ENCODING SERIAL DATA FOR ENERGY-DELAY-PRODUCT AND ENERGY MINIMIZATION

A Thesis

by

SASIDHARAN EKAMBAVANAN

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August 2007

Major Subject: Electrical Engineering

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ABSTRACT

Encoding Serial Data for Energy-Delay-Product and Energy Minimization. (August 2007)

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Serial or parallel buses are widely used to communicate information in most electronic devices. The energy consumed by bus interconnects may comprise a significant portion of the overall energy consumption of the device. Hence, techniques to reduce the energy consumption of bus interconnects have become an important area of research. One common method adopted to reduce energy is *Bus Encoding*, where redundant bits are added to the original data stream either in time or space to reduce the energy consumption. In this thesis, a novel bus encoding technique, called the *Multiple Codebook Approach (MCA)*, is presented to reduce the Energy-Delay-Product (EDP) and Energy for data transmission over serial buses.

For any symbol that is to be transmitted on the bus, the best code is selected (from an EDP or energy minimization standpoint) from among a set of codebooks. In particular, the implementation utilizes 3 codebooks. To minimize EDP, the codeword for each symbol is selected based on the product of the number of transitions resulting from its transmission in a serial manner, and the codeword length. To minimize energy, the codeword for each symbol is selected based on the number of transitions alone.

The *MCA* is compared with other reported techniques in the literature, and the results are quite promising. The *MCA* achieves a 11% improvement in EDP and 3% improvement

in Energy over the best approach known for serial data transmission, which was reported by Macii and others.

To my parents, sister, uncle, aunt and grand-parents

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I would also like to thank my parents, sister, uncle, aunt and grand-parents who taught me the value of sincerity, hard work and discipline in life. I would also like to share my moment of happiness with them. Without their encouragement and confidence in me, I would have never been able to pursue and complete my Master's study.

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CHAPTER I

INTRODUCTION AND MOTIVATION

I-A. Introduction

Recently, energy has become a major issue in computing [1]. A major determinant of the weight and size of portable electronic devices is the size of batteries used, which is directly impacted by the energy consumed by the electronic circuit. Even in non-portable devices, the cost of delivering power along with the associated cooling cost, has resulted in a significant interest in power or energy reduction in electronic devices. Low energy solutions are desired for many applications such as multimedia devices, microprocessors, wireless communications, etc. This has led to a great deal of interest in design approaches that are energy aware.

Serial and parallel buses are widely used as a communication scheme in most electronic devices. The energy consumed by bus based interconnects makes up a significant portion of the overall energy consumption of the device. As a result, techniques to reduce the energy consumption of bus based interconnects have become an important area of research [2, 3, 4, 5, 6, 7]. The energy consumption in the transmission of a data stream is directly proportional to the number of transitions in the data stream. Hence, most of the techniques in the literature reduce energy consumption in serial and parallel buses by reducing the number of transitions in the transmitted data stream. One common method adopted to reduce the number of transitions is *bus encoding* [2, 3, 4, 5, 6, 7], where redundant bits are added to the original data stream either in time or space, in order to reduce the number of transitions. This has opened a new and active area of research, which fuses

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This thesis follows the style of the *IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems.*

coding theory and circuit design.

Coding theorists have analyzed this problem from an information theory perspective and have provided lower bounds [8, 9] on the achievable transition minimization, given a rate R of transmission and an entropy H of source symbols. Theoretical techniques [8] which achieve this lower bound asymptotically as the block length tends to infinity have also been provided. However, the implementation cost of such techniques is prohibitive, limiting their practical applicability. Note that the encoding and decoding blocks should provide a low overhead in terms of area and computational complexity, and more importantly, should consume low power in order to obtain a net power saving.

Circuit designers have tried to solve the problem from an implementation perspective, providing solutions which are easily realizable in a circuit. Bus encoding has been proposed for on/off-chip memory/processor buses to reduce power/energy consumption by minimizing switching activities [4, 10, 5, 6, 7]. Although these techniques are easily implementable, none of them achieve the lower bound on transition minimization of [8, 9].

There is a clear trade-off between the reduction in the number of transitions achieved by bus encoding and the associated implementation cost. Hence there is a need to devise techniques which obtain close to optimum energy savings, with a minimal implementation cost.

Among the various bus encoding schemes in the literature, many try to use the probability distribution of the transmitted data-stream to effectively reduce the transmission energy [3, 11, 2]. Applications which inherently have a non-uniform probability distribution of their transmitted data provide greater opportunities for energy minimization. One such application is the transmission of serial data in Liquid Crystal Displays (LCDs).

LCDs are one of the most power/energy consuming components of modern multimedia devices. Until a few years ago, the LCD panel consumed most of the power of the LCD sub-system. With technological advances, the LCD panel power consumption has been reduced considerably [3]. As a result, the power consumed by the *serial bus* connecting the LCD to the graphics controller has become a significant fraction of the total power consumption (usually more than 10-15% [2]) of the entire LCD system. This bus is usually implemented using a serial cable such as a Digital Visual Interface (DVI) cable. These cables have a mutual capacitance of the order of tens of pF/m, with cable lengths as high as few meters [2] (much higher than the lengths of on/off-chip buses). Therefore, power/energy reducing bus encoding techniques for serial buses can be effectively used for LCD buses. Also, the large capacitance of the LCD serial bus allows the designer to expend more power/energy in the encoding/decoding electronics, and still obtain a significant net power/energy reduction. Energy-Delay Product (EDP) reduction is a crucial metric in a serial data transmission setting, since we not only need to minimize energy, but also the total duration of the serial data transmission.

There exist various LCD interface standards such as DVI [12], OpenLDI (Open LVDS Digital Interface) [13], GVIF (Gigabyte Video Interface) [14], etc. Although some of these standards have been designed to reduce the number of transitions by encoding the pixels, power, energy or EDP minimization was not the driving reason behind these standards. The standards were devised mainly to avoid excessive electromagnetic interference (EMI) levels from the cable. Recently, some approaches have been proposed for power/energy efficient [3, 11, 15, 2] data transmission for some of these standards; however, none of them have explored the *Multiple Codebook Approach (MCA)* proposed in this thesis, and hence these methods are not able to achieve large energy or EDP savings.

The proposed MCA scheme uses a widely exploited property of digital images, that is, their inter-pixel correlations. Pixel *differences* are encoded rather than the pixel value itself, and large energy and EDP savings are achieved. For the DVI-compliant interface, this method is able to reduce EDP by 72% over the *Transition-Minimized Differential Signaling* (TMDS) encoding scheme [12]. The best known approach [2] achieves a 61% improvement in EDP over TMDS. Although the main goal of this thesis is to minimize EDP, results show that the *MCA* also reduces the energy consumption (by 3% for the same rate of [2]) compared to [2]. Although this thesis demonstrates the usefulness of the MCA scheme by applying it to the DVI interface, the MCA scheme can be applied to any serial data transmission protocol.

I-B. Motivation

Energy reduction is essential for any electronic system. Serial or parallel buses are an important part of any electronic system. The energy consumption of these bus interconnects plays an important role in the overall energy of the system. Hence there is a necessity to design techniques such as *bus encoding* to reduce the energy consumption. Bus encoding had been widely studied in the literature for parallel buses, whereas very little work has been done for serial buses. Since serial buses are frequently encountered in designs, energy reduction in serial links is an important problem.

LCD interfaces utilize a serial bus, and hence are a natural application for energy saving techniques used for serial links. A key property of digital images (their inter-pixel correlations) is exploited in this work. The difference between adjacent pixels in an image follows a non-uniform distribution with zero mean and a majority of the pixel difference values concentrated near zero. Hence, pixel differences close to zero can be encoded with very low transition codewords, thereby reducing energy. As a beneficial side effect, compression of the transmitted data is also achieved.

However, there is scope for *simultaneously* reducing energy and achieving compression. In this scenario, rate need not be sacrificed for reducing energy. The first major contribution of this thesis is the use of multiple codebooks to achieve compression and energy minimization (i.e. intra-vector transition minimization) at the same time.

The non-uniform distribution of input symbols (pixel differences) also results in a non-uniform distribution of leading and trailing 1's or 0's in the codewords of the encoded data stream. The second major contribution of this thesis is to use this information in assigning codewords so as to minimize the inter-vector transitions as well. The probability of leading and trailing 1's in an encoded vector are calculated in a successive manner after each symbol is assigned a codeword, and this information is used in assigning codewords to subsequent symbols.

The proposed scheme has been simulated for various benchmark images and average results have been provided.

I-C. Thesis Organization

The remainder of this thesis is organized as follows. Chapter II provides some background information required to understand the various concepts used in this thesis. Chapter II also discusses about the previous work done in the area of energy minimization for serial buses. In Chapter III, the *Multiple Codebook Approach (MCA)* is explained. Also, alternative methods studied in this thesis are also presented in this chapter. In Chapter IV, experimental results are provided, comparing the performance of MCA with that of LIWT [2]. Conclusions and future work are discussed in Chapter V.

CHAPTER II

BACKGROUND AND PREVIOUS WORK

II-A. Background

This thesis presents a bus encoding technique to minimize EDP and energy consumption during serial data transmission. Some background regarding energy, EDP and bus encoding has been provided in this chapter. Also, since the proposed scheme is applied to a serial bus in an LCD interface, a discussion on the Digital Visual Interface is presented, to help the reader understand the field where the technique is applied. Finally, the LIWT method proposed in [2] has been explained briefly, to enable the reader in understanding the comparison between the MCA and the LIWT techniques.

II-A.1. Energy Consumption in Serial Data Link

II-A.1.a. Energy

The dynamic energy consumption in a serial data link is given by

$$E = \frac{1}{2}TCV^2 \tag{2.1}$$

where T is the total number of transitions in the serial data stream, C is the wire capacitance and V is the supply voltage. From Equation 2.1 it is clear that the total energy consumption is directly proportional to the number of transitions in the transmitted data stream. Hence minimizing the number of transitions minimizes the overall energy consumption.

II-A.1.b. Energy-Delay-Product (EDP)

Energy is not the only metric of concern in serial data transmission. Energy can be minimized by sending a long codeword with few transitions. However, this would decrease the rate of transmission, increasing the total time for the serial data transmission. Hence we also need to take care that the length of the transmitted (encoded) sequence is as short as possible. This is taken care by the metric called the Energy-Delay-Product (EDP) which is given by

$$EDP = EL \tag{2.2}$$

where E is the total (dynamic) energy consumption of the serial data transmission, and L is the length of the transmitted sequence. Since E is directly proportional to T, we can consider the product TL as a measure of the EDP.

II-A.2. Bus Encoding

In a serial data transmission context, bus encoding is the process of encoding the input serial data stream into another bit stream which has fewer transitions. In order to reduce the number of transitions, the encoded sequence contains redundant bits either in time or space. In a parallel bus, redundant bits can be added both in time and in space (by adding extra bus lines). On the other hand, in a serial bus, redundancy can be added only in time, since time is the only degree of freedom we have if the data transmission is constrained to be serial.

We consider the serial input data stream to be made up of a sequence of contiguous *input data vectors* of length m bits. Each such vector is encoded into a *output data vector* in a manner that minimizes EDP or energy. The resulting output data vectors are then serially transmitted. The input data vector to be encoded is called a *Symbol*, whereas the encoded output vector is called a *Codeword*. The set of all possible codewords used for the encoding is called a *Code*. In any bus encoding scenario, the *Code* used is usually non-linear (i.e. the sum of two codewords need not necessarily give another codeword in the same code). Also the *Encoder* used to map the input symbols to the codewords is non-linear as well.

II-A.3. Entropy Rate

To understand the *entropy rate* of a source, we need to know the definition of *entropy* and *joint entropy*.

The *entropy* of a discrete random variable X with probabilities p_i is defined as

$$H(X) = -\sum_i \left(p_i \log_2 p_i\right) \tag{2.3}$$

The *joint entropy* of discrete random variables X_1, X_2,...,X_N is given by

$$H(X_1, X_2, ..., X_N) = -\sum_{x_1, x_2, ..., x_N} \left(p(x_1, x_2, ..., x_N) \log_2 p(x_1, x_2, ..., x_N)\right) \tag{2.4}$$

where $p(x_1, x_2, ..., x_N)$ is the joint probability distribution of random variables X_1, X_2,...,X_N.

Now, the *entropy rate* of a stochastic process $\{X_i\}$ is defined by

$$\mathcal{H}(\mathcal{X}) = \lim_{N \to \infty} \frac{1}{N} H(X_1, X_2, ..., X_N) \tag{2.5}$$

The joint entropy $H(X_1, X_2, ..., X_N)$ can be upper-bounded by the entropy of each random variable X_1, X_2,...,X_N as

$$H(X_1, X_2, ..., X_N) \leq \sum_{i=1}^{N} H(X_i) \tag{2.6}$$

with equality if and only if the random variables X_1, X_2,...,X_N are independent. If the random variables X_i are identically distributed, then they all have the same entropy $H(X_i) = H(X)$. Then Equation 2.6 becomes

$$H(X_1, X_2, ..., X_N) \leq N H(X) \tag{2.7}$$

Hence, if a stochastic process $\{X_i\}$ is identically distributed at each time instant i, then its entropy rate $\mathcal{H}(\mathcal{X})$ can be upper-bounded as

$$\mathcal{H}(\mathcal{X}) \leq H(X) \tag{2.8}$$

where $H(X)$ is the entropy of the outcome of the source at each time instant.

II-A.4. Information Theoretic Lower Bound on Energy and EDP

In [8], information theoretic bounds on the average signal transition activity in a bus, given a source entropy rate H and an average rate R (bits per symbol) of transmission, have been provided. A lower bound on the *Energy-Delay-Product (EDP)*[1], given H and R, has also been provided. These bounds have been used in this thesis to measure the proximity of the proposed scheme to the theoretical lower bound.

II-A.4.a. Lower Bound on Energy

The lower bound on the average number of transitions (which is proportional to the energy consumed) per symbol is given by [8]

$$T \geq H^{-1}\left(\frac{\mathcal{H}}{R}\right) \tag{2.9}$$

where $\mathcal{H}$ is the entropy rate of the source in bits/symbol, R is the rate of transmission in bits/symbol and H^{-1} is the inverse of the binary entropy function $H(\,)$ defined as follows :

$$H^{-1}(y) = x, \text{ if } y = H(x) \text{ and } x \in \left[0, \frac{1}{2}\right] \tag{2.10}$$

A plot of the binary entropy function is shown in Figure II.1. The function $H^{-1}(\,)$ maps the entropy of a binary-valued discrete random variable to a probability value that lies between 0 and 1/2.

[1]Note that [8] assumes that frequency is constant, and hence energy is proportional to power. Therefore the Power-Delay Product reported in [8] is directly proportional to the EDP metric used in this thesis

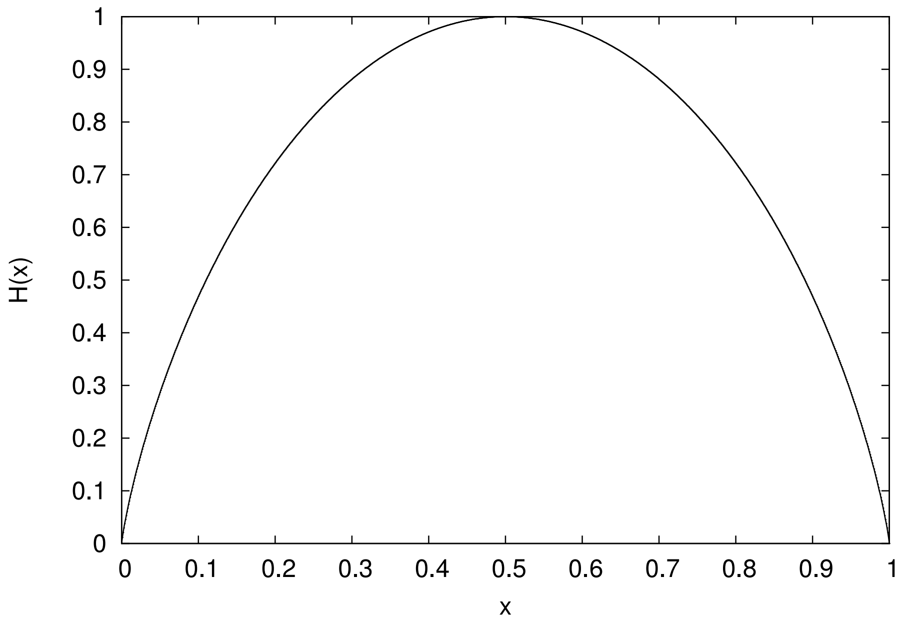

Fig. II.1. Binary entropy function

II-A.4.b. Lower Bound on EDP

The lower bound on EDP is given by [8]

$$EDP_{min} = KH^{-1}\left(\frac{\mathcal{H}}{R}\right)R^2 \tag{2.11}$$

where K is a constant of proportionality. A plot of EDP_{min} versus R is shown in Figure II.2. In Figure II.2, EDP_{min} is represented as a fraction of $K\mathcal{H}^2$ and R is represented in multiples of $\mathcal{H}$. From Figure II.2, the value of R that minimizes EDP is found to be [8],

$$R_{min,EDP} = 1.25392\mathcal{H} \tag{2.12}$$

Hence Equation 2.12 indicates that a source with entropy rate $\mathcal{H}$ requires approximately an average of $1.25\mathcal{H}$ bits per symbol to encode for minimum EDP. If $R > 1.25\mathcal{H}$, the delay component will increase, reducing the overall rate of transmission. On the other hand, if $R < 1.25\mathcal{H}$, the energy component will increase, since less redundancy is being used.

