90%.¹⁴ This scenario would save over 240,000 tons of paper each year and result in annual cost savings of close to \$270 million.

¹⁴ See discussion about theoretical maximum on page 12.

Table 11. Duplexing Rate Near Maximum

Machine Class	Copies Made	Duplex Rate	Annual Paper Demand (tons)	Percentage of Demand
1AA	4,376,000,000	0.0%	21,880	1.4%
1	35,513,622,603	5.0%	173,129	11.1%
2	67,072,671,443	20.0%	301,827	19.3%
3	55,655,026,455	33.0%	232,360	14.8%
4	89,408,791,209	70.0%	290,579	18.6%
5	96,162,962,963	85.0%	276,469	17.7%
6	98,047,026,279	90.0%	269,629	17.2%
Total	446,236,100,953		1,565,872	100.0
Sheets of paper used:			313,174,415,870	
Net duplex rate:			59.6%	
Paper saved vs. base scenario:			373,308 tons	19.3%
Savings in purchase of paper (\$1000/ton):			\$373,307,000	
Avoided disposal costs (\$25/cubit yard):			\$40,576,948	
Total cost savings			\$413,883,948	

Table 12. Summary of Savings from Increased Duplexing*

Strategy	Paper Savings		Cost Savings (\$ million)		
	Tons (thousands)	Percent	Paper purchase	Disposal	Total
Duplex rate increased 50%	146	7.5%	\$146	\$16	\$162
Duplex rate doubled	241	12.4%	\$241	\$26	\$267
Duplex rate increased to maximum	373	19.3%	\$373	\$41	\$414

*Compared to baseline scenario of 26% duplex rate.

Table 11 shows the savings from increasing duplexing to a theoretical maximum for each class of machine. For any class of machine, the maximum duplex rate will always be less than 100% because of the constraints of duplexing. Many smaller machines are unable to duplex. One-page documents cannot be duplexed. Documents with odd numbers of pages

cannot be completely duplexed. For example, a duplexed three-page document will use two sheets of paper, for a duplex rate of 66.7%. Finally, two-sided copying may not be appropriate for some types of documents, such as those to be faxed. Constraints on duplexing are discussed in more detail in Section V. This “maximum” scenario would annually save al-

Table 13. Total Copies Reduced by 20%

Machine Class	Copies Made	Duplex Rate	Annual Paper Demand (tons)	Percentage of Demand
1AA	3,500,800,000	0.0%	17,504	1.1%
1	28,410,898,083	1.8%	140,776	9.1%
2	53,658,137,155	4.6%	262,120	16.9%
3	44,524,021,164	11.0%	210,376	13.6%
4	71,527,032,967	18.0%	325,448	21.0%
5	76,930,370,370	38.0%	311,568	20.1%
6	78,437,621,024	55.4%	283,552	18.3%
Total	356,988,990,762		1,551,344	100.0%
Sheets of paper used:			310,268,800,000	
Net duplex rate:			26.2%	
Paper saved vs. base scenario:			387,836 tons	
			20.0%	
Savings in purchase of paper (\$1000/ton):			\$387,836,000	
Avoided disposal costs (\$25/cubit yard):			\$42,156,087	
Total cost savings:			\$429,992,087	

most 375,000 tons of paper, for a total cost savings of over \$410 million. It corresponds to a maximum net duplex rate of 59.6%.

Compared to the baseline scenario with a 26% duplex rate, paper savings in these three scenarios range from 7.5% for the 50% increase in duplexing to 19.3% for the maximum. Table 12 summarizes the paper and cost savings for each of the three scenarios.

Increasing Duplex Copying and Reducing Number of Copies

Duplexing alone can save paper and money, as the preceding section showed, but increasing duplexing combined with reducing the number of copies made can result in even greater savings. The next set of four scenarios examines the effect of various combinations of reductions in the number of copies made and increases in duplexing, again compared to the baseline scenario of current photocopying practices. The individual scenarios are decreasing the number

of copies by 20%; reducing copies by 20% and increasing duplexing 50%; reducing the number of copies by 25% while doubling the duplex rate; and reducing the number of copies by 33% while increasing duplexing to the theoretical maximum.