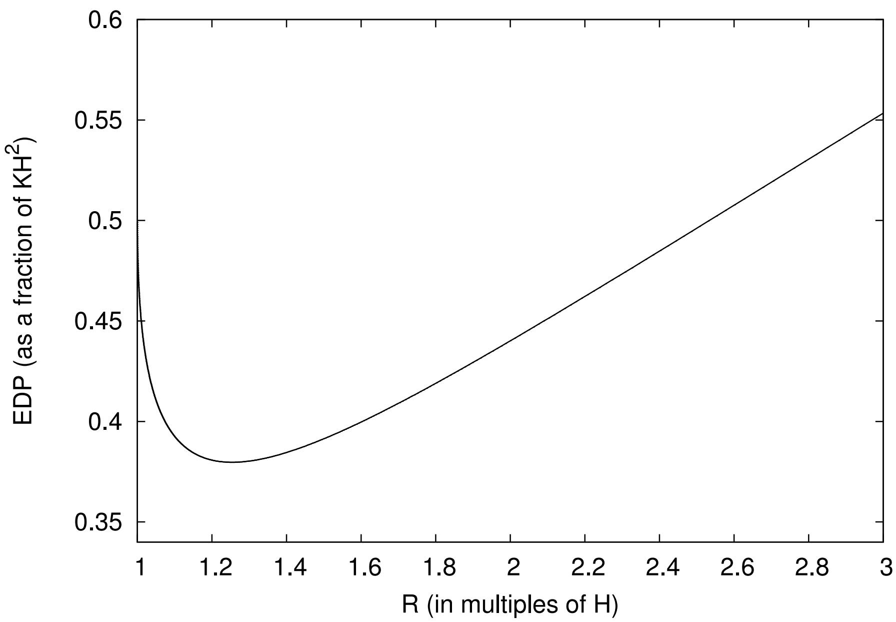

Fig. II.2. Lower bound on EDP versus R for a given $\mathcal{H}$

II-A.5. Digital Visual Interface

There exist various LCD interface standards such as DVI (Digital Visual Interface) [12], OpenLDI (Open LVDS Digital Interface) [13], GVIF (Gigabyte Video Interface) [14], etc. The DVI standard, proposed by DDWG (Digital Display Working Group), a working group driven by Intel, has generated a significant industry interest. Approximately 100 companies have submitted participation agreements to the DDWG [2].

Figure II.3 shows a typical LCD system with a DVI connection. The system consists of a graphics controller, an LCD display and a DVI connection between them. The pixel data to be transmitted is stored in the frame-buffer. The graphics controller fetches the data from the frame-buffer and transmits it through the DVI cable to the LCD. The scanning of the pixels on the display happens in a left-to-right and top-down order. Hence the data of two adjacent pixels on the same row of the image is transmitted through the channel consecutively.

The DVI scheme uses a serial data-link protocol standard called Transition-Minimized Differential Signaling (TMDS). In [2], the percentage transition savings of the LIWT scheme have been presented with respect to that of the TMDS. Hence in order to compare the results of the MCA scheme proposed in this thesis with that of the LIWT[2] scheme, the percentage energy and EDP savings of the MCA scheme are also presented with respect to that of the TMDS scheme.

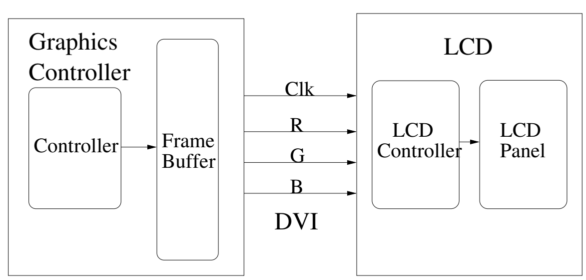

Fig. II.3. LCD System with DVI

II-A.6. TMDS

The DVI standard is based on TMDS [12]. This interface encodes and serializes the digital RGB data and then serially transmits the data on three twisted-pair cables, one each for the

R, G and B colors. An additional twisted pair is used for the clock signal. Each pixel data, which is 8 bits long, is encoded and serialized into 10 bits. TMDS uses transition coding, where *transitions* are encoded instead of actual values, to obtain lowered transition counts. Of the 2 additional bits, the first additional bit determines the type of encoding. When the first additional bit is 1 (0), transitions are encoded by a Boolean XOR (XNOR) operation. The second additional bit determines whether the transmitted word is complemented or not. This is done for DC balancing, i.e., to balance the number of 0's and 1's sent on the bus.

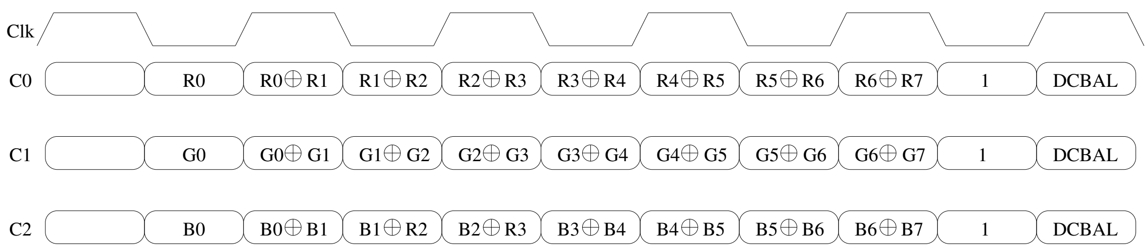

Fig. II.4. 24-bit, XOR-based, Single-Link TMDS

Figure II.4 describes the timing diagram of a 24-bit, XOR-based, Single-Link TMDS scheme. R_i, G_i and B_i denote the i-th bit of R, G, and B channel. In this figure, $C0$, $C1$ and $C2$ are the sequence of codewords transmitted on the R, G and B color channels respectively.

II-A.7. LIWT Encoding

The LIWT encoding approach exploits the spatial correlation of digital images. For a set of benchmark images, the distribution of the difference between adjacent pixel values is given in [2]. This distribution turns out to be non-uniform with zero mean and a majority of the pixel difference values concentrated near zero.

The LIWT approach encodes inter-pixel difference values which are within a range *R*, into a 9-bit word with fewer transitions. The other pixel values are transmitted in an uncoded manner (8 bits long). Whether the transmitted data is encoded or not is indicated by a *conditional* bit. Hence the serially transmitted data is either 10 bits long (when encoded) or 9 bits long (when not encoded), for an 8 bit pixel value.

Algorithm 1 LIWT Algorithm

$Encode(w_t, w_{t-1})\{$

$Diff = w_t - w_{t-1}$

if $abs(Diff) \leq R$ **then**

  $Code_t = map(Diff)$

else

  $Code_t = w_t$

end if

return $Code_t$

$\}$

Algorithm 1 describes the LIWT algorithm. The two consecutive pixel values are denoted as w_t and w_{t-1}. The pixel-differences (called symbols) within the range *R* are mapped in decreasing order of occurrence probability, to codewords sorted in increasing order of their number of intra-word transitions. If the absolute value of the pixel-difference is greater than *R*, then w_t is transmitted without encoding. The value of *R* depends on the number of bits per pixel. The codewords are chosen such that for a *k*-LIWT approach, the intra-word transitions of the codeword (including the conditional bit) is less than or equal to *k*.

II-B. Previous Work

A significant amount of work has been done for reducing power/energy consumption on on/off-chip memory/processor (parallel) buses by bus encoding [4, 10, 5, 6, 7], but there has not been much attention devoted to (serial) LCD buses until a few years ago. As mentioned in the last section, bus encoding is crucial for the serial data link of the LCD because of the large capacitance of these links compared to the relatively short memory/processor buses. The LCD data link is serial in nature and hence, only serial bus encoding techniques are useful in this context.

As mentioned in Section II-A.4, information theoretic bounds on the average signal transition activity in a bus, given a source entropy rate H and an average rate R (bits per symbol) of transmission, have been provided in [8]. A lower bound on the *Energy-Delay-Product (EDP)*[2], given H and R, has also been provided. These bounds are used to determine the activity-reducing efficiency of various algorithms like entropy coding, transition signaling and bus-invert coding. The authors of [8] also present an approach called the Modified Lempel-Ziv encoding algorithm, which asymptotically achieves the lower bound on the transition activity as the encoding block length n tends to infinity. Although [8] provides a strong theoretical analysis of the bus transition activity, practical schemes which achieve this lower bound were not presented.

In [16], an XOR-based encoding scheme was presented for serial communication. Here, each bit in a data word is XOR-ed (or *differentially encoded*) with the previous bit in the same data word. After this differential encoding, the bits are serialized and transmitted. The idea behind [16] is that adjacent bits in a data word will be identical with high probability, hence several transmitted bits will be zero during transmission. After serialization,

[2]Note that [8] assumes that frequency is constant, and hence energy is proportional to power. Therefore the Power-Delay Product reported in [8] is directly proportional to the EDP metric used in this thesis

the data stream will likely contain many 0's and few 1's. Since the number of 1's is very low, and transitions only occur at the interface of a 0 and 1, the number of transitions (or energy) is reduced. This method has been applied for 3D graphics applications, instruction memory access and data memory access, and the percentage energy savings have been reported. The method in [16] can work only in a setting were the adjacent bits in a data-word are identical with a high probability. Also, the method aims only to reduce the number of 1's and does not attempt to directly reduce the number of *transitions*. Reducing the number of 1's does not always reduce the number of transitions.

In the literature, methods for energy-efficient LCD sub-systems have been mostly restricted to specific control circuits inside the LCD controller [17] [18], or to the design of individual components of the display systems [19] [20]. The first low power encoding technique for data transmission on the digital LCD interface was proposed in [3], for the DVI standard. This technique is called *Chromatic Encoding*. One of the observations made in [3] is that the difference between adjacent pixel-values in images follows a non-uniform distribution with zero mean and a majority of the pixel difference values concentrated near zero. A plot of this distribution for some images in SIPI database [21] is also shown in [3]. Based on this distribution, an optimal code assignment is performed to minimize the transition counts, using a *single codebook*. Also the three color channels of the DVI interface are reciprocally encoded (i.e. the difference between the R, G and B color symbol values are encoded) to obtain further power savings. Although significant savings have been reported, there are has several cases in which pixels cannot be encoded (such as overflow or underflow conditions, or situations in which the encoding must switch to plain TMDS).

Another low power encoding technique, called *Differential Bar-Encoding* was proposed in [11], also for the DVI standard. In this method, pixel difference values within a range *R* (which is chosen so as to cover the majority of the distribution of difference values) are encoded using a *single codebook*, and "plain" pixel values are transmitted for the other cases. The codewords are chosen such that all 1's are packed towards the beginning or the end of the codeword. This guarantees that the serial transmission is performed with exactly zero or one transitions within the codeword. Since only zero or one transitions are allowed within a codeword, long codewords need to be chosen in order to encode all the input symbols. This would increase the overall EDP, decreasing the rate of transmission.

The approach of [11] was improved upon in [15] and [2], using a technique called Limited Intra-Word Transition (LIWT) Codes. Details of the LIWT approach were presented in Section II-A.7. In [15], the technique was applied for DVI and OpenLDI, whereas in [2] it was applied for the DVI, OpenLDI and GVIF interface standards. These approaches improve the power/energy consumption compared to the work done in [3]. In [15] and [2], the single or no transition restriction in a codeword [11] was generalized to $\leq k$, transitions and hence the approach was called *k-LIWT*. Apart from reducing the number of transitions, a technique to perform DC balancing (ensuring an equal number of 0's and 1's in the transmitted stream) has also been provided. Results were provided for 10 images in the SIPI database [21], by applying the technique to TMDS, LVDS and GVIF. Again, the approaches of [15] and [2] utilize a *single codebook*, with all codewords of the same length. The scheme does not directly attempt to minimize EDP. It tries to minimize energy without considering the rate of transmission. Results do not report the EDP of the resulting encoded data.

All the above mentioned methods deal with the problem of power/energy savings, but do not directly consider the problem of minimizing the energy-delay product (EDP). Energy can be minimized by sending a long codeword with fewer transitions. However, this would reduce the rate of transmission, increasing the total time for serial data transmission. Hence there is a direct trade-off between the transmission rate and energy. In order to take into account both these factors *simultaneously*, the *MCA* scheme proposed in this thesis minimizes the *product* of the number of transitions and the length of the final encoded data. This product is called the Energy-Delay Product (EDP) for serial data transmission. Another significant contribution of this work is the use of multiple codebooks (of varying lengths) to minimize the EDP. In particular, the experiments in this thesis were performed with 3 codebooks.

II-C. Conclusion

This chapter briefly discussed the background information required to understand the rest of this thesis. Also the previous work done in the area of energy minimization for serial buses have been discussed. The next chapter will describe the *Multiple Codebook Approach (MCA)*, proposed in this thesis, for minimizing EDP and energy in a serial data transmission.

CHAPTER III

MULTIPLE CODEBOOK APPROACH

III-A. Introduction

The major thrust of the *Multiple Codebook Approach (MCA)* is EDP minimization, as opposed to power/energy minimization as in [3, 11, 15, 2]. However, the MCA *also* achieves better energy savings compared to the best known approach [2] in the literature.

The MCA exploits the inter-pixel correlation of digital images. The difference between adjacent pixels in a digital image was found to follow a non-uniform distribution with zero mean and a majority of the pixel difference values concentrated near zero. This distribution, for the blue, green and red components of 10 images in the SIPI database [21] are shown in Figures III.1, III.2 and III.3 respectively. Although the variance of the probability distribution for each of the 10 images is different, the shape of the probability distribution remains almost the same for all the images. This property is essential for the working of the MCA.

The MCA scheme encodes pixel differences which are within a range R, and transmits the remaining pixel data values as such (uncoded). The key difference between the MCA and the previous techniques [3, 11, 15, 2] is that the MCA employs a *variable length encoding* using N codebooks, each of different length. Also, while assigning symbols to codewords, the MCA scheme directly tries to minimize either EDP or energy (rather than power/energy as in the previous techniques [3, 11, 15, 2]). As we have seen in Section II-A.1.b, EDP is a more relevant metric for the serial data transmission.

The MCA method consists of several steps, which are briefly outlined below.

- First the MCA considers the serial data stream to be transmitted, and splits it up into contiguous segments of size m bits (for serial LCD data transmission, m is 8, the

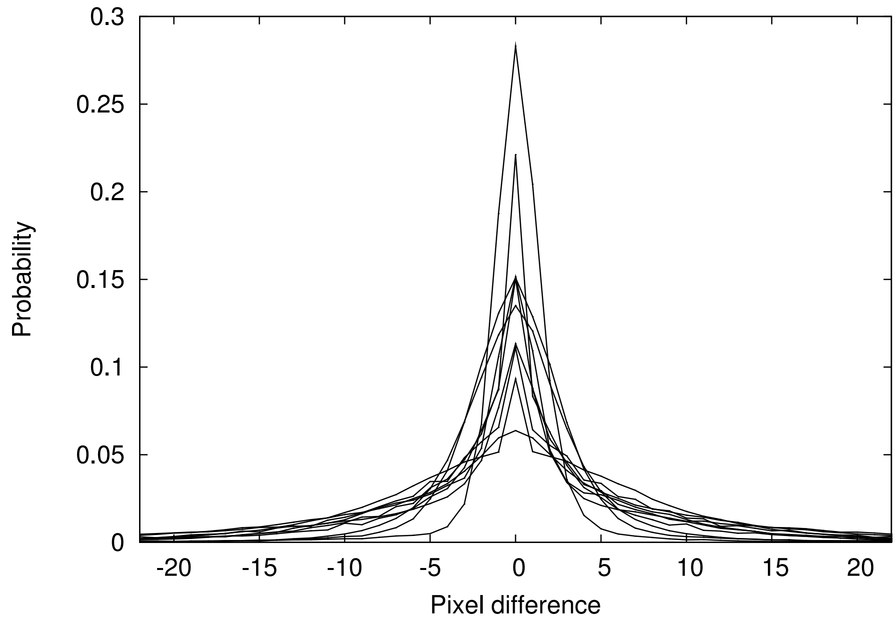

Fig. III.1. Distribution of pixel difference for Blue component of 10 images

number of bits used to represent a pixel value). The difference between adjacent pixels can be represented using $m+1$ bits and hence there are $2^{m+1}-1$ difference values. Each of these $2^{m+1}-1$ difference value is henceforth referred to as a *symbol*.

- The $2^{m+1}-1$ symbols are arranged in decreasing order of probability, and only those difference values which fall within a range R are encoded. The remaining pixel values are transmitted without encoding. R is chosen such that difference values whose magnitude is $\leq R$ cover a majority of the pixel-difference distribution. The difference values whose magnitude is $> R$ would have a cumulative probability less than the difference values whose magnitude is $\leq R$.

- The symbols to be encoded are assigned to codewords, in a manner that minimizes

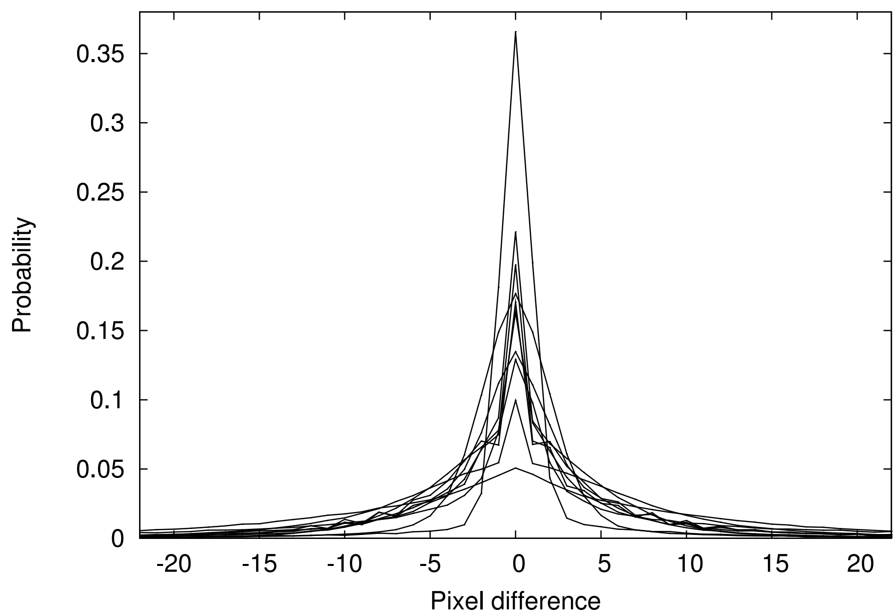

Fig. III.2. Distribution of pixel difference for Green component of 10 images

EDP or energy. The algorithm selects a codeword for each symbol from *one of N codebooks*. In this work $N = 3$ was chosen to demonstrate the results.

Since the MCA scheme uses $N = 3$ codebooks, and also does not perform encoding when the difference values fall outside the range R, 2 bits are required for the preamble of the codeword. These two bits indicate which of the $N = 3$ codebooks are utilized, in case encoding is performed. They also indicate if no encoding is performed. The lengths of the 3 codebooks are denoted as k, n and p with $k \leq n \leq p$. Table III.1 indicates the meaning of each combination of preamble values. The two preamble bits are referred to as $pre1$ and $pre2$ in Figure III.4. Note that the preamble bits for smaller codewords (length k and n) are assigned such that there are no transitions between $pre1$ and $pre2$, thereby minimizing EDP or energy for the symbols that occur most frequently.

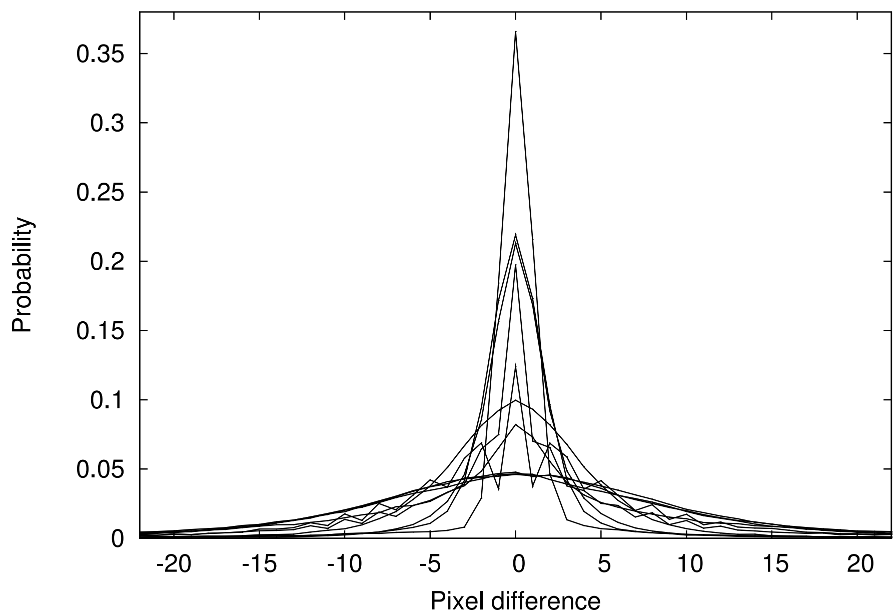

Fig. III.3. Distribution of pixel difference for Red component of 10 images

The application of the serial EDP reducing code is primarily targeted to the serial transmission of pixel color information for LCD displays. Therefore, the probability p_i of each symbol (i.e. adjacent pixel-difference) s_i among the $2^{m+1}-1$ alternatives, is computed first. These probabilities were computed for 10 different images in the SIPI database [21]. Since each pixel value was represented using 8 bits for these images, $m = 8$ was chosen. The pixel-differences were observed to follow the non-uniform distribution as claimed in [3] and [2], and are shown in Figures III.1, III.2 and III.3.

Next all the symbols s_i are sorted in decreasing order of their probability of occurrence p_i. After this, symbols are assigned to codewords, starting with the symbol with the highest probability. For each symbol, a codeword is assigned from one of N codebooks. The codeword is prefixed by the appropriate preamble bits and transmitted through the serial

pre1	pre2	codeword

Fig. III.4. Codeword with preamble bits

Table III.1. Preamble bits description

*pre*1	*pre*2	*Description*
0	0	*k* bit codeword
0	1	not encoded
1	0	*p* bit codeword
1	1	*n* bit codeword

channel. The codeword prefixed by the preamble bits is hereafter referred to as a *vector*. The MCA scheme has two variants, namely the Intra-Vector Transition Minimization (IVTM) approach and the Inter-Vector Probability Aware (IVPA) approach.

In the remainder of this chapter, the different aspects of the two MCA variants are described in detail.

III-B. Intra-Vector Transition Minimization (IVTM) Approach

The IVTM scheme tries to minimize the intra-vector transitions, without accounting for the inter-vector transitions.

III-B.1. EDP Minimization

In order to minimize the EDP, codewords are sorted in increasing order of EDP (the EDP of a codeword c_i is defined as $l_i \cdot t_i$, where t_i is the number of transitions in c_i, and l_i is its length). Note that the EDP metric includes the transitions due to the preamble bits (which are used to indicate the codebook from which any codeword is taken) as well. The next highest probability symbol is assigned to a free codeword c_i with the lowest EDP. This codeword is now removed from consideration. In case of a tie in the EDP value of two codewords, the codeword of smaller length is selected.

III-B.2. Energy Minimization

If energy minimization is the main goal, then the codewords are sorted in increasing order of the number of transitions t_i (including the transitions due to the preamble bis). The next highest probability symbol is assigned to a free codeword c_i with the lowest energy (or number of transitions). This codeword is now removed from consideration. In case of a tie in the energy value of two codewords, the codeword of smaller length is selected.

This process is performed for each symbol, in decreasing order of probability, until all the symbols within a range R are covered.

III-C. Inter-Vector Probability Aware (IVPA) Approach

The IVTM mainly focuses on reducing the intra-vector transitions and does not directly attempt to reduce the inter-vector transitions in the transmitted serial data stream. Once we have assigned codewords to minimize the intra-vector transitions, the inter-vector transitions become a significant portion of the total number of transitions. Hence, reducing the inter-vector transitions *along with* the intra-vector transitions is the next goal of this thesis. This is achieved by a scheme called the Inter-Vector Probability Aware (IVPA) Approach, which is explained below.

In order to reduce the inter-vector transitions, the probability of transitions occurring at the interface of two consecutive vectors should be known at the time of mapping the symbols to the codewords. In other words, the probability of the occurrence of a "1" value at the front (P_f) and at the back (P_b) of a vector should be known apriori. However, without mapping the symbols to the codewords, these two probabilities cannot be found. Hence, this is a chicken and egg problem. To solve this problem, the probabilities P_f and P_b are calculated in a successive manner as explained below.

After each symbol is assigned a codeword, the probabilities P_f and P_b are updated. These probabilities are used as an *apriori information* in assigning a codeword to the next symbol so as to avoid the inter-vector transitions as much as possible. In this manner, the codebook generator, after each assignment, *successively* gets a better *estimate* of P_f and P_b, and thereby reduces the inter-vector transitions.

III-C.1. Successive Probability Calculation

Assume that we have assigned a codeword to the $(q-1)^{th}$ symbol, and now we are assigning the codeword to the q^{th} symbol. Let p_q denote the probability of the q^{th} symbol sorted in descending order of probability. Let P_f^o denote the old probability P_f (i.e. it is the value of P_f after assigning a codeword to the $(q-2)^{th}$ symbol) and P_f^n denote the new probability P_f (i.e. it is the value of P_f after assigning a codeword to the $(q-1)^{th}$ symbol). Similarly P_b^o and P_b^n are defined accordingly for the back bit of a vector. We now discuss how the P_f^n and P_b^n are computed after assigning codeword to the $(q-1)^{th}$ symbol, and used in assigning the codeword for the q^{th} symbol.

- The first highest probable symbol is always assigned the all-zero codeword from the shortest codebook (i.e. the k codebook with preamble "00"), since this codeword has the least EDP or energy. Hence, initially $P_f = 0$ and $P_b = 0$. The second highest probable symbol is assigned a codeword based on these values of P_f and P_b in a manner that minimizes the inter-vector transitions along with the intra-vector transitions.

- Once the $(q-1)^{th}$ codeword has been assigned, the value of P_f and P_b need to be updated. Hence, the new value of P_f and P_b are calculated by the following two equations.

$$P_f^n = \frac{P_f^o\left(\sum_{i=1}^{q-2} p_i\right) + p_{q-1}F}{\sum_{i=1}^{q-1} p_i} \tag{3.1}$$

$$P_b^n = \frac{P_b^o\left(\sum_{i=1}^{q-2} p_i\right) + p_{q-1}B}{\sum_{i=1}^{q-1} p_i} \tag{3.2}$$

  where F and B are the value of bits at the front and back of the $(q-1)^{th}$ vector (codeword prefixed by preamble) assigned to the current (i.e. $(q-1)^{th}$) symbol respectively.

- Now based on these two new probabilities, the next highest probable symbol (i.e. the q^{th}) is assigned a codeword.

- The probabilities P_f and P_b are updated in a successive manner after each symbol is assigned a codeword.

From Equations 3.1 and 3.2, it is clear that the current value of P_f and P_b (i.e. after the codeword assignment of the $(q-1)^{th}$ symbol) depends on the codeword assignments made to all $q-2$ previous symbols. Hence, as the mapping of the symbols to codewords proceeds, the probabilities P_f and P_b are expected to approach the true probabilities of a bit being "1" at the front and back of a vector in an encoded data stream.

III-C.2. Codebook Generation

As in the IVTM approach, the symbols are sorted in decreasing order of probability and the codewords from the 3 codebooks are arranged in increasing order of EDP or energy (depending on whether EDP or energy is minimized respectively). In the sorted list of codewords, we may find groups of codewords with the same EDP or energy. Let us denote each of these groups as g_i.

During the codeword assignment of the q^{th} symbol, the probabilities P_f and P_b available at that time are used to sort the codewords within each of the groups g_i, based on the following rules.

- If $P_f > 0.5$, then the probability of bit "1" occurring at the front of a vector is higher. Hence, in order to decrease the probability of inter-vector transitions, codewords which end with a bit "1" must be given more preference. On the other hand, if $P_f \leq 0.5$, then codewords which end with a bit "0" must be given more preference.

- If $P_b > 0.5$, then the probability of bit "1" occurring at the back of a vector is more. Hence, in order to decrease the probability of inter-vector transitions, codewords which begin with a bit "1" must be given more preference. On the other hand, if $P_b \leq 0.5$, then codewords which begin with a bit "0" must be given more preference.

Combining the above rules, the algorithm for assigning codewords within each group g_i is as follows.

- Based on the above rules, let F_b and B_b denote front and back bits which would be preferred in the selected codeword vector (codeword prefixed by the preamble). A codeword starting with F_b and ending in B_b would minimize inter-vector transitions. Let F and B denote the front and back bit of any codeword vector in the group g_i.

- To each codeword within a group g_i, assign a *weight* W as follows.

  - $W = 0$, if $F = F_b$ and $B = B_b$
  - $W = 1$, if ($F \neq F_b$ and $B = B_b$) or ($F = F_b$ and $B \neq B_b$)
  - $W = 2$, if $F \neq F_b$ and $B \neq B_b$

- Now the codewords within each group g_i are sorted in ascending order of W.

After the above sorting, the next highest probable (q^{th}) symbol is assigned the first codeword in the sorted list. Then this codeword is removed from consideration. Now the probabilities P_f and P_b are updated based on Equations 3.1 and 3.2. The updated probabilities are then used to assign a codeword to the next symbol. This process continues until all symbols (pixel-differences) within a range R are assigned a codeword.

Note that the codeword vectors of the same codebook (with lengths k, n or p) have the same preamble and hence have the same front bit. Since codeword vectors (in the group g_i) belonging to the same codebook have identical preambles, they have the same number of transitions, and hence end up having the same back bit as well. Hence they do not compete with each other for reducing inter-vector transitions. This is true regardless of whether EDP or energy is being minimized.

The IVPA helps in reducing the inter-vector transitions in addition to reducing the intra-vector transitions. Results show that the IVPA yields an improvement of 0.5-0.9% over IVTM in EDP and energy savings. The IVTM results in an improvement of 11% over the best known approach [2] to date.

Finally, the excellent performance of both variants of the MCA is due to the fact that the symbols are non-uniformly distributed, which suggests that the data can be compressed before transmission. The use of N codebooks, each of different length, allows us to have codeword lengths which are less than m. This inherently means that we are compressing the data (thereby minimizing delay) to be transmitted, while simultaneously minimizing the energy by selecting minimum transition codewords. Also the IVPA, a variant of the

MCA, uses a novel *successive probability* based approach to minimize the inter-vector transitions along with the intra-vector transitions. Hence the MCA is able to obtain a better EDP reduction compared to the previously proposed methods. The MCA also provides improvement in energy over the previously proposed methods.

III-D. Alternative Approaches Studied

During the course of this thesis work, many alternative methods were studied. Some of them are discussed below.

III-D.1. Constrained Encoding

The problem of reducing the number of transitions can be turned into a problem of reducing the number of 1's by applying transition signaling to the input data stream. Transition signaling gives an output of "1" if a transition occurs and an output of "0" if no transition occurs in the input data stream. The problem of reducing the number of 1's is solved by using a class of codes called *constrained codes*. Constrained codes are non-linear codes. A non-linear encoder is also essential for this problem, because we need unequal probability of 1's and 0's at the output of the encoder, i.e. in the transition domain, the number of 1's should be much less than the number of 0's. A linear encoder on the other hand, would maintain the same probability of 1's and 0's at the output of the encoder as at the input of the encoder. Hence, if uniformly distributed data is input to a linear encoder, there is no way that we can reduce the expected number of 1's at the output of the encoder. Hence we only consider non-linear encoders. Some of the constrained codes (all operating in the transition domain) studied during this thesis work are explained below.

III-D.1.a. Modified Run-Length Encoding

Run-length encoding is a data compression scheme where long lengths of contiguous 1's and 0's are encoded with the bit "1" or "0", followed by a vector of bits indicating the length of the run of the bit. This method can be slightly modified to reduce the number of 1's by applying run-length encoding only to 1's and leaving 0's uncoded. Though this may reduce energy, the rate of transmission will be low, since 0's are not encoded, and hence very little EDP savings can be achieved. It should be noted that in the transition domain, 1's correspond to a transition, and 0's correspond to no transition. Also, the encoded run-lengths would induce additional transitions, resulting in low EDP or energy savings.

III-D.1.b. Hamming Code

The Hamming code is a single-error correcting linear block code used as a channel code. It can be turned into a constrained code by viewing it from a different perspective. Consider the mapping between the syndromes and the single-error patterns of a Hamming code. The syndromes can be considered as input symbols and the one error patterns can be considered as codewords. The mapping between them forms a constrained encoding, where the code-word has a single 1. In the actual transmitted data stream, this implies a single transition in each codeword. This has identical performance as any single transition code, such as the Differential Bar-Encoding proposed in [11] or the 1-LIWT proposed in [2]. Since only single transitions are allowed, the rate of the encoded output is very low.

III-D.1.c. Convolutional Code

The Convolutional code is also a linear code used for correcting channel errors. Viterbi decoding is a popular algorithm for decoding the convolutional codes at the receiver. By appropriately adding "errors" (in the place of 1's) to the output of the convolutional encoder, we can reduce the number of 1's, thereby reducing energy. These errors can be corrected at the decoder. Also the energy consumed by the Viterbi decoder may be more than the energy saved due to this method, and it is well known that the energy of the Viterbi decoder is higher than the energy of a table-lookup based decoder (such as is used in the MCA scheme).

III-D.1.d. Huffman Code

The Huffman code is an optimal source code used for data compression. It can be first used to compress any non-uniformly distributed data. Then any technique to reduce the number of transitions, (such as the MCA technique proposed in this thesis) can be used to minimize energy. However, the more interesting problem would be to turn the Huffman encoding into a constrained encoding by inserting EDP or energy constraints into the tree structure of the Huffman code. To the extent studied in this thesis, this technique did not yield any fruitful result.

III-D.2. Iterative Inter-Vector Transition Probability Calculation Approach

In order to reduce the inter-vector transitions, a technique similar to the IVPA scheme was used. In this technique, for calculating the probability of front and back bits of a vector being "1", the codebook (i.e. mapping between symbols and codewords) was first created, and then the probabilities were calculated. These probabilities were used to re-create the codebook again in an iterative manner. This was done for a few iterations with an expectation that the probabilities would converge to their true values (i.e. their values obtained during actual data transmission). However, this technique did not work even after many iterations, because probabilities were not the same as they were in the previous iteration. In other words, the values of the probabilities were not converging. In fact, this observation helped in the formulation of the IVPA approach, where the probabilities are calculated successively as the codebook was constructed. Hence, in IVPA the calculated probabilities closely followed the true probabilities, which enabled the technique to yield good savings in terms of EDP and energy.