Table 13 illustrates the impact of reducing the number of copies made by 20%, without increasing duplexing above the current 26.2% rate. With paper savings of 387,836 tons and cost savings of almost \$430 million, the savings are actually greater than those that could be achieved by increasing duplexing to the maximum.

Table 14 shows the effects of reducing the number of copies made by 20% and increasing the duplexing rate by 50%. The result is a savings of 504,636 tons of paper and almost \$560 million compared to the baseline scenario. Compared to the scenario in Table 9, which included a 50% increase in the duplexing rate but no reduction in number of copies made, this scenario saves an additional 263,620 tons of paper and \$3 18 million.

Table 14. Total Copies Reduced by 20% and Duplexing Rate Increased 50%

Machine Class	Copies Made	Duplex Rate	Annual Paper Demand (tons)	Percentage of Demand
1AA	3,500,800,000	0.0%	17,504	1.2%
1	28,410,898,083	2.7%	140,137	9.8%
2	53,658,137,155	6.9%	259,035	18.1%
3	44,524,021,164	16.5%	204,254	14.2%
4	71,527,032,967	27.0%	309,354	21.6%
5	76,930,370,370	57.0%	275,026	19.2%
6	78,437,621,024	83.1%	229,234	16.0%
Total	356,988,880,762		1,434,644	100.0
Sheets of paper used:			286,908,759,619	
Net duplex rate:			39.3%	
Paper saved vs. base scenario:			504,636 tons	
			26.0%	
Savings in purchase of paper (\$1000/ton):			\$504,636,000	
Avoided disposal costs (\$25/cubit yard):			\$54,851,761	
Total cost savings			\$559,487,761	

Table 15. Total Copies Reduced by 25% and Duplexing Rate Doubled*

Machine Class	Copies Made	Duplex Rate	Annual Paper Demand (tons)	Percentage of Demand
1AA	3,282,000,000	0.0%	16,410	1.3%
1	26,635,216,953	3.6%	130,779	10.3%
2	50,304,503,582	9.2%	239,952	18.8%
3	41,741,269,841	22.0%	185,749	14.6%
4	67,056,593,407	36.0%	274,932	21.6%
5	72,122,222,222	76.0%	223,579	17.6%
6	73,535,269,710	90.0%	202,222	15.9%
Total	334,677,075,715		1,273,623	100.0%
Sheets of paper used:			254,724,592,335	
Net duplex rate:			47.8%	
Paper saved vs. base scenario:			665,557 tons	
			34.3%	
Savings in purchase of paper (\$1000/ton):			\$665,557,000	
Avoided disposal costs (\$25/cubit yard):			\$72,343,156	
Total cost savings			\$737,900,156	

*Except for class 6, where it is raised to 90%

Table 16. Total Copies Reduced by 33% and Duplexing Rate Near Maximum

Machine Class	Copies Made	Duplex Rate	Annual Paper Demand (tons)	Percentage of Demand
1AA	2,931,920,000	0.0%	14,660	1.4%
1	23,794,127,144	5.0%	115,996	11.1%
2	44,938,689,867	20.0%	202,224	19.3%
3	37,288,867,725	33.0%	155,681	14.8%
4	59,903,890,110	70.0%	194,688	18.6%
5	64,429,185,185	85.0%	185,234	17.7%
6	65,691,507,607	90.0%	180,652	17.2%
Total	298,978,187,638	1,049,134		100.0%
Sheets of paper used:			209,826,858,633	
Net duplex rate:			59.6%	
Paper saved vs. base scenario:			890,046 tons	
			45.9%	
Savings in purchase of paper (\$1000/ton):			\$890,046,000	
Avoided disposal cost (\$25/cubit yard):			\$96,745,099	
Total cost savings:			\$986,790,099	