III-D.3. Re-Encoding

Another technique tried, was to re-encode the output of the MCA scheme by using another MCA, with various values of m, k, n and p. The motivation for this came from the fact that the difference values of consecutive codeword vectors at the output of the MCA followed a non-uniform distribution as shown in Figures III.5, III.6 and III.7. The plots are shown for $m = 8$, $k = 4$, $n = 4$, $p = 10$ and $R = 255$ after the first level of encoding. From the figures, it is clear that all the 10 images follow almost the same distribution at the output of the first level of encoding using the MCA. The output of the first level of MCA encoding was again encoded using the MCA with $m = 6$ (since smallest codeword vector has 4 bits + 2 preamble bits = 6 total bits) and for various values of k, n and p. Results show that this method decreased the savings obtained by just one level of MCA. This might be due to the fact that in the 2nd level of encoding, the whole range of values ($2 * 2^6 = 128$ values) were encoded. Hence, all values (including the very low probability difference values) might be getting an almost equal opportunity of being encoded, which decreases the EDP. The results could have been better if the symbols corresponding to the peaks (as seen in Figures III.5, III.6 and III.7) were picked and encoded with good codewords and other symbols sent as such.

III-E. Conclusion

This chapter described the MCA scheme along with two of its variants. Also some alternative techniques studied during this thesis work were discussed in this chapter. The MCA

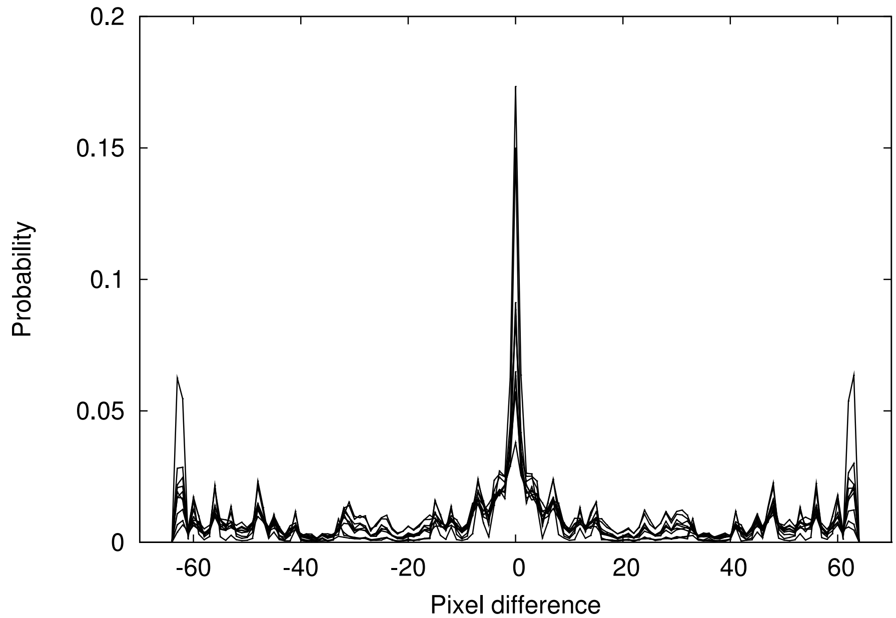

Fig. III.5. Distribution of difference values for Blue component of 10 images for 1st level of encoding using MCA (IVTM)

scheme was simulated for various values of k, n, p and R and the experimental results are shown in the next chapter.

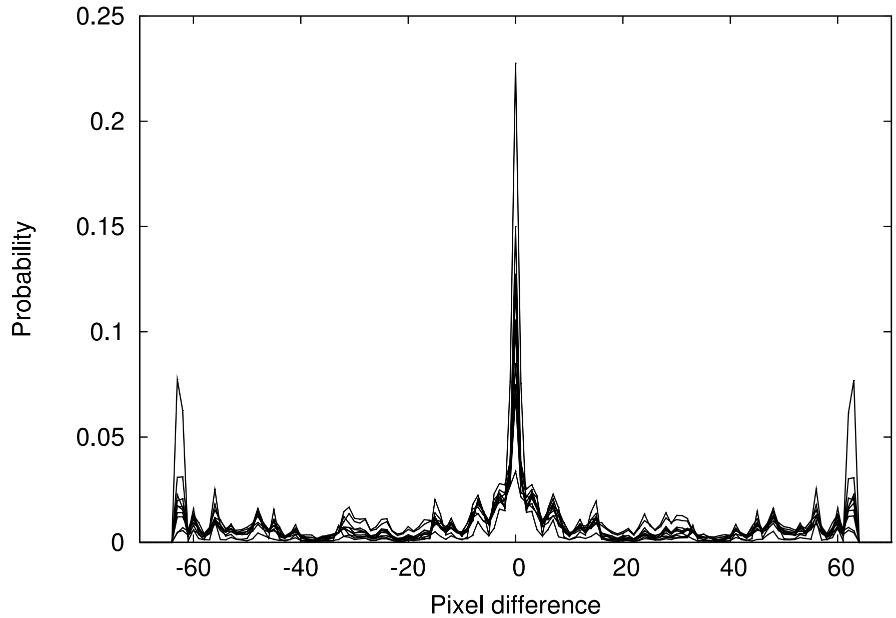

Fig. III.6. Distribution of difference values for Green component of 10 images for 1st level of encoding using MCA (IVTM)

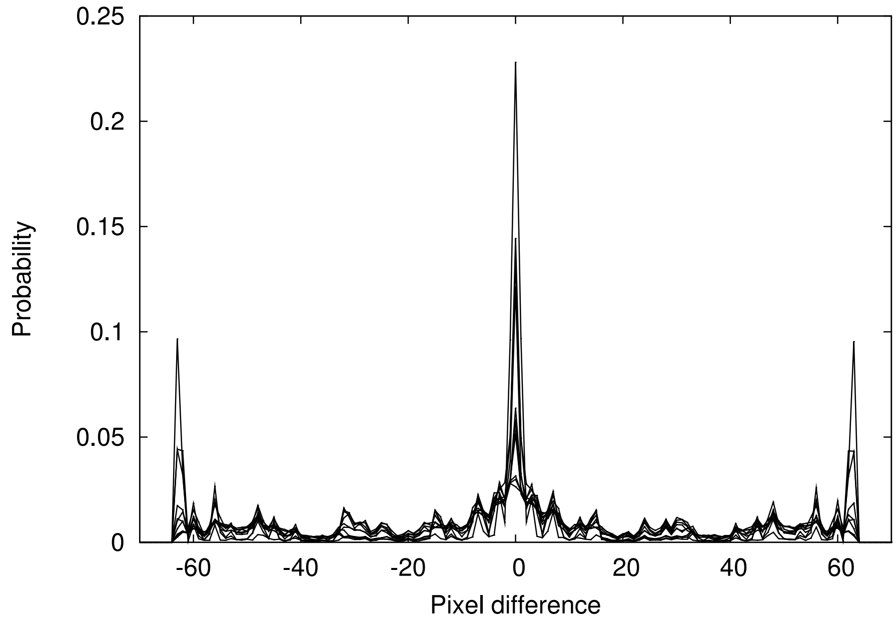

Fig. III.7. Distribution of difference values for Red component of 10 images for 1st level of encoding using MCA (IVTM)

CHAPTER IV

EXPERIMENTAL RESULTS

The TMDS scheme [12], the 2-LIWT scheme [2] and both MCA schemes were implemented in the C programming language. The experiments were run on a 1.66 GHz Intel Duo Core machine with 1 GB of RAM.

The two variants of the MCA scheme (i.e. the IVTM and the IVPA) were applied to 10 different images in the SIPI database [21]. The IVTM as well as the IVPA approach were simulated for various values of R, k, n and p. Since the images in the SIPI database use 8 bits per pixel value, $m = 8$ was used for generating all the results. The parameter k was varied from 2 to 6, n from 2 to 10 and p from 2 to 14. This was done for four values of range R = 10, 20, 50 and 255. The range R = 255 implies that *all* the pixel-differences are encoded.

Initially, results were obtained for all the 3 channels (RGB) using the TMDS standard. The performance of the IVTM and IVPA schemes were analyzed in terms of the percentage savings of EDP and energy over TMDS. These results are compared with the implementation of the 2-LIWT encoding scheme [2]. It was verified that the results obtained for the 2-LIWT were identical to those reported in [2]. The results of the TMDS scheme and that of the 2-LIWT scheme are shown in Table IV.1 and Tables IV.2, IV.3 and IV.4 respectively.

In Table IV.1, the length of the transmitted data stream and the associated total and intra-vector transitions for the TMDS scheme are shown for the 3 channels (RGB). Tables IV.2, IV.3 and IV.4 report the percentage total and intra-vector EDP and energy savings of the 2-LIWT scheme over that of the TMDS scheme, for the blue, green and red channels respectively. The results are shown for 10 images in the SIPI database [21]. The average percentage EDP and energy savings (total and intra-vector) are presented in the bottom row of each table. The length of transmission, the total number of transitions and the number of intra-vector transitions are also shown in these tables.

Table IV.1. Results of TMDS

	BLUE			GREEN			RED		
		Transitions			Transitions			Transitions	
Image	Length	Total	Intra	Length	Total	Intra	Length	Total	Intra
Couple	655360	258656	220690	655360	257117	218023	655360	260334	224226
Girl1	655360	264318	228752	655360	263925	228523	655360	270067	236365
Girl2	655360	269843	236654	655360	257981	224497	655360	262778	227992
House	655360	261742	228672	655360	275750	244128	655360	278504	244430
Jellyb	655360	278280	245268	655360	279969	250543	655360	243155	220228
Peppers	2621440	1062423	925284	2621440	1067678	931205	2621440	1078916	947837
Sail	2621440	1118204	990100	2621440	1100844	971888	2621440	1092560	957862
Splash	2621440	1066812	924644	2621440	1049917	905722	2621440	1121516	989212
Tree	655360	275485	241244	655360	273029	240927	655360	277041	243885
Moon	655360	253386	218358	655360	253386	218358	655360	253386	218358

IV-A. Results for IVTM

IV-A.1. EDP Minimization

The results of the IVTM technique optimized for EDP minimization are reported in Tables IV.5, IV.6 and IV.7 for the 3 channels (RGB). These tables present the results for $k = 3$, $n = 5$, $p = 6$ and $R = 50$, which yield the maximum percentage saving in terms of the total EDP, among all the k, n, p and R values simulated. The percentage total and intra-vector EDP and energy savings for each of the 10 images as well their average values have been listed in these tables. These tables also list the transmission length, the total number of transitions and the number of intra-vector transitions.

Comparing these tables with Tables IV.2, IV.3 and IV.4, we note that on an average, the IVTM (optimized for EDP minimization), yields a 10.94%, 10.91% and 11.1% improvement in the total EDP, and a 14.36%, 14.01% and 13.92% improvement in the intra-vector EDP over the 2-LIWT encoding scheme [2] for the Blue, Green and Red channels respectively. Since the IVTM is optimized for reducing EDP, the energy savings are less than that

Table IV.2. Results of 2-LIWT for Blue Channel

		Transitions		% Energy Savings		% EDP Savings	
Image	Length	Total	Intra	% Total	% Intra	% Total	% Intra
Couple	652183	100389	67781	61.19	69.29	61.38	69.44
Girl1	651943	110425	76345	58.22	66.63	58.44	66.80
Girl2	654280	79861	52917	70.40	77.64	70.45	77.68
House	652720	102756	66034	60.74	71.12	60.90	71.24
Jellyb	653955	69851	39153	74.90	84.04	74.95	84.07
Peppers	2609635	452760	310584	57.38	66.43	57.58	66.58
Sail	2590952	520961	376404	53.41	61.98	53.95	62.43
Splash	2616861	339549	220463	68.17	76.16	68.23	76.20
Tree	647364	128183	90046	53.47	62.67	54.04	63.13
Moon	651300	126339	87764	50.14	59.81	50.45	60.06
Avg				60.80	69.58	61.04	69.76

Table IV.3. Results of 2-LIWT for Green Channel

		Transitions		% Energy Savings		% EDP Savings	
Image	Length	Total	Intra	% Total	% Intra	% Total	% Intra
Couple	652288	91639	61413	64.36	71.83	64.53	71.96
Girl1	652581	97609	65768	63.02	71.22	63.17	71.34
Girl2	654291	76659	49928	70.29	77.76	70.33	77.80
House	652547	96969	63042	64.83	74.18	64.99	74.29
Jellyb	652698	71707	39091	74.39	84.40	74.49	84.46
Peppers	2606393	454210	311757	57.46	66.52	57.70	66.71
Sail	2585174	562823	409347	48.87	57.88	49.58	58.46
Splash	2614996	365208	232336	65.22	74.35	65.30	74.41
Tree	646262	126202	87633	53.78	63.63	54.42	64.13
Moon	651300	126339	87764	50.14	59.81	50.45	60.06
Avg				61.24	70.16	61.5	70.36

Table IV.4. Results of 2-LIWT for Red Channel

		Transitions		% Energy Savings		% EDP Savings	
Image	Length	Total	Intra	% Total	% Intra	% Total	% Intra
Couple	651656	99107	67032	61.93	70.11	62.15	70.27
Girl1	652629	107755	74253	60.10	68.59	60.27	68.72
Girl2	654123	74429	46116	71.68	79.77	71.73	79.81
House	653491	96594	63003	65.32	74.22	65.42	74.30
Jellyb	653368	72687	36316	70.11	83.51	70.20	83.56
Peppers	2610455	485460	340799	55.00	64.04	55.19	64.20
Sail	2602903	516450	364500	52.73	61.95	53.06	62.22
Splash	2617033	302743	183340	73.01	81.47	73.05	81.50
Tree	648424	128703	90175	53.54	63.03	54.04	63.42
Moon	651300	126339	87764	50.14	59.81	50.45	60.06
Avg				61.36	70.65	61.55	70.80

Table IV.5. Results of IVTM optimized for EDP minimization for Blue Channel with $k = 3$, $n = 5$, $p = 6$ and $R = 50$

		Transitions		% Energy Savings		% EDP Savings	
Image	Length	Total	Intra	% Total	% Intra	% Total	% Intra
Couple	411675	114843	55711	55.60	74.76	72.11	84.14
Girl1	419873	126163	62567	52.27	72.65	69.42	82.48
Girl2	394130	91770	39526	65.99	83.30	79.55	89.96
House	410178	113575	55689	56.61	75.65	72.84	84.76
Jellyb	377046	76792	31420	72.40	87.19	84.12	92.63
Peppers	1693320	511587	261884	51.85	71.70	68.90	81.72
Sail	1747467	590286	313437	47.21	68.34	64.81	78.90
Splash	1596289	385767	169883	63.84	81.63	77.98	88.81
Tree	429757	139960	73472	49.20	69.54	66.68	80.03
Moon	432524	140558	73667	44.53	66.26	63.39	77.73
Avg				55.95	75.10	71.98	84.12

Table IV.6. Results of IVTM optimized for EDP minimization for Green Channel with $k = 3$, $n = 5$, $p = 6$ and $R = 50$

		Transitions		% Energy Savings		% EDP Savings	
Image	Length	Total	Intra	% Total	% Intra	% Total	% Intra
Couple	402524	105293	50167	59.05	76.99	74.85	85.87
Girl1	407091	111535	53303	57.74	76.67	73.75	85.51
Girl2	388616	88574	36990	65.67	83.52	79.64	90.23
House	405209	107874	51031	60.88	79.10	75.81	87.08
Jellyb	379755	77205	33169	72.42	86.76	84.02	92.33
Peppers	1694085	512404	262902	52.01	71.77	68.99	81.76
Sail	1776565	630710	340944	42.71	64.92	61.17	76.23
Splash	1620904	408120	192156	61.13	78.78	75.96	86.88
Tree	429991	139502	73067	48.91	69.67	66.48	80.10
Moon	432524	140558	73667	44.53	66.26	63.39	77.73
Avg				56.50	75.45	72.41	84.37

of the 2-LIWT encoding scheme [2] by 4-5%. However, as discussed in Chapter II, the EDP is a more relevant metric for comparing the serial bus encoding schemes.

The average EDP and energy savings for the k, n and p values which yield the maximum percentage total EDP savings for each range R have been summarized in Table IV.17 for comparing the performance of the IVTM over different R values.

Table IV.7. Results of IVTM optimized for EDP minimization for Red Channel with $k = 3$, $n = 5$, $p = 6$ and $R = 50$

		Transitions		% Energy Savings		% EDP Savings	
Image	Length	Total	Intra	% Total	% Intra	% Total	% Intra
Couple	406074	113142	55317	56.54	75.33	73.07	84.71
Girl1	416976	123716	59587	54.19	74.79	70.85	83.96
Girl2	382757	85508	35195	67.46	84.56	81.00	90.98
House	407902	106968	49821	61.59	79.62	76.09	87.31
Jellyb	378106	75320	30865	69.02	85.98	82.13	91.91
Peppers	1726065	552746	289474	48.77	69.46	66.27	79.89
Sail	1737652	576561	303798	47.23	68.28	65.02	78.98
Splash	1545414	338176	140131	69.85	85.83	82.22	91.65
Tree	431223	141172	74013	49.04	69.65	66.47	80.03
Moon	432524	140558	73667	44.53	66.26	63.39	77.73
Avg				56.82	75.98	72.65	84.72

IV-A.2. Energy Minimization

The results of the IVTM technique optimized for energy minimization are reported in Tables IV.8, IV.9 and IV.10 for the 3 channels (RGB). These tables present the results for $k = 6$, $n = 10$, $p = 14$ and $R = 255$, which yield the maximum percentage saving in terms of the total energy, out of all the k, n, p and R values simulated. The percentage total and intra-vector EDP and energy savings for each of the 10 images, as well their average values, have been listed in these tables. These tables also list the transmission length, the total number of transitions and the number of intra-vector transitions.

Comparing these tables with Tables IV.2, IV.3 and IV.4, we note that on an average, the IVTM (optimized for energy minimization), yields a 2.01%, 2.36% and 2.15% improvement in the total energy and 6.7%, 6.68% and 6.36% improvement in the intra-vector energy over the 2-LIWT encoding scheme [2] for the Blue, Green and Red channels respectively. At the same time, it should also be observed that the corresponding total and intra-vector EDP savings are also above that of the 2-LIWT encoding scheme [2]. The IVTM yields a 2.7%, 3.05% and 2.9% improvement in the total EDP, and a 7.06%, 7.03% and 6.72% improvement in intra-vector EDP, over the 2-LIWT encoding scheme [2] for the

Table IV.8. Results of IVTM optimized for energy minimization for Blue Channel with $k = 6$, $n = 10$, $p = 14$ and $R = 255$

		Transitions		% Energy Savings		% EDP Savings	
Image	Length	Total	Intra	% Total	% Intra	% Total	% Intra
Couple	634264	97023	53679	62.49	75.68	63.70	76.46
Girl1	644396	103574	59304	60.81	74.07	61.47	74.51
Girl2	606188	88937	44252	67.04	81.30	69.51	82.70
House	638044	95499	52723	63.51	76.94	64.48	77.55
Jellyb	600180	74239	34140	73.32	86.08	75.57	87.25
Peppers	2606804	417558	244197	60.70	73.61	60.92	73.76
Sail	2634192	465746	275839	58.35	72.14	58.15	72.00
Splash	2466532	360169	183549	66.24	80.15	68.23	81.32
Tree	651992	110265	64001	59.97	73.47	60.18	73.61
Moon	662100	112397	66908	55.64	69.36	55.19	69.04
Avg				62.81	76.28	63.74	76.82

Table IV.9. Results of IVTM optimized for energy minimization for Green Channel with $k = 6$, $n = 10$, $p = 14$ and $R = 255$

		Transitions		% Energy Savings		% EDP Savings	
Image	Length	Total	Intra	% Total	% Intra	% Total	% Intra
Couple	620884	89687	48998	65.12	77.53	66.95	78.71
Girl1	627304	94485	51843	64.20	77.31	65.73	78.29
Girl2	600236	87313	42572	66.16	81.04	69.00	82.63
House	629156	94298	50644	65.80	79.26	67.17	80.08
Jellyb	606384	68450	31677	75.55	87.36	77.38	88.30
Peppers	2607780	417370	242715	60.91	73.94	61.11	74.07
Sail	2672704	486476	294118	55.81	69.74	54.94	69.15
Splash	2530336	352276	191569	66.45	78.85	67.61	79.58
Tree	654184	108332	62664	60.32	73.99	60.39	74.04
Moon	662100	112397	66908	55.64	69.36	55.19	69.04
Avg				63.60	76.84	64.55	77.39

Blue, Green and Red channels respectively.

The average EDP and energy savings for the k, n and p values corresponding to the maximum percentage total energy savings for each range R have been summarized in Table IV.18 for comparing the performance of the IVTM over different R values.

Table IV.10. Results of IVTM optimized for energy minimization for Red Channel with $k = 6$, $n = 10$, $p = 14$ and $R = 255$

		Transitions		% Energy Savings		% EDP Savings	
Image	Length	Total	Intra	% Total	% Intra	% Total	% Intra
Couple	627476	93760	52285	63.98	76.68	65.52	77.67
Girl1	637008	102203	59488	62.16	74.83	63.22	75.54
Girl2	600308	82833	39845	68.48	82.52	71.13	83.99
House	632944	94397	50386	66.11	79.39	67.27	80.09
Jellyb	607412	67775	29728	72.13	86.50	74.17	87.49
Peppers	2636948	451230	265984	58.18	71.94	57.93	71.77
Sail	2653744	460875	274268	57.82	71.37	57.30	71.01
Splash	2422568	325120	156224	71.01	84.21	73.21	85.41
Tree	656048	111923	65228	59.60	73.25	59.56	73.23
Moon	662100	112397	66908	55.64	69.36	55.19	69.04
Avg				63.51	77.01	64.45	77.52

IV-B. Results for IVPA

IV-B.1. EDP Minimization

The results of the IVPA technique optimized for EDP minimization are presented in Tables IV.11, IV.12 and IV.13 for the 3 channels (RGB). These tables report the results for $k = 3$, $n = 5$, $p = 6$ and $R = 50$ which yield the maximum percentage saving in terms of the total EDP, out of all the k, n, p and R values simulated. The percentage total and intra-vector EDP and energy savings for each of the 10 images as well their average values have been listed in these tables. These tables also list the transmission length, the total number of transitions and the number of intra-vector transitions.

Comparing these tables with Tables IV.2, IV.3 and IV.4, we note that on an average, the (IVPA optimized for EDP minimization), yields a 10.94%, 10.91% and 11.1% improvement in the total EDP, and a 14.36%, 14.01% and 13.92% improvement in the intra-vector EDP, over the 2-LIWT encoding scheme [2] for the Blue, Green and Red channels respectively. It should be noted that the best results for both IVTM and IVPA are identical when optimized for EDP minimization. This is due to the fact that, in the best case of the IVTM, the mapping between the symbols and codewords were identical to that of the best case of

Table IV.11. Results of IVPA optimized for EDP minimization for Blue Channel with $k = 3$, $n = 5$, $p = 6$ and $R = 50$

		Transitions		% Energy Savings		% EDP Savings	
Image	Length	Total	Intra	% Total	% Intra	% Total	% Intra
Couple	411675	114843	55711	55.60	74.76	72.11	84.14
Girl1	419873	126163	62567	52.27	72.65	69.42	82.48
Girl2	394130	91770	39526	65.99	83.30	79.55	89.96
House	410178	113575	55689	56.61	75.65	72.84	84.76
Jellyb	377046	76792	31420	72.40	87.19	84.12	92.63
Peppers	1693320	511587	261884	51.85	71.70	68.90	81.72
Sail	1747467	590286	313437	47.21	68.34	64.81	78.90
Splash	1596289	385767	169883	63.84	81.63	77.98	88.81
Tree	429757	139960	73472	49.20	69.54	66.68	80.03
Moon	432524	140558	73667	44.53	66.26	63.39	77.73
Avg				55.95	75.10	71.98	84.12

Table IV.12. Results of IVPA optimized for EDP minimization for Green Channel with $k = 3$, $n = 5$, $p = 6$ and $R = 50$

		Transitions		% Energy Savings		% EDP Savings	
Image	Length	Total	Intra	% Total	% Intra	% Total	% Intra
Couple	402524	105293	50167	59.05	76.99	74.85	85.87
Girl1	407091	111535	53303	57.74	76.67	73.75	85.51
Girl2	388616	88574	36990	65.67	83.52	79.64	90.23
House	405209	107874	51031	60.88	79.10	75.81	87.08
Jellyb	379755	77205	33169	72.42	86.76	84.02	92.33
Peppers	1694085	512404	262902	52.01	71.77	68.99	81.76
Sail	1776565	630710	340944	42.71	64.92	61.17	76.23
Splash	1620904	408120	192156	61.13	78.78	75.96	86.88
Tree	429991	139502	73067	48.91	69.67	66.48	80.10
Moon	432524	140558	73667	44.53	66.26	63.39	77.73
Avg				56.50	75.45	72.41	84.37

the IVPA scheme. This may not always be true. Since the IVPA is optimized for reducing EDP, the energy savings are less than that of the 2-LIWT encoding scheme [2] by 4-5%.

The average EDP and energy savings for the k, n and p values corresponding to the maximum percentage total EDP savings for each range R have been summarized in Table IV.19 for comparing the performance of the IVPA over different R values.

Table IV.13. Results of IVPA optimized for EDP minimization for Red Channel with $k = 3$, $n = 5$, $p = 6$ and $R = 50$

		Transitions		% Energy Savings		% EDP Savings	
Image	Length	Total	Intra	% Total	% Intra	% Total	% Intra
Couple	406074	113142	55317	56.54	75.33	73.07	84.71
Girl1	416976	123716	59587	54.19	74.79	70.85	83.96
Girl2	382757	85508	35195	67.46	84.56	81.00	90.98
House	407902	106968	49821	61.59	79.62	76.09	87.31
Jellyb	378106	75320	30865	69.02	85.98	82.13	91.91
Peppers	1726065	552746	289474	48.77	69.46	66.27	79.89
Sail	1737652	576561	303798	47.23	68.28	65.02	78.98
Splash	1545414	338176	140131	69.85	85.83	82.22	91.65
Tree	431223	141172	74013	49.04	69.65	66.47	80.03
Moon	432524	140558	73667	44.53	66.26	63.39	77.73
Avg				56.82	75.98	72.65	84.72

IV-B.2. Energy Minimization

The results of the IVPA technique optimized for energy minimization are reported in Tables IV.14, IV.15 and IV.16 for the 3 channels (RGB). These tables present the results for $k = 6$, $n = 10$, $p = 14$ and $R = 255$, which yield the maximum percentage saving in terms of the total energy, out of all the k, n, p and R values simulated. The percentage total and intra-vector EDP and energy savings for each of the 10 images as well their average values have been listed in these tables. These tables also list the transmission length, the total number of transitions and the number of intra-vector transitions.

Comparing these tables with Tables IV.2, IV.3 and IV.4, we note that on an average, the IVPA optimized for energy minimization, yields a 2.88%, 3.46% and 2.89% improvement in the total energy and 7.21%, 7.17% and 6.96% improvement in the intra-vector energy over the 2-LIWT encoding scheme [2] for the Blue, Green and Red channels respectively. We also note that the total and intra-vector EDP savings are also above that of the 2-LIWT encoding scheme [2]. The IVTM yields a 2.46%, 3.31% and 2.65% improvement in the total EDP, and a 6.89%, 6.99% and 6.73% improvement in intra-vector EDP, over the 2-LIWT encoding scheme [2] for the Blue, Green and Red channels respectively.

Table IV.14. Results of IVPA optimized for energy minimization for Blue Channel with $k = 6$, $n = 10$, $p = 14$ and $R = 255$

		Transitions		% Energy Savings		% EDP Savings	
Image	Length	Total	Intra	% Total	% Intra	% Total	% Intra
Couple	653856	95667	52882	63.01	76.04	63.10	76.09
Girl1	661404	102962	58565	61.05	74.40	60.69	74.16
Girl2	650608	82663	42143	69.37	82.19	69.59	82.32
House	650588	93859	51649	64.14	77.41	64.40	77.58
Jellyb	633176	68095	29422	75.53	88.00	76.36	88.41
Peppers	2642688	416884	244526	60.76	73.57	60.44	73.36
Sail	2684528	459200	273790	58.93	72.35	57.95	71.68
Splash	2615744	342527	178187	67.89	80.73	67.96	80.77
Tree	666780	108563	62733	60.59	74.00	59.91	73.54
Moon	668952	112689	67191	55.53	69.23	54.60	68.59
Avg				63.68	76.79	63.50	76.65

Another important observation to be made is that the IVPA optimized for energy minimization yields a 0.87%, 1.1% and 0.74% improvement in the total energy and 0.51%, 0.49% and 0.6% improvement in the intra-vector energy over the IVTM (optimized for energy minimization), for the Blue, Green and Red channels respectively. This improvement is due to the fact that the IVPA attempts to minimize the inter-vector transitions in addition to the intra-vector transitions, as opposed to the IVTM which attempts to reduce the intra-vector transitions only.

The average EDP and energy savings for the k, n and p values corresponding to the maximum percentage total energy savings for each range R have been summarized in Table IV.20 for comparing the performance of the IVPA over different R values.

IV-C. Results with Different Images

When implementing the MCA scheme, the codebook (lookup table) was generated using the average empirical probability distribution of pixel difference from images of the SIPI database [21]. Using this codebook, the performance of the MCA scheme was compared with 2-LIWT [2] and TMDS [12], using images from a different source [22]. These images

Table IV.15. Results of IVPA optimized for energy minimization for Green Channel with $k = 6$, $n = 10$, $p = 14$ and $R = 255$

		Transitions		% Energy Savings		% EDP Savings	
Image	Length	Total	Intra	% Total	% Intra	% Total	% Intra
Couple	637240	87999	47659	65.77	78.14	66.72	78.74
Girl1	643656	92345	50813	65.01	77.76	65.64	78.16
Girl2	636784	76001	39124	70.54	82.57	71.38	83.07
House	651892	90026	48579	67.35	80.10	67.53	80.21
Jellyb	619996	66860	29582	76.12	88.19	77.41	88.83
Peppers	2640696	406819	243177	61.90	73.89	61.62	73.69
Sail	2694580	478630	292999	56.52	69.85	55.31	69.01
Splash	2595224	346182	190858	67.03	78.93	67.36	79.14
Tree	667956	105772	61230	61.26	74.59	60.52	74.10
Moon	668952	112689	67191	55.53	69.23	54.60	68.59
Avg				64.70	77.33	64.81	77.35

Table IV.16. Results of IVPA optimized for energy minimization for Red Channel with $k = 6$, $n = 10$, $p = 14$ and $R = 255$

		Transitions		% Energy Savings		% EDP Savings	
Image	Length	Total	Intra	% Total	% Intra	% Total	% Intra
Couple	644956	92590	50857	64.43	77.32	65.00	77.68
Girl1	655408	101385	57693	62.46	75.59	62.46	75.59
Girl2	639824	75427	35571	71.30	84.40	71.98	84.77
House	662424	92143	49904	66.92	79.58	66.56	79.36
Jellyb	620944	66693	27356	72.57	87.58	74.01	88.23
Peppers	2659692	447854	266376	58.49	71.90	57.88	71.49
Sail	2675844	458963	273834	57.99	71.41	57.12	70.82
Splash	2572356	306442	144022	72.68	85.44	73.19	85.71
Tree	671004	110501	64257	60.11	73.65	59.16	73.02
Moon	668952	112689	67191	55.53	69.23	54.60	68.59
Avg				64.25	77.61	64.20	77.53

Table IV.17. Results for IVTM (EDP minimization) with best values of k, n and p within each range ($R = 10, 20, 50, 255$) averaged over all the 10 images

				Blue				Green				Red			
				% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings	
R	k	n	p	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra
10	3	3	3	42.94	66.59	65.7	79.79	44.79	67.78	66.81	80.5	44.03	67.13	66.43	80.14
20	3	4	5	51.88	72.92	71.02	83.64	52.53	73.28	71.35	83.81	52.76	73.74	71.7	84.2
50	3	5	6	55.95	75.1	71.98	84.12	56.5	75.45	72.41	84.37	56.82	75.98	72.65	84.72
255	3	5	9	56.12	74.51	71.09	83.14	56.9	75.06	71.6	83.49	56.85	75.33	71.72	83.73

Table IV.18. Results for IVTM (energy minimization) with best values of k, n and p within each range ($R = 10, 20, 50, 255$) averaged over all the 10 images

				Blue				Green				Red			
				% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings	
R	k	n	p	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra
10	6	10	10	48.31	66.2	49.76	67.09	50.02	67.39	51.62	68.38	49.57	66.78	50.91	67.58
20	6	10	10	57.95	73	59.81	74.16	58.4	73.37	60.33	74.56	59.04	73.84	60.83	74.93
50	6	10	14	62.13	75.83	63.13	76.41	62.79	76.34	63.83	76.95	63.07	76.69	64.04	77.23
255	6	10	14	62.81	76.28	63.74	76.82	63.6	76.84	64.55	77.39	63.51	77.01	64.45	77.52

Table IV.19. Results for IVPA (EDP minimization) with best values of k, n and p within each range ($R = 10, 20, 50, 255$) averaged over all the 10 images

				Blue				Green				Red			
				% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings	
R	k	n	p	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra
10	2	3	4	41.62	67.37	65.61	80.58	43.47	68.53	66.82	81.33	42.66	67.95	66.23	80.89
20	3	4	5	51.88	72.92	71.02	83.64	52.53	73.28	71.35	83.81	52.76	73.74	71.7	84.2
50	3	5	6	55.95	75.1	71.98	84.12	56.5	75.45	72.41	84.37	56.82	75.98	72.65	84.72
255	3	5	9	56.12	74.51	71.09	83.14	56.9	75.06	71.6	83.49	56.85	75.33	71.72	83.73

Table IV.20. Results for IVPA (energy minimization) with best values of k, n and p within each range ($R = 10, 20, 50, 255$) averaged over all the 10 images

				Blue				Green				Red			
				% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings	
R	k	n	p	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra
10	6	10	10	49.25	66.71	49.26	66.69	51.17	67.88	51.66	68.17	50.33	67.39	50.4	67.37
20	6	10	10	58.85	73.52	59.47	73.9	59.53	73.85	60.5	74.46	59.78	74.45	60.48	74.85
50	6	10	14	63	76.34	62.87	76.23	63.9	76.83	64.08	76.9	63.81	77.29	63.78	77.22
255	6	10	14	63.68	76.79	63.5	76.65	64.7	77.33	64.81	77.35	64.25	77.61	64.2	77.53

were not considered in obtaining the average probability distribution. The results for the MCA scheme are shown in Tables IV.25 - IV.36. The corresponding results for the 2-LIWT [2] scheme are shown in Tables IV.22 - IV.24. The results of the TMDS scheme with the new images are shown in Table IV.21.