Table 17. Summary of Savings from Increased Duplexing and Reduced Copies*

Strategy	Paper Savings		Cost Savings (\$ million)		
	Tons (thousands)	Percent	Paper purchase	Disposal	Total
Duplex rate increased 50%	146	7.5%	\$146	\$16	\$162
Duplex rate doubled	241	12.4%	\$241	\$26	\$267
Duplex rate increased to maximum	373	19.3%	\$373	\$41	\$414
Copies reduced 20%	388	20.0%	\$388	\$42	\$430
Copies reduced 20% and duplex rate increased 50%	505	26.0%	\$505	\$55	\$560
Copies reduced 25% and duplex rate doubled	666	34.3%	\$666	\$72	\$738
Copies reduced 33% and duplex rate increased to maximum	890	45.9%	\$890	\$97	\$987

*Compared to existing baseline scenario of 26% duplex rate.

Table 15 illustrates the combined impact of reducing the total number of copies made by 25% while essentially doubling the duplex rate. Compared to the baseline scenario, savings total 665,557 tons and almost \$738 million. Compared to the scenario with a doubling of the duplexing rate but no reduction in the number of copies made (Table 10), savings amount to an additional 424,541 tons and more than \$470 million.

The final scenario in this series, shown in Table 16, combines the “maximum” duplexing scenario with a cut of one-third in the total number of photocopies made. Total paper use is cut almost in half (890,046 tons) compared to the baseline scenario, resulting in a total cost savings of almost \$1 billion. Compared to the scenario with only maximum duplexing and no reduction in copies made (Table 11), savings amount to an additional 516,738 tons and \$573 million.

Table 17 summarizes the impact of all the scenarios examined. Clearly, if maximum source reduction is to be obtained, it will require a combination of increased duplexing and a reduction in the total number of copies made.

A Case Study: New York City Government

INFORM analyzed the potential for reducing the New York City government’s use of photocopying as a case study because governments are both major employers and major paper users. In New York City, for example, one in fifteen workers is employed by the city government, and one in six by government in general (federal and state as well). Reducing city government photocopying could thus have a significant impact on the amount of office paper used in the

city. Further, facing serious budget difficulties and a rapidly filling landfill, the city could benefit both economically and environmentally by reducing its paper waste.

Before applying the same scenarios already described to the New York City government, it is necessary to obtain or estimate information about the amount of copy paper used and the cost of waste disposal. While there is a shortage of specific data on photocopy usage by the city government, estimates can be based on the national numbers and the data that are available.

First, how much does it cost to dispose of the city’s garbage? Waste disposal costs for the government of New York City are somewhat different from the generic case used in the preceding scenarios. City agencies do not pay for their trash pickup based on how much waste is generated. It is collected “free” by the city’s Department of Sanitation. Since the costs of Sanitation’s operations are borne by the city, it is reasonable to use those costs as the disposal cost in the model.

The Tellus Institute, a Cambridge, Massachusetts, based research group, estimates the direct cost to the city for operating garbage trucks at \$104 per ton.” In addition, the Department of Sanitation estimates the cost of marine transfer operations to be \$29 per ton¹⁶ for total collection costs of about \$133 per ton. Further, the Department estimated the value of depletion of the limited landfill space at Fresh Kills at \$120 per ton in 1988.¹⁷ Thus, the city’s total cost for disposing of a ton of trash is about \$253, or about \$58 per cubic yard for paper.

Next, how much paper does the city use? The city purchased \$9 million worth of photocopier paper in 1990,¹⁸ at a price of \$25 per carton of 5000 sheets.

¹⁵ Energy Systems Research Group (now Tellus), Recourse Systems, and Anderson Associates, “Phase One Draft Report to Manhattan Citizen’s Advisory Committee,” Department of Sanitation, New York City, July 12, 1989.

¹⁶ New York City, memorandum from Brendan Sexton to members of the Board of Estimate concerning disposal prices, June 1, 1988.