From these tables, we note that on average, the best variants of the MCA scheme yield around 77-88% savings in EDP, and around 73-82% savings in energy over the TMDS scheme. The best variant of the MCA scheme, when optimized to minimize EDP, yields an improvement of 6-10% in EDP over the 2-LIWT [2] scheme. In terms of energy, it yields around 2.5% less savings than that of the 2-LIWT [2] scheme. The best variant of the MCA scheme, when optimized to minimize energy, yields an improvement of 1.7-2.5% savings in EDP over the 2-LIWT [2] scheme. The energy savings in this case are almost the same as that of the 2-LIWT [2] scheme.

These results indicate that the MCA scheme performs well, even when the codebook generated using the average empirical probability distribution is used to encode different images (which were not considered during codebook construction). This validates the practical applicability of the MCA scheme.

Table IV.21. Results of TMDS with different images

	BLUE			GREEN			RED		
		Transitions			Transitions			Transitions	
Image	Length	Total	Intra	Length	Total	Intra	Length	Total	Intra
ball1	2981160	646997	386798	2981160	748148	492518	2981160	636371	377334
blocks	2981160	834241	596816	2981160	862981	624816	2981160	758699	518028
book3	2981160	851806	621944	2981160	922390	702752	2981160	855933	635346
book4	2981160	879465	659944	2981160	947557	733974	2981160	870307	653732
hairgel	2981160	793860	545564	2981160	768246	518502	2981160	661108	406531
rollups	2981160	902990	676428	2981160	887988	656489	2981160	787224	553092
shirt2	2981160	1103261	919332	2981160	1134788	955624	2981160	1099010	917191
shorts	2981160	833163	590456	2981160	819982	576102	2981160	808228	571922

Table IV.22. Results of 2-LIWT with different images for Blue Channel

		Transitions		% Energy Savings		% EDP Savings	
Image	Length	Total	Intra	% Total	% Intra	% Total	% Intra
ball1	2981118	60954	21970	90.58	94.32	90.58	94.32
blocks	2981158	183472	65905	78.01	88.96	78.01	88.96
book3	2977828	223158	111486	73.80	82.07	73.83	82.09
book4	2977186	208888	123470	76.25	81.29	76.28	81.32
hairgel	2978956	175702	70932	77.87	87.00	77.88	87.01
rollups	2972706	234388	122111	74.04	81.95	74.12	82.00
shirt2	2966695	447710	305289	59.42	66.79	59.62	66.95
shorts	2981096	192202	86010	76.93	85.43	76.93	85.43
Avg				75.86	83.48	75.91	83.51

Table IV.23. Results of 2-LIWT with different images for Green Channel

		Transitions		% Energy Savings		% EDP Savings	
Image	Length	Total	Intra	% Total	% Intra	% Total	% Intra
ball1	2981044	132224	43802	82.33	91.11	82.33	91.11
blocks	2980105	172902	72647	79.96	88.37	79.97	88.38
book3	2977180	231208	117975	74.93	83.21	74.97	83.23
book4	2975696	251698	141697	73.44	80.69	73.49	80.73
hairgel	2978195	172422	68863	77.56	86.72	77.58	86.73
rollups	2970804	228038	122307	74.32	81.37	74.41	81.43
shirt2	2965987	445840	305534	60.71	68.03	60.91	68.19
shorts	2980637	199322	90412	75.69	84.31	75.70	84.31
Avg				74.87	82.98	74.92	83.01

Table IV.24. Results of 2-LIWT with different images for Red Channel

		Transitions		% Energy Savings		% EDP Savings	
Image	Length	Total	Intra	% Total	% Intra	% Total	% Intra
ball1	2980885	21650	9663	96.60	97.44	96.60	97.44
blocks	2979552	100330	56450	86.78	89.10	86.78	89.11
book3	2977288	170054	103009	80.13	83.79	80.16	83.81
book4	2975191	182900	118588	78.98	81.86	79.03	81.90
hairgel	2978240	54768	34401	91.72	91.54	91.72	91.55
rollups	2971102	146518	96639	81.39	82.53	81.45	82.59
shirt2	2966864	423078	296121	61.50	67.71	61.69	67.87
shorts	2980173	160030	91488	80.20	84.00	80.21	84.01
Avg				82.16	84.75	82.20	84.78

Table IV.25. Results of IVTM with different images optimized for EDP minimization for Blue Channel with $k = 3$, $n = 5$, $p = 6$ and $R = 50$

		Transitions		% Energy Savings		% EDP Savings	
Image	Length	Total	Intra	% Total	% Intra	% Total	% Intra
ball1	1531390	68888	20391	89.35	94.73	94.53	97.29
blocks	1606564	191008	61101	77.10	89.76	87.66	94.48
book3	1654489	247912	95984	70.90	84.57	83.85	91.44
book4	1652815	241616	102226	72.53	84.51	84.77	91.41
hairgel	1611159	184278	65873	76.79	87.93	87.45	93.47
rollups	1660759	256588	106194	71.58	84.30	84.17	91.25
shirt2	1863175	514227	255008	53.39	72.26	70.87	82.66
shorts	1622097	205026	72916	75.39	87.65	86.61	93.28
Avg				73.38	85.71	84.99	91.91

Table IV.26. Results of IVTM with different images optimized for EDP minimization for Green Channel with $k = 3$, $n = 5$, $p = 6$ and $R = 50$

		Transitions		% Energy Savings		% EDP Savings	
Image	Length	Total	Intra	% Total	% Intra	% Total	% Intra
ball1	1574713	133985	42008	82.09	91.47	90.54	95.49
blocks	1603805	181272	63359	78.99	89.86	88.70	94.54
book3	1661730	251145	100479	72.77	85.70	84.82	92.03
book4	1681222	279539	118407	70.50	83.87	83.36	90.90
hairgel	1608171	180092	64201	76.56	87.62	87.35	93.32
rollups	1659149	253253	106695	71.48	83.75	84.13	90.95
shirt2	1861857	509129	253726	55.13	73.45	71.98	83.42
shorts	1629992	212514	77996	74.08	86.46	85.83	92.60
Avg				72.70	85.27	84.59	91.66

Table IV.27. Results of IVTM with different images optimized for EDP minimization for Red Channel with $k = 3$, $n = 5$, $p = 6$ and $R = 50$

		Transitions		% Energy Savings		% EDP Savings	
Image	Length	Total	Intra	% Total	% Intra	% Total	% Intra
ball1	1509326	22608	8056	96.45	97.87	98.20	98.92
blocks	1563640	116945	44785	84.59	91.35	91.92	95.47
book3	1627060	194292	86103	77.30	86.45	87.61	92.60
book4	1638278	211962	96771	75.65	85.20	86.62	91.87
hairgel	1535572	64416	29201	90.26	92.82	94.98	96.30
rollups	1610077	171574	80869	78.21	85.38	88.23	92.10
shirt2	1848346	488449	245972	55.56	73.18	72.44	83.37
shorts	1614594	182582	73408	77.41	87.16	87.77	93.05
Avg				79.43	87.43	88.47	92.96

Table IV.28. Results of IVTM with different images optimized for energy minimization for Blue Channel with $k = 6$, $n = 10$, $p = 14$ and $R = 255$

		Transitions		% Energy Savings		% EDP Savings	
Image	Length	Total	Intra	% Total	% Intra	% Total	% Intra
ball1	2460692	68240	20949	89.45	94.58	91.29	95.53
blocks	2605816	189094	64071	77.33	89.26	80.19	90.62
book3	2649500	232612	98334	72.69	84.19	75.73	85.95
book4	2615116	225086	105764	74.41	83.97	77.55	85.94
hairgel	2602808	176536	64928	77.76	88.10	80.58	89.61
rollups	2653188	230600	101106	74.46	85.05	77.27	86.70
shirt2	2880216	432382	239140	60.81	73.99	62.14	74.87
shorts	2610872	202948	80844	75.64	86.31	78.67	88.01
Avg				75.32	85.68	77.93	87.15

Table IV.29. Results of IVTM with different images optimized for energy minimization for Green Channel with $k = 6$, $n = 10$, $p = 14$ and $R = 255$

		Transitions		% Energy Savings		% EDP Savings	
Image	Length	Total	Intra	% Total	% Intra	% Total	% Intra
ball1	2546932	133561	42923	82.15	91.28	84.75	92.55
blocks	2587620	178556	68690	79.31	89.01	82.04	90.46
book3	2654664	234421	102852	74.59	85.36	77.37	86.97
book4	2664092	258707	119863	72.70	83.67	75.60	85.41
hairgel	2594332	170754	62126	77.77	88.02	80.66	89.57
rollups	2641396	223983	99936	74.78	84.78	77.65	86.51
shirt2	2874832	427494	238019	62.33	75.09	63.67	75.98
shorts	2617340	207148	83362	74.74	85.53	77.82	87.30
Avg				74.79	85.34	77.45	86.84

Table IV.30. Results of IVTM with different images optimized for energy minimization for Red Channel with $k = 6$, $n = 10$, $p = 14$ and $R = 255$

		Transitions		% Energy Savings		% EDP Savings	
Image	Length	Total	Intra	% Total	% Intra	% Total	% Intra
ball1	2415944	21718	8525	96.59	97.74	97.23	98.17
blocks	2491372	114673	50484	84.89	90.25	87.37	91.86
book3	2582112	173828	85592	79.69	86.53	82.41	88.33
book4	2580384	189414	97325	78.24	85.11	81.16	87.11
hairgel	2448588	55206	27080	91.65	93.34	93.14	94.53
rollups	2543368	142332	74546	81.92	86.52	84.57	88.50
shirt2	2847228	409204	230940	62.77	74.82	64.44	75.95
shorts	2564136	175278	80789	78.31	85.87	81.35	87.85
Avg				81.76	87.52	83.96	89.04

Table IV.31. Results of IVPA with different images optimized for EDP minimization for Blue Channel with $k = 3$, $n = 5$, $p = 6$ and $R = 50$

		Transitions		% Energy Savings		% EDP Savings	
Image	Length	Total	Intra	% Total	% Intra	% Total	% Intra
ball1	1531390	68888	20391	89.35	94.73	94.53	97.29
blocks	1606564	191008	61101	77.10	89.76	87.66	94.48
book3	1654489	247912	95984	70.90	84.57	83.85	91.44
book4	1652815	241616	102226	72.53	84.51	84.77	91.41
hairgel	1611159	184278	65873	76.79	87.93	87.45	93.47
rollups	1660759	256588	106194	71.58	84.30	84.17	91.25
shirt2	1863175	514227	255008	53.39	72.26	70.87	82.66
shorts	1622097	205026	72916	75.39	87.65	86.61	93.28
Avg				73.38	85.71	84.99	91.91

Table IV.32. Results of IVPA with different images optimized for EDP minimization for Green Channel with $k = 3$, $n = 5$, $p = 6$ and $R = 50$

		Transitions		% Energy Savings		% EDP Savings	
Image	Length	Total	Intra	% Total	% Intra	% Total	% Intra
ball1	1574713	133985	42008	82.09	91.47	90.54	95.49
blocks	1603805	181272	63359	78.99	89.86	88.70	94.54
book3	1661730	251145	100479	72.77	85.70	84.82	92.03
book4	1681222	279539	118407	70.50	83.87	83.36	90.90
hairgel	1608171	180092	64201	76.56	87.62	87.35	93.32
rollups	1659149	253253	106695	71.48	83.75	84.13	90.95
shirt2	1861857	509129	253726	55.13	73.45	71.98	83.42
shorts	1629992	212514	77996	74.08	86.46	85.83	92.60
Avg				72.70	85.27	84.59	91.66

Table IV.33. Results of IVPA with different images optimized for EDP minimization for Red Channel with $k = 3$, $n = 5$, $p = 6$ and $R = 50$

		Transitions		% Energy Savings		% EDP Savings	
Image	Length	Total	Intra	% Total	% Intra	% Total	% Intra
ball1	1509326	22608	8056	96.45	97.87	98.20	98.92
blocks	1563640	116945	44785	84.59	91.35	91.92	95.47
book3	1627060	194292	86103	77.30	86.45	87.61	92.60
book4	1638278	211962	96771	75.65	85.20	86.62	91.87
hairgel	1535572	64416	29201	90.26	92.82	94.98	96.30
rollups	1610077	171574	80869	78.21	85.38	88.23	92.10
shirt2	1848346	488449	245972	55.56	73.18	72.44	83.37
shorts	1614594	182582	73408	77.41	87.16	87.77	93.05
Avg				79.43	87.43	88.47	92.96

Table IV.34. Results of IVPA with different images optimized for energy minimization for Blue Channel with $k=6$, $n=10$, $p=14$ and $R=255$

		Transitions		% Energy Savings		% EDP Savings	
Image	Length	Total	Intra	% Total	% Intra	% Total	% Intra
ball1	2466048	67710	20654	89.53	94.66	91.34	95.58
blocks	2622940	186906	61080	77.60	89.77	80.29	91.00
book3	2696208	226276	94400	73.44	84.82	75.97	86.27
book4	2679196	216518	100221	75.38	84.81	77.87	86.35
hairgel	2617660	174882	62650	77.97	88.52	80.66	89.92
rollups	2683328	226128	97815	74.96	85.54	77.46	86.98
shirt2	2939828	426902	235887	61.31	74.34	61.84	74.70
shorts	2658120	197202	75326	76.33	87.24	78.90	88.63
Avg				75.81	86.21	78.04	87.43

Table IV.35. Results of IVPA with different images optimized for energy minimization for Green Channel with $k=6$, $n=10$, $p=14$ and $R=255$

		Transitions		% Energy Savings		% EDP Savings	
Image	Length	Total	Intra	% Total	% Intra	% Total	% Intra
ball1	2552916	133139	42297	82.20	91.41	84.76	92.65
blocks	2616428	172844	63925	79.97	89.77	82.42	91.02
book3	2692724	226885	98897	75.40	85.93	77.78	87.29
book4	2717464	251107	114809	73.50	84.36	75.84	85.74
hairgel	2608448	169972	60628	77.88	88.31	80.64	89.77
rollups	2669524	218367	96813	75.41	85.25	77.98	86.79
shirt2	2931492	429472	234322	62.15	75.48	62.78	75.89
shorts	2653044	203552	79099	75.18	86.27	77.91	87.78
Avg				75.21	85.85	77.52	87.12

Table IV.36. Results of IVPA with different images optimized for energy minimization for Red Channel with $k=6$, $n=10$, $p=14$ and $R=255$

		Transitions		% Energy Savings		% EDP Savings	
Image	Length	Total	Intra	% Total	% Intra	% Total	% Intra
ball1	2423444	21188	7645	96.67	97.97	97.29	98.35
blocks	2538864	107295	45405	85.86	91.24	87.96	92.54
book3	2624132	168690	82316	80.29	87.04	82.65	88.60
book4	2639140	182058	92695	79.08	85.82	81.48	87.45
hairgel	2466684	54528	24550	91.75	93.96	93.18	95.00
rollups	2575532	137738	71712	82.50	87.03	84.88	88.80
shirt2	2918676	402976	227422	63.33	75.20	64.10	75.72
shorts	2631260	168420	74561	79.16	86.96	81.61	88.49
Avg				82.33	88.15	84.14	89.37

IV-D. Conclusion

Pareto curves for EDP-Energy pairs for the 3 channels (RGB) are shown in Figures IV.1, IV.2 and IV.3. The quantity $(100 - \%EDPSavings)/100$ is used as a measure of EDP improvement and the quantity $(100 - \%EnergySavings)/100$ is used as a measure of energy improvement while plotting the Pareto curves. Each point on the Pareto curve indicates the EDP and energy metric for a particular code (i.e. an MCA variant with some value of k, n, p and R). Points for which the MCA wins over 2-LIWT [2] in EDP alone, wins in both EDP and energy and does not win over the 2-LIWT [2], are indicated with different colors and marks. It should be noted that there is no point where the MCA wins the 2-LIWT in energy, but looses in EDP. Ideally, we expect the value of EDP and energy to approach to zero. Points close to the x-axis represent codes that are EDP-efficient. Points close to the y-axis represent codes that are energy-efficient. All points to the left of the 2-LIWT scheme are more efficient in terms of energy. Likewise, all points below the 2-LIWT scheme are more efficient in terms of EDP. The Pareto curves shown, indicate the trade-off between EDP and energy and are useful in choosing the desired EDP-Energy pair.