¹⁷ *Ibid.*

¹⁸ This is the amount authorized for purchase through the Department of General Services. While this is the bulk of the city’s paper purchases, it is unclear how much more is purchased by individual agencies. The city’s procurement system does not yet allow determination of city-wide purchases of materials.

Table 18. Estimated NYC Government Photocopier Paper Use (1990)

Machine Class	Paper Demand, NYC (tons)	Percent of Paper Demand (national average)
1AA	102	1.1%
1	817	9.1%
2	1,521	16.9%
3	1,220	13.6%
4	1,888	21.0%
5	1,808	20.1%
6	1,645	18.3%
Total	9,000	100.0%

Sheets of paper used: 1,800,000,000

Table 19. Baseline Scenario: Estimated Copies by Machine Class, New York City Government (1990)

Machine Class	Copies Made	Percent of Copies
1AA	20,309,615	1.0%
1	164,823,587	8.0%
2	311,293,455	15.0%
3	258,302,601	12.5%
4	414,958,447	20.0%
5	446,305,483	21.5%
6	455,049,679	22.0%
Total	2,071,042,868	100.0%

Table 20. Photocopying by New York City Government: Duplexing Rate Increased 50%

Machine Class	Copies Made	Duplex Rate	Annual Paper Demand (tons)	Percentage of Demand
1AA	20,309,615	0.0%	102	1.2%
1	164,823,587	2.7%	813	9.8%
2	311,293,455	6.9%	1,503	18.1%
3	258,302,601	16.5%	1,185	14.2%
4	414,958,447	27.0%	1,795	21.6%
5	446,305,483	57.0%	1,596	19.2%
6	455,049,679	83.1%	1,330	16.0%
Total	2,071,042,868		8,324	100.0%

Sheets of paper used: 1,664,478,566
 Net duplex rate: 39.3%
 Papersaved vs.base scenario: 678 tons
 7.5%
 Savings in purchase of paper (\$1000/ton): \$678,000
 Avoided disposal costs (\$58/cubic yard): \$170,875
 Total cost savings: \$848,875

This is 9000 tons per year, or 1.8 billion sheets of paper. Some of this is used in laser printers, but that amount is assumed to be small enough to ignore. Knowing the city's approximate paper use, we can use the national data to estimate paper demand by machine class, as shown in Table 18. To calculate the number of copies made by each class of the city's

machines, we can use the same formula we used to calculate the number of copies made per machine class on the national level (shown in Table 7). Table 19 shows the results of these calculations. With these estimates of the number of copies by machine class, it is possible to analyze the potential impacts of different scenarios for increasing duplexing and re-

Table 21. Photocopying by New York City Government: Total Copies Reduced by 20% and Duplexing Rate Increased 50%

Machine Class	Copies Made	Duplex Rate	Annual Paper Demand (tons)	Percentage of Demand
1AA	16,247,692	0.0%	81	1.2%
1	131,858,870	2.7%	650	9.8%
2	249,034,764	6.9%	1,202	18.1%
3	206,642,081	16.5%	948	14.2%
4	331,966,757	27.0%	1,436	21.6%
5	357,044,386	57.0%	1,276	19.2%
6	364,039,743	83.1%	1,064	16.0%
Total	1,656,634,294		6,657	100.0%
Sheets of paper used:			1,331,582,853	
Net duplex rate:			39.3%	
Paper saved vs. base scenario:			2,342 tons	26.0%
Savings in purchase of paper (\$1000/ton):			\$2,342,000	
Avoided disposal costs (\$58/cubit yard):			\$590,613	
Total cost savings:			\$2,932,613	

ducing paper use. We look in depth at two scenarios (increasing the duplexing rate by 50% for all machine classes and increasing duplexing 50% and reducing the number of copies made 20%) and then summarize the impact of other scenarios.

First, Table 20 examines the impact of increasing the duplex rate by 50% for all classes of machines. Such a program could save the city government close to \$1 million per year. Further, if the city government combined the 50% increase in the duplexing rate with a total reduction of 20% in the number of copies made, the city could save close to \$3 million annually, as illustrated in Table 21.

Table 22 summarizes the impact of all the increased duplexing/decreased number of copies scenarios on paper use by the New York City government. These scenarios parallel those applied to all photocopying in the United States in the preceding sections. As with the US examples, the greatest savings are

achieved by a combination of increased duplexing and reduced number of copies. In the most effective scenario analyzed, the combination of reducing the number of copies made by one-third while increasing duplexing to its theoretical maximum yields annual savings for New York City government of more than 4000 tons of paper and \$5 million.

A Corporate Initiative: AT&T

A look at a recent corporate initiative to reduce office paper use provides some additional perspective on the cost- and paper-saving potential of increasing double-sided copying. To help meet a corporate goal of reducing office paper waste 15% by the end of 1994 (from 1990 levels), AT&T's main internal photocopy service unit initiated a plan to increase duplexing in their centralized reproduction facilities.¹⁹ Under the plan, "default service is duplex," which means that all documents will be copied

¹⁹ Information for this section was provided by AT&T, in personal communications with Bette Fishbein in August 1991.

Table 22. Summary of New York City Government Savings from Increased Duplexing and Reduced Copies'

Strategy	Paper Savings		Cost Savings (\$ thousands)		
	Tons	Percent	Paper purchase	Disposal	Total
Duplex rate increased 50%	678	7.5%	\$678	\$171	\$848
Duplex rate doubled	1119	12.4%	\$1119	\$282	\$1401
Maximum duplex rate	1733	19.3%	\$1733	\$437	\$2169
Copies reduced 20% and duplex rate increased 50%	2342	26.0%	\$2342	\$591	\$2932
Copies reduced 25% and duplex rate doubled	3089	34.3%	\$3089	\$779	\$3868
Copies reduced 33% and maximum duplex rate	4131	45.9%	\$4130	\$1042	\$5172

*Compared to existing baseline scenario of 26% duplex rate.

double-sided unless the client requests otherwise. Before this source reduction plan was initiated, all copies were made single-sided unless specified otherwise.

The company estimates that, before implementation of the new plan, the average monthly volume at its 140 centralized copying facilities was 46 million impressions, with an average duplex rate of 22%. Increasing the duplex rate to 50% - the goal set by AT&T - would thus have the potential to reduce paper usage by 77 million sheets of paper annually²⁰ equating to approximately \$385,000 in reduced costs.

At the first AT&T copying center to introduce the default duplexing approach, in Kansas City, the duplexing rate prior to the new plan was 10%. The new initiative increased the duplex rate at the center to 79%, with no client complaints. AT&T is also developing a company-wide "duplex awareness" campaign, and as will be discussed further in the section on procurement policies, is working with its photocopier suppliers to improve duplexing perfor-

mance and to increase the speed of photocopiers in duplex mode.

In a related initiative, AT&T now internally advertises job vacancies electronically. Previously, the company printed 2 million impressions a month for this purpose.

V. Constraints on Reducing Office Paper Waste by Increasing Duplexing

There are several constraints on reducing office paper waste by increasing duplexing rates. Some of these can be overcome, such as photocopiers that currently do not have duplexing capabilities, the unreliability of existing duplexing machines, and the lack of procurement policies that emphasize duplexing. Others are limitations that make it impossible ever to achieve a 100% duplexing rate, such as the inability to duplex one-page documents or all

²⁰ Before the plan was initiated, 22% of 46 million, or 10.12 million, impressions were duplexed, for a paper savings of 5.06 million sheets of paper (compared to no duplexing). At the 50% duplex rate, 23 million impressions would be duplexed, for a paper savings of 11.50 million sheets. The increase in paper savings is 6.44 million sheets per month, or 77 million per year.

pages of odd-numbered documents. And, of course, even with a theoretical 100% duplexing rate, the paper savings would be only 50%.