As mentioned in Sections II-A and II-B, information theoretic lower bounds on the achievable transitions per symbol (given the average rate R in bits/symbol and the source entropy H) were reported in [8]. The pixel differences can be assumed to be identically distributed at each time instant. Hence, in order to get an intuition on the proximity of the MCA scheme to the lower bound, we can calculate an upper bound approximation of the lower bound by using the entropy $H(X)$ of the pixel difference at each time instant, instead of the entropy rate $\mathcal{H}(\mathcal{X})$ (see Section II-A.3). For the rate of transmission of the best variant of the MCA, the lower bound is 1.56 transitions per symbol (a symbol here refers to 8 bits of a pixel value of an image), whereas the best variant of the MCA achieves 1.73 transitions per symbol. This indicates that the average number of transitions of the

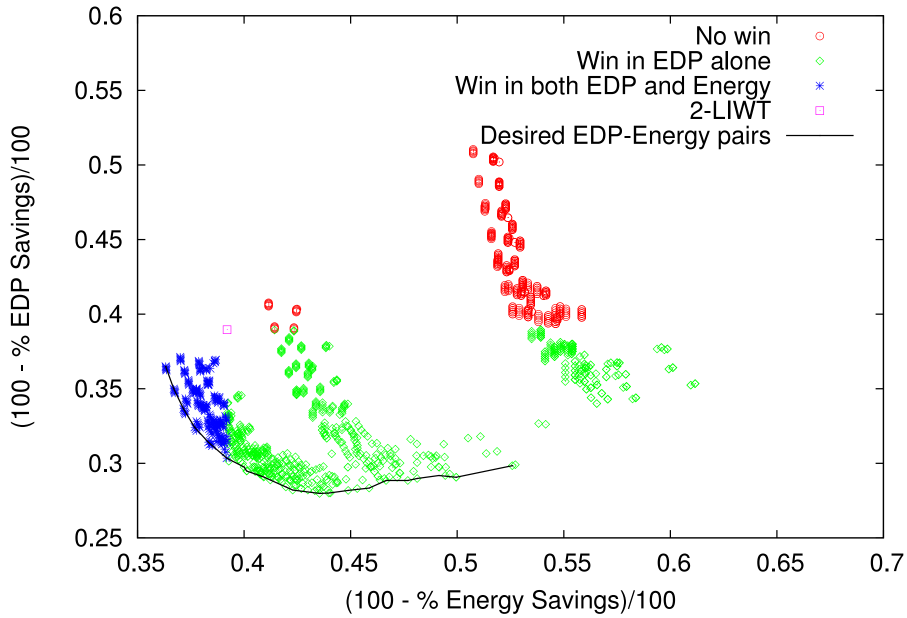

Fig. IV.1. Pareto curve of EDP-energy pairs for Blue Channel

MCA is 10.9% above the lower bound. Similar calculations for the 2-LIWT [2] indicate that for the rate of transmission of the 2-LIWT the lower bound on the average number of transitions is 1.09 transitions per symbol. The 2-LIWT is able to achieve 1.5 transitions per symbol. This implies that the average number of transitions of the 2-LIWT is 37.6% above the lower bound (in contrast to the MCA scheme which is 10.9% above the lower bound). This shows the significant EDP and energy savings provided by the MCA compared to the 2-LIWT.

In Section II-A.4.b, it was explained that for achieving the minimum lower bound on EDP, the rate of transmission should be approximately $1.25H$ bits per symbol on average. It turns out that for the best variant of the MCA scheme, the rate is $1.23H$, whereas that for the 2-LIWT [2] scheme is $1.984H$. Since the rate for the MCA scheme is much closer to

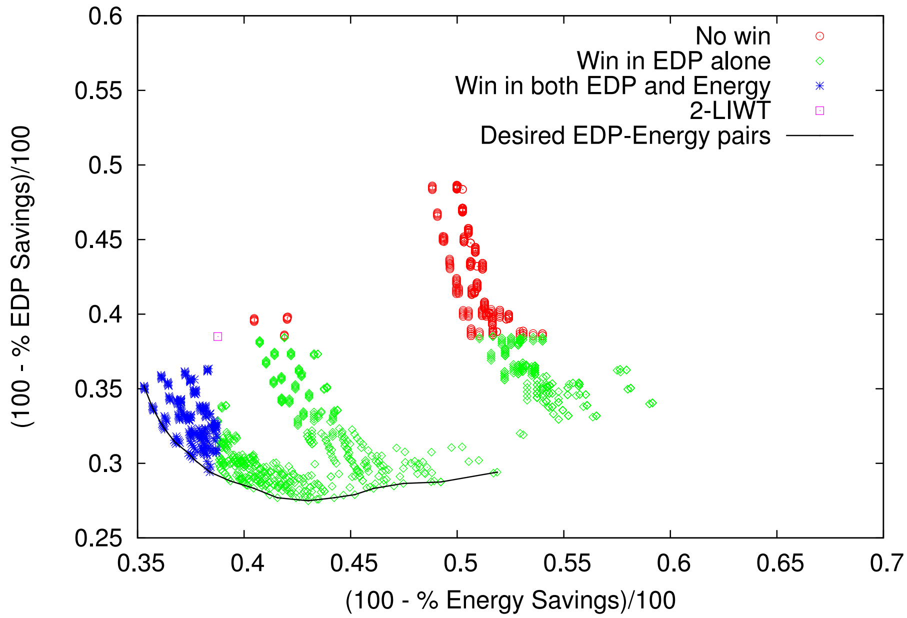

Fig. IV.2. Pareto curve of EDP-energy pairs for Green Channel

$1.25H$ (compared to the rate of the 2-LIWT [2] scheme), the MCA scheme is able to yield better EDP savings than the 2-LIWT [2] scheme.

Based on the above results we note that the MCA provides impressive improvements in EDP and energy over that of [2], which is the best energy reducing serial data encoding technique available to date.

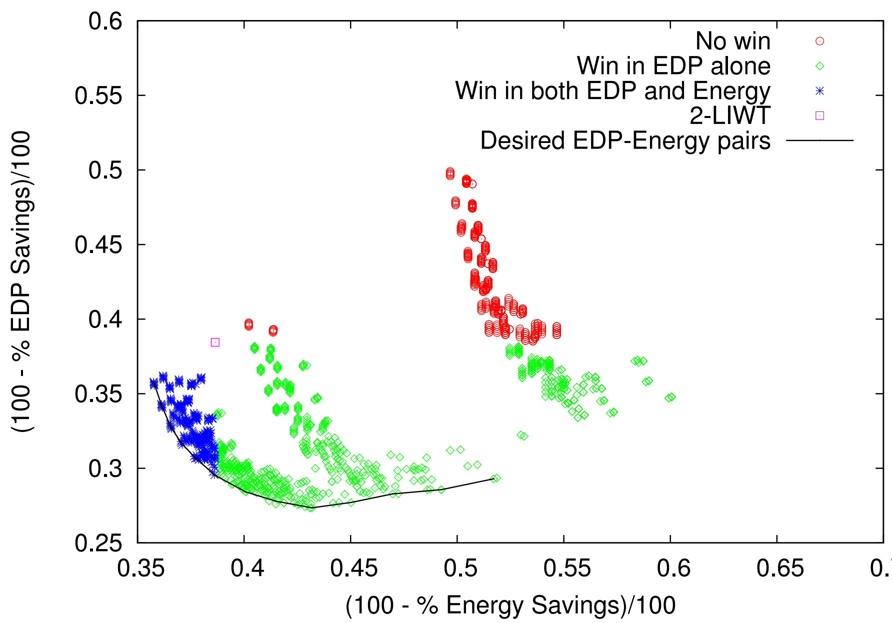

Fig. IV.3. Pareto curve of EDP-energy pairs for Red Channel

CHAPTER V

CONCLUSIONS AND FUTURE WORK

V-A. Conclusions

In serial data transmission, it is crucial to reduce the energy associated with the data transfer, as well as the total time required for transmission. As a result, the Energy Delay Product (EDP) is the important metric to be minimized. Previous encoding approaches in this area have targeted energy minimization alone. In this thesis, a bus encoding based EDP and energy minimization technique called the MCA was presented for serial data transmission. The experimental results were generated for an MCA utilizing 3 codebooks of varying lengths.

Two variants of the MCA, namely the IVTM and the IVPA were studied in this thesis. The IVTM attempts to reduce the EDP and energy by reducing the intra-vector transitions alone. In order to reduce the inter-vector transitions in addition to the intra-vector transitions, a technique called the IVPA was formulated. The IVPA successively calculates the probability of a transition occurring at the interface of two codeword vectors, at the time of forming the codebook. This probability is used in constructing the mapping between the symbols and the codewords in a manner that minimizes inter-vector transitions.

It should be noted that the MCA scheme is a variable rate scheme, since it uses codewords of different length (k, n and p). Hence provision should be made both at the transmitter and the receiver to buffer the data correctly. The buffer size should be maximum($m+2$, $p+2$), where m is the length of the actual pixel value (which is transmitted if the absolute pixel difference is greater than a range R) and p is the length of the longest codeword. The term 2 is to include the two preamble bits. For example, for the LCD interface studied in this thesis, $m = 8$ bits, and the best variant of the MCA scheme has $p = 6$ bits. This indicates that the buffer size should be $m+2=10$ bits. Since, the preamble bits indicate the length of the codeword being transmitted, the data can be buffered without ambiguity and uniquely decoded at the receiver. When the MCA scheme is used for applications like the LCD interface, which require a constant rate, the transmitter can be switched off after sufficient data is transmitted (in order to save energy). For instance, since an LCD requires a constant frame rate for its display, the transmitter can be switched off after sending each frame (i.e. an entire screen) of data, until the time for transmitting the next frame arrives. In such applications, the savings obtained in rate would manifest as *further* savings in energy.

The 2-LIWT encoding scheme is the best known energy minimization technique to date, for serial data transmission. The best variant of the MCA, when optimized to minimize EDP, yields an improvement of 11% in the total EDP savings over the 2-LIWT encoding scheme [2]. On the other hand, when optimized to minimize energy, the best variant of the MCA yields an improvement of 3% in the total energy savings over the 2-LIWT encoding scheme [2]. Moreover, when optimized to minimize energy, the IVPA yields an improvement of 0.7-1.1% over the IVTM scheme, mainly due to the considerable reduction of inter-vector transitions in the IVPA scheme.

Also the best variant of the MCA is just 10.9% above the information theoretic lower bound on the average number of transitions per symbol, whereas the 2-LIWT is 37.6% above the lower bound.

The significant EDP savings obtained by the MCA over the 2-LIWT scheme is due to the fact that, the MCA scheme simultaneously 1. compresses the data by using very small codewords of different length, and 2. reduces the transitions by assigning the minimum transition codewords to the most probable symbols.

V-B. Future Work

The effectiveness of the proposed MCA scheme may be improved further by focusing on ways to reduce the inter-vector transitions. One way of achieving this is to find a more accurate way of calculating the probability of a transition at the codeword-vector interfaces.

The problem of reducing the inter-vector transitions can also be visualized as a problem of reducing the errors introduced by some hypothetical channel at the codeword-vector interfaces. The occurrence of a inter-vector transition can be thought of as an error. In general, the probability distribution of inter-vector transitions can be visualized as the probability distribution of the hypothetical channel introducing the errors. For example, if the hypothetical channel was the *Binary Symmetric Channel (BSC)*, the probability of a inter-vector transition could be thought of as the crossover probability of the BSC. Hence methods to correct the errors introduced by this hypothetical channel, would be methods to reduce the inter-vector transitions. In general, the channel need not be a BSC. It could be any general channel.

The EDP metric (which is the product of the number of transitions and the length of transmission) used in this thesis can be replaced by any other metric (such as the weighted sum of the number of transitions (or energy) and the length of transmission). The weights can be chosen depending on whether energy or rate is more important.

The idea of MCA introduced in this thesis can be extended to energy minimization in a parallel bus. However, the codewords should be chosen carefully so as to avoid the compatibility problems with the next codeword transmitted.

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APPENDIX A

RESULTS OF IVTM OPTIMIZED FOR EDP MINIMIZATION

The EDP and energy savings of the IVTM scheme (optimized for EDP minimization), for various values of codeword lengths (k, n and p) and range (R), averaged over 10 images of the SIPI database [21], have been presented below.

				Blue				Green				Red			
				% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings	
R	k	n	p	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra
10	2	2	4	38.84	67.57	64.66	81.02	40.84	68.69	65.95	81.73	39.94	68.05	65.22	81.22
10	2	2	5	39.88	67.45	63.58	80.01	41.86	68.58	64.96	80.80	41.01	67.94	64.13	80.18
10	2	2	6	40.14	67.30	62.33	79.13	42.06	68.45	63.74	79.98	41.27	67.81	62.80	79.25
10	2	3	4	41.62	67.37	65.61	80.58	43.47	68.53	66.82	81.33	42.66	67.95	66.23	80.89
10	2	3	5	42.06	67.50	64.85	80.07	43.91	68.67	66.12	80.86	43.12	68.09	65.45	80.35
10	2	3	6	42.09	67.57	64.03	79.63	43.97	68.63	65.39	80.40	43.22	68.07	64.65	79.84
10	2	3	7	42.39	67.83	63.27	79.25	44.27	68.91	64.70	80.07	43.53	68.39	63.88	79.48
10	2	4	4	43.73	67.57	64.93	79.60	45.54	68.71	66.22	80.40	44.79	68.17	65.65	79.96
10	2	4	5	44.03	67.89	64.52	79.45	45.82	69.00	65.84	80.26	45.11	68.50	65.23	79.80
10	2	4	6	43.98	67.40	64.00	78.85	45.68	68.53	65.32	79.71	45.00	68.03	64.65	79.19
10	2	4	7	42.50	65.55	63.49	77.92	44.29	66.78	64.83	78.82	43.51	66.15	64.14	78.24
10	2	4	8	42.50	65.55	63.25	77.78	44.29	66.78	64.60	78.68	43.51	66.15	63.89	78.08
10	2	5	5	44.63	66.61	62.66	77.30	46.35	67.79	64.06	78.23	45.66	67.18	63.41	77.63
10	2	5	6	44.59	66.60	62.49	77.20	46.37	67.78	63.93	78.13	45.68	67.17	63.26	77.53
10	2	5	7	44.59	66.60	62.33	77.10	46.37	67.78	63.78	78.04	45.68	67.17	63.10	77.42
10	2	5	8	44.59	66.60	62.17	77.00	46.37	67.78	63.63	77.95	45.68	67.17	62.93	77.32
10	2	5	9	44.59	66.60	62.01	76.90	46.37	67.78	63.48	77.86	45.68	67.17	62.77	77.22
10	2	6	6	44.16	66.87	60.22	76.19	46.00	68.11	61.82	77.25	45.33	67.52	61.05	76.56
10	2	6	7	44.16	66.87	60.09	76.11	46.00	68.11	61.69	77.17	45.33	67.52	60.91	76.48
10	2	6	8	44.16	66.87	59.96	76.03	46.00	68.11	61.57	77.09	45.33	67.52	60.77	76.39
10	2	6	9	44.16	66.87	59.83	75.95	46.00	68.11	61.44	77.02	45.33	67.52	60.63	76.31
10	2	6	10	44.16	66.87	59.69	75.87	46.00	68.11	61.31	76.94	45.33	67.52	60.49	76.22
10	3	3	3	42.94	66.59	65.70	79.79	44.79	67.78	66.81	80.50	44.03	67.13	66.43	80.14
10	3	3	4	43.22	66.96	65.31	79.69	45.05	68.11	66.44	80.39	44.30	67.49	66.02	80.02
10	3	3	5	43.44	67.22	64.74	79.43	45.25	68.39	65.91	80.18	44.52	67.81	65.43	79.78
10	3	3	6	43.00	66.33	64.21	78.72	44.82	67.51	65.41	79.49	44.08	66.87	64.90	79.03
10	3	3	7	43.00	66.33	63.70	78.41	44.82	67.51	64.94	79.20	44.08	66.87	64.39	78.71
10	3	4	4	44.47	66.39	64.39	78.32	46.26	67.59	65.59	79.12	45.57	66.99	65.16	78.71
10	3	4	5	44.47	66.39	64.08	78.13	46.26	67.59	65.31	78.95	45.57	66.99	64.84	78.51
10	3	4	6	44.19	66.07	63.80	77.86	45.99	67.28	65.05	78.69	45.27	66.64	64.56	78.23
10	3	4	7	43.97	65.75	63.63	77.64	45.78	66.98	64.89	78.48	45.04	66.31	64.40	78.01
10	3	4	8	43.82	65.56	63.55	77.52	45.65	66.81	64.79	78.36	44.92	66.17	64.29	77.89
10	3	5	5	45.16	66.72	62.51	77.13	46.93	67.87	63.85	77.99	46.24	67.26	63.32	77.49
10	3	5	6	45.16	66.72	62.36	77.03	46.93	67.87	63.71	77.90	46.24	67.26	63.16	77.39
10	3	5	7	45.16	66.72	62.20	76.93	46.93	67.87	63.56	77.81	46.24	67.26	63.00	77.29
10	3	5	8	44.96	66.32	62.14	76.70	46.76	67.52	63.51	77.61	46.05	66.89	62.95	77.09
10	3	5	9	44.96	66.32	62.02	76.63	46.76	67.52	63.41	77.54	46.05	66.89	62.83	77.01
10	3	6	6	45.38	67.15	60.64	76.22	47.14	68.29	62.08	77.13	46.45	67.72	61.47	76.62
10	3	6	7	45.38	67.15	60.51	76.14	47.14	68.29	61.96	77.05	46.45	67.72	61.34	76.53
10	3	6	8	45.31	67.04	60.42	76.04	47.05	68.14	61.89	76.95	46.35	67.58	61.27	76.43
10	3	6	9	45.31	67.04	60.31	75.97	47.05	68.14	61.79	76.89	46.35	67.58	61.16	76.36
10	3	6	10	45.31	67.04	60.20	75.90	47.05	68.14	61.69	76.82	46.35	67.58	61.05	76.29
10	3	7	7	45.94	67.23	58.76	74.89	47.69	68.38	60.33	75.89	47.03	67.82	59.66	75.32
10	3	7	8	45.84	66.97	58.73	74.71	47.58	68.09	60.29	75.70	46.93	67.54	59.61	75.13
10	3	7	9	45.84	66.97	58.63	74.66	47.58	68.09	60.20	75.65	46.93	67.54	59.51	75.06
10	3	7	10	45.84	66.97	58.54	74.60	47.58	68.09	60.11	75.59	46.93	67.54	59.41	75.00
10	3	7	11	45.84	66.97	58.44	74.54	47.58	68.09	60.02	75.54	46.93	67.54	59.31	74.93
10	4	4	4	45.43	65.82	62.85	76.65	47.14	66.95	64.01	77.41	46.51	66.31	63.65	77.00
10	4	4	5	45.43	65.82	62.70	76.55	47.14	66.95	63.86	77.32	46.51	66.31	63.49	76.90
10	4	4	6	45.43	65.82	62.54	76.45	47.14	66.95	63.71	77.22	46.51	66.31	63.33	76.80
10	4	4	7	45.43	65.82	62.38	76.35	47.14	66.95	63.57	77.13	46.51	66.31	63.17	76.70
10	4	4	8	45.43	65.82	62.22	76.25	47.14	66.95	63.42	77.04	46.51	66.31	63.01	76.59
10	4	5	5	46.08	66.09	61.56	75.75	47.75	67.27	62.79	76.61	47.12	66.66	62.37	76.17
10	4	5	6	46.08	66.09	61.44	75.67	47.75	67.27	62.67	76.53	47.12	66.66	62.24	76.08
10	4	5	7	46.08	66.09	61.31	75.58	47.75	67.27	62.54	76.45	47.12	66.66	62.10	76.00
10	4	5	8	46.08	66.09	61.18	75.50	47.75	67.27	62.42	76.37	47.12	66.66	61.97	75.91
10	4	5	9	46.08	66.09	61.05	75.42	47.75	67.27	62.30	76.29	47.12	66.66	61.83	75.82
10	4	6	6	46.67	66.25	60.18	74.72	48.33	67.44	61.50	75.65	47.74	66.82	61.03	75.15
10	4	6	7	46.67	66.25	60.05	74.64	48.33	67.44	61.38	75.57	47.74	66.82	60.90	75.06
10	4	6	8	46.67	66.25	59.93	74.56	48.33	67.44	61.26	75.49	47.74	66.82	60.77	74.98
10	4	6	9	46.67	66.25	59.80	74.48	48.33	67.44	61.14	75.42	47.74	66.82	60.64	74.89