Machines without Duplexing Capabilities

Machine classes 1AA to 3, the personal or convenience machines, have a duplexing rate of 11% or less, as demonstrated in Table 6. This low rate is substantially, but not entirely, due to a lack of duplexing capability in many smaller machines. These classes make up 88.9% of machines and use approximately 40% of the paper. To the extent that multipage, rather than one-page, documents are copied on these machines, they present a significant obstacle to increasing duplexing rates.

Machine Malfunctions and Unreliability

A second constraint on duplexing is the unreliability of existing machines. Duplexing is inherently more complicated than single-sided copying, and duplex copiers tend to jam and break down more frequently. The director of testing at a large office machine testing company estimated that eight out of ten jams occur when machines are in the duplex mode.²¹ Jams and other breakdowns lead to increased repair time and costs, lost productivity, and employee frustration.

Use of high-quality paper is vital for avoiding much of the jamming. Xerographic images are formed first in toner dust on a photosensitive drum. This image is transferred to paper, which passes through a unit that bonds the image onto the paper, generally with heat. The image on the second side is formed on the other side of the already bonded paper.²² However, the paper with the bonded image is often curled by the heat. The curling increases the likelihood of jams with the second image. This curling does not

affect jamming with single-sided copies, as the copies are ejected from the machine immediately after fusing.

Curling is sensitive to the moisture content of the paper. For best results in duplexing, paper has to meet very tight standards for moisture content. Inexpensive or poorly stored paper often does not meet these standards. Recycled paper is more variable in performance than paper from virgin pulp because the raw material is under less control of the manufacturer. To avoid jamming and thereby minimize the amount of paper used and reduce related maintenance costs, it may be necessary to use higher quality paper.

Newer models of machines tend to jam less often in duplex mode than older machines. As competition for market share has intensified, manufacturers have worked to improve the performance of their machines. Many of the older, more jam-prone machines are, however, still in use. Machines that duplex reliably tend to cost more than those that do not, although this is difficult to quantify in the absence of good performance data. One industry source estimated duplexing adds between \$1000 and \$1500 to the cost of a machine²³

Speed is another factor in duplexing. The more complex process of duplexing takes more time than making single-sided copies on the same machine. An operator of a large copying center for a law firm in Manhattan estimated that it took about 25% longer to do two-sided copies with his high-end machines due solely to the longer cycle time.

Procurement Policies

A third constraint on duplexing is current procurement policies which rarely focus on duplexing performance. Defined procurement policies for duplexing performance could provide copier manufacturers with an incentive to improve duplexing reliability.

²¹ Terry Wirth, Buyer's Laboratory, Hackensack, NJ.

²² The Kodak Ektaprint 300 Duplicator, a class 6 machine, is the sole exception to this rule. In it, the image is put on both sides prior to fusing. This technology should thus avoid jams caused by paper curling.

²³ Terry Wirth, Buyer's Laboratory, Hackensack, NJ.

One possible way to evaluate reliability is to quantify jamming rates in duplex mode. Copier testing laboratories could provide the mean time between jams and mean time between repairs for single sided and two-sided copying for each machine tested. Companies could then determine how machine performance degrades in two-sided mode. The necessary data are already collected by testing laboratories.²⁴

Service contracts and warranties can also have an important impact on duplexing reliability. Although there are many different types of maintenance arrangements, most machines are serviced under fixed-cost contracts, where unlimited repairs and scheduled maintenance are provided for a specified period of time. If increasing the use of duplexing were to increase the amount of service required, there would be pressure on the service companies. Providing photocopier service is a very competitive business, and service companies have close ties to manufacturers. It is likely that rather than raise prices, service providers would pressure manufacturers to improve the performance of their machines, or raise service contract prices selectively on machines known to perform poorly, which would serve to discourage procurement agents from buying them.

One company that is using procurement policy to improve performance of photocopy machines is AT&T, which has set a company goal to reduce the amount of paper used internally by 15% by the end of 1994 (from a baseline of 1990). With more than 7000 photocopy machines, they are using their influence as a large-volume buyer of photocopiers to encourage copy machine manufacturers to improve duplexing performance by reducing jams and increasing speed. They are also working with copier suppliers to retrofit machines to make "default mode duplex." That is, these machines will automatically make double-sided copies unless the user instructs otherwise. Duplexing will also be a key issue in new AT&T copier contracts.

These efforts by AT&T to increase the use of machines in duplex mode and to improve the duplexing performance of machines are likely to have benefits

well beyond that specific company. Manufacturers, in order to preserve or increase market share, respond to the concerns of their customers. If buyers of large quantities of copy machines make duplexing performance a top priority, the entire copy industry is likely to respond significantly, increasing the potential for source reduction.

Finite Limitations on Paper Savings by Duplexing

The constraints on increasing duplexing rates discussed above can be overcome. But there are limitations on duplexing which make it impossible to ever reach a 100% duplexing rate.

Many documents are only one page, about half have an odd number of pages (which means that one page cannot be duplexed), and some documents are not suited for duplexing, such as those that will be faxed. Unfortunately there are no data on the length of documents that are copied, so we could only estimate the impact of these factors on duplexing potential. Table 11 showed the estimated maximum duplexing rates for each class of copiers, predicated on the use of existing machines, some of which do not have duplex capacity. These estimates produced a maximum potential for duplexing of about 60%, with paper savings of 19% compared to current practice.

Further, duplexing alone cannot reduce paper usage below a finite point. Everything else being equal, it is clearly better from a source reduction standpoint to make two-sided rather than one-sided photocopies. However, as noted earlier, there is a two for one trade-off: for every two copies made duplex, only one sheet of paper is saved. Thus, even under the scenario of maximum duplexing (Table 11), total paper usage is reduced by less than 20% compared to current practice.

VI. Paper Reduction

Given the constraints on reducing paper use by duplexing alone, it is even more important to look at

²⁴ Terry Wirth, Buyer's Laboratory. Hackensack, NJ.

ways to reduce or eliminate paper use for certain purposes. Making two copies in duplex mode saves one piece of paper, while not making those copies in the first place saves twice as much paper. As the analysis of the increased duplexing/reduced copying scenarios showed, maximum reduction of office paper use and waste is achieved by combining the two strategies.

This is intuitively true. For example, consider making 10 copies of a 10-page document. Making all 10 copies single-sided would use 100 sheets of paper. Making them all double-sided would use 50 sheets of paper, as would making only five copies single-sided. But reducing the number of copies made by half **and** duplexing the copies made would use only 25 sheets of paper, saving 75.

It is important to note that the decision to single space a document rather than double space it has the same impact on paper use as the decision to duplex rather than copy one-sided. In each case, the decision can reduce the amount of paper used by half. The cumulative effect of these strategies can be substantial. A document that is double-spaced and copied on one side uses four times as much paper as one that is single-spaced and duplexed.

Other strategies for reducing paper use include electronic communication, carefully checking documents

on the computer screen before printing, using central bulletin boards and circulating memos and documents instead of distributing multiple individual copies, avoiding fax cover sheets, and using central rather than individual filing. Besides using paper on both sides and single-spacing documents, opportunities for increasing the intensity of usage include decreasing margin widths and using smaller type faces, and formatting documents to avoid largely blank pages.

Further, the analysis of copy paper can be extrapolated to all office paper. Almost every piece of office paper can be used on both sides. Office workers can write on both sides of pads, use laser printers to print drafts of documents and interoffice memos on the back of discarded one-sided copies or computer paper, take notes on the clean side of used paper, and reverse file folders or replace old file labels with new ones.

Given the large amount of office paper now in the US waste stream (7.3 million tons), and the projected increase to 16 million tons by the year 2010, these strategies deserve a high priority. At present, using one half of all office paper on two sides would save 1.8 million tons of paper. In 2010, this could save 4 million tons of paper. The potential for combined intensity of use and reduction of use is far greater.

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