				Blue				Green				Red			
				% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings	
R	k	n	p	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra
10	4	6	10	46.51	65.84	59.84	74.27	48.15	66.98	61.18	75.19	47.55	66.38	60.68	74.68
10	4	7	7	47.00	65.61	58.75	73.16	48.64	66.80	60.14	74.15	48.07	66.08	59.67	73.54
10	4	7	8	47.00	65.61	58.64	73.09	48.64	66.80	60.04	74.08	48.07	66.08	59.56	73.46
10	4	7	9	47.00	65.61	58.53	73.01	48.64	66.80	59.94	74.02	48.07	66.08	59.45	73.39
10	4	7	10	46.84	65.31	58.55	72.88	48.50	66.52	59.96	73.88	47.94	65.86	59.46	73.29
10	4	7	11	46.84	65.31	58.49	72.83	48.50	66.52	59.90	73.84	47.94	65.86	59.38	73.24
10	4	8	8	47.68	66.39	57.17	72.40	49.32	67.53	58.68	73.44	48.78	66.88	58.15	72.81
10	4	8	9	47.68	66.39	57.06	72.33	49.32	67.53	58.59	73.38	48.78	66.88	58.05	72.74
10	4	8	10	47.56	66.04	57.09	72.13	49.19	67.20	58.60	73.18	48.66	66.57	58.05	72.55
10	4	8	11	47.56	66.04	57.03	72.09	49.19	67.20	58.54	73.14	48.66	66.57	57.98	72.50
10	4	8	12	47.56	66.04	56.96	72.04	49.19	67.20	58.48	73.10	48.66	66.57	57.91	72.45
10	5	5	5	46.55	64.72	59.36	73.11	48.35	66.00	60.71	74.07	47.83	65.32	60.38	73.58
10	5	5	6	46.55	64.72	59.23	73.02	48.35	66.00	60.59	73.99	47.83	65.32	60.25	73.49
10	5	5	7	46.55	64.72	59.11	72.94	48.35	66.00	60.47	73.91	47.83	65.32	60.12	73.40
10	5	5	8	46.55	64.72	58.99	72.86	48.35	66.00	60.35	73.83	47.83	65.32	59.99	73.31
10	5	5	9	46.55	64.72	58.86	72.77	48.35	66.00	60.24	73.75	47.83	65.32	59.86	73.22
10	5	6	6	46.93	64.84	58.17	72.22	48.72	66.10	59.59	73.22	48.20	65.38	59.20	72.65
10	5	6	7	46.93	64.84	58.06	72.15	48.72	66.10	59.49	73.15	48.20	65.38	59.09	72.57
10	5	6	8	46.93	64.84	57.95	72.07	48.72	66.10	59.39	73.09	48.20	65.38	58.99	72.50
10	5	6	9	46.93	64.84	57.84	72.00	48.72	66.10	59.29	73.02	48.20	65.38	58.88	72.42
10	5	6	10	46.93	64.84	57.73	71.93	48.72	66.10	59.19	72.95	48.20	65.38	58.77	72.35
10	5	7	7	47.30	65.05	56.77	71.26	49.07	66.27	58.28	72.30	48.55	65.53	57.83	71.65
10	5	7	8	47.30	65.05	56.67	71.19	49.07	66.27	58.19	72.24	48.55	65.53	57.72	71.58
10	5	7	9	47.30	65.05	56.56	71.12	49.07	66.27	58.09	72.17	48.55	65.53	57.62	71.51
10	5	7	10	47.30	65.05	56.45	71.04	49.07	66.27	57.99	72.11	48.55	65.53	57.52	71.44
10	5	7	11	47.30	65.05	56.35	70.97	49.07	66.27	57.90	72.04	48.55	65.53	57.41	71.36
10	5	8	8	47.62	65.41	55.19	70.34	49.38	66.65	56.80	71.46	48.87	65.96	56.26	70.78
10	5	8	9	47.62	65.41	55.10	70.28	49.38	66.65	56.71	71.41	48.87	65.96	56.16	70.71
10	5	8	10	47.62	65.41	55.01	70.21	49.38	66.65	56.63	71.35	48.87	65.96	56.07	70.65
10	5	8	11	47.62	65.41	54.92	70.15	49.38	66.65	56.54	71.29	48.87	65.96	55.97	70.58
10	5	8	12	47.30	64.52	55.19	69.76	49.07	65.77	56.79	70.89	48.55	65.03	56.28	70.18
10	5	9	9	47.92	65.86	53.44	69.40	49.68	67.09	55.16	70.59	49.18	66.44	54.52	69.84
10	5	9	10	47.92	65.86	53.35	69.33	49.68	67.09	55.08	70.54	49.18	66.44	54.42	69.78
10	5	9	11	47.92	65.86	53.26	69.27	49.68	67.09	54.99	70.48	49.18	66.44	54.32	69.71
10	5	9	12	47.62	64.97	53.53	68.84	49.38	66.21	55.23	70.04	48.87	65.50	54.62	69.26
10	5	9	13	47.62	64.97	53.53	68.84	49.38	66.21	55.23	70.04	48.87	65.50	54.62	69.26
10	6	6	6	47.05	64.69	55.52	70.30	48.81	65.97	56.98	71.36	48.33	65.26	56.62	70.78
10	6	6	7	47.05	64.69	55.41	70.22	48.81	65.97	56.88	71.30	48.33	65.26	56.52	70.70
10	6	6	8	47.05	64.69	55.30	70.15	48.81	65.97	56.79	71.23	48.33	65.26	56.41	70.63
10	6	6	9	47.05	64.69	55.20	70.08	48.81	65.97	56.69	71.17	48.33	65.26	56.31	70.56
10	6	6	10	47.05	64.69	55.09	70.01	48.81	65.97	56.59	71.10	48.33	65.26	56.20	70.48
10	6	7	7	47.41	65.06	54.33	69.61	49.15	66.35	55.86	70.76	48.68	65.69	55.44	70.15
10	6	7	8	47.41	65.06	54.24	69.55	49.15	66.35	55.78	70.70	48.68	65.69	55.35	70.09
10	6	7	9	47.41	65.06	54.15	69.49	49.15	66.35	55.69	70.64	48.68	65.69	55.25	70.02
10	6	7	10	47.41	65.06	54.06	69.43	49.15	66.35	55.61	70.58	48.68	65.69	55.15	69.95
10	6	7	11	47.41	65.06	53.97	69.37	49.15	66.35	55.52	70.52	48.68	65.69	55.06	69.88
10	6	8	8	47.73	65.50	52.96	68.90	49.48	66.79	54.59	70.11	49.02	66.16	54.09	69.46
10	6	8	9	47.73	65.50	52.87	68.84	49.48	66.79	54.51	70.05	49.02	66.16	54.00	69.39
10	6	8	10	47.73	65.50	52.78	68.78	49.48	66.79	54.42	69.99	49.02	66.16	53.90	69.33
10	6	8	11	47.73	65.50	52.69	68.72	49.48	66.79	54.34	69.94	49.02	66.16	53.80	69.26
10	6	8	12	47.73	65.50	52.60	68.66	49.48	66.79	54.25	69.88	49.02	66.16	53.71	69.20
10	6	9	9	48.03	65.83	51.44	68.01	49.75	67.06	53.16	69.25	49.29	66.42	52.57	68.51
10	6	9	10	48.03	65.83	51.36	67.96	49.75	67.06	53.09	69.20	49.29	66.42	52.49	68.45
10	6	9	11	48.03	65.83	51.28	67.91	49.75	67.06	53.03	69.15	49.29	66.42	52.41	68.40
10	6	9	12	48.03	65.83	51.20	67.85	49.75	67.06	52.96	69.11	49.29	66.42	52.34	68.35
10	6	9	13	48.03	65.83	51.13	67.80	49.75	67.06	52.89	69.06	49.29	66.42	52.26	68.30
10	6	10	10	48.31	66.20	49.76	67.09	50.02	67.39	51.62	68.38	49.57	66.78	50.91	67.58
10	6	10	11	48.31	66.20	49.69	67.04	50.02	67.39	51.55	68.33	49.57	66.78	50.83	67.52
10	6	10	12	48.31	66.20	49.61	66.99	50.02	67.39	51.48	68.29	49.57	66.78	50.76	67.47
10	6	10	13	48.31	66.20	49.53	66.94	50.02	67.39	51.41	68.24	49.57	66.78	50.68	67.42
10	6	10	14	48.03	65.44	49.80	66.56	49.75	66.71	51.63	67.89	49.29	66.05	50.94	67.07
20	2	2	6	45.70	72.55	67.32	83.28	46.63	72.92	67.97	83.56	46.63	73.29	67.75	83.64
20	2	3	5	47.27	72.83	70.09	84.47	48.13	73.22	70.59	84.69	48.14	73.64	70.65	84.95
20	2	3	6	48.13	73.05	69.20	83.85	48.99	73.31	69.80	84.06	49.06	73.80	69.76	84.28
20	2	3	7	48.91	73.83	68.20	83.55	49.77	74.13	68.90	83.82	49.85	74.63	68.75	84.00
20	2	4	5	50.35	73.14	70.72	84.06	51.08	73.49	71.18	84.28	51.27	73.98	71.39	84.59
20	2	4	6	50.87	73.36	70.23	83.74	51.50	73.69	70.69	83.98	51.70	74.19	70.82	84.26
20	2	4	7	50.40	72.47	69.36	82.85	51.00	72.79	69.86	83.12	51.20	73.27	69.93	83.36
20	2	4	8	50.63	72.64	68.72	82.51	51.21	72.95	69.25	82.80	51.44	73.44	69.28	83.00
20	2	5	5	52.68	73.04	69.98	82.79	53.22	73.35	70.43	83.04	53.53	73.82	70.67	83.33
20	2	5	6	52.91	73.26	69.67	82.66	53.47	73.54	70.16	82.91	53.81	74.04	70.39	83.19
20	2	5	7	53.14	73.45	69.33	82.50	53.68	73.71	69.84	82.75	54.04	74.23	70.04	83.03
20	2	5	8	53.26	73.48	68.98	82.26	53.77	73.73	69.51	82.53	54.17	74.26	69.70	82.79
20	2	5	9	52.19	72.39	68.38	81.60	52.85	72.80	68.97	81.95	53.12	73.17	69.10	82.12
20	2	6	6	53.47	73.38	68.18	81.65	53.98	73.78	68.70	82.02	54.48	74.28	68.97	82.26
20	2	6	7	53.62	73.49	67.99	81.55	54.11	73.88	68.51	81.92	54.63	74.38	68.77	82.15
20	2	6	8	53.76	73.59	67.75	81.42	54.25	73.99	68.28	81.81	54.77	74.49	68.53	82.03
20	2	6	9	53.88	73.69	67.46	81.27	54.37	74.08	68.01	81.66	54.90	74.59	68.24	81.87
20	2	6	10	52.32	71.97	66.92	80.39	52.94	72.47	67.53	80.83	53.29	72.86	67.66	80.98

				Blue				Green				Red			
				% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings	
R	k	n	p	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra
20	3	3	5	49.56	72.81	70.66	84.12	50.33	73.19	71.01	84.28	50.47	73.66	71.28	84.66
20	3	3	6	50.06	72.90	70.00	83.64	50.78	73.21	70.40	83.81	50.92	73.62	70.60	84.11
20	3	3	7	50.51	72.98	69.22	83.10	51.21	73.30	69.68	83.31	51.37	73.74	69.81	83.59
20	3	4	5	51.88	72.92	71.02	83.64	52.53	73.28	71.35	83.81	52.76	73.74	71.70	84.20
20	3	4	6	52.05	72.67	70.53	83.13	52.69	73.01	70.88	83.32	52.91	73.44	71.19	83.67
20	3	4	7	51.78	72.27	69.94	82.64	52.43	72.64	70.33	82.85	52.67	73.09	70.61	83.20
20	3	4	8	51.78	72.22	69.52	82.36	52.44	72.61	69.93	82.59	52.70	73.07	70.17	82.91
20	3	5	5	53.63	72.98	70.20	82.57	54.16	73.29	70.55	82.76	54.50	73.77	70.91	83.15
20	3	5	6	53.71	73.04	69.95	82.43	54.23	73.34	70.31	82.63	54.59	73.84	70.67	83.01
20	3	5	7	53.85	73.26	69.67	82.36	54.37	73.56	70.05	82.56	54.74	74.05	70.38	82.92
20	3	5	8	53.79	73.08	69.41	82.10	54.31	73.40	69.81	82.34	54.69	73.90	70.13	82.69
20	3	5	9	52.90	71.81	69.05	81.39	53.55	72.26	69.49	81.69	53.80	72.63	69.78	81.99
20	3	6	6	54.73	73.42	68.62	81.50	55.19	73.75	69.02	81.77	55.62	74.22	69.38	82.11
20	3	6	7	54.82	73.50	68.43	81.41	55.28	73.83	68.84	81.68	55.72	74.30	69.19	82.01
20	3	6	8	54.83	73.48	68.24	81.27	55.27	73.76	68.67	81.53	55.70	74.25	69.00	81.86
20	3	6	9	54.92	73.56	68.01	81.15	55.35	73.84	68.44	81.42	55.78	74.33	68.78	81.75
20	3	6	10	53.90	72.49	67.72	80.65	54.41	72.83	68.19	80.95	54.75	73.27	68.47	81.25
20	3	7	7	55.51	73.49	66.73	80.09	55.95	73.81	67.22	80.41	56.42	74.29	67.55	80.72
20	3	7	8	55.40	73.23	66.64	79.89	55.83	73.52	67.13	80.20	56.31	74.01	67.45	80.50
20	3	7	9	55.40	73.23	66.52	79.81	55.83	73.52	67.01	80.12	56.31	74.01	67.32	80.42
20	3	7	10	55.40	73.23	66.40	79.74	55.83	73.52	66.90	80.05	56.31	74.01	67.20	80.34
20	3	7	11	55.40	73.23	66.28	79.66	55.83	73.52	66.78	79.98	56.31	74.01	67.07	80.27
20	4	4	4	53.29	72.32	70.60	82.56	53.84	72.59	70.80	82.64	54.15	73.05	71.29	83.10
20	4	4	5	53.45	72.25	70.29	82.26	53.97	72.52	70.50	82.36	54.30	72.97	70.97	82.80
20	4	4	6	53.42	72.26	69.90	82.04	53.93	72.52	70.13	82.15	54.28	72.99	70.58	82.58
20	4	4	7	53.05	71.62	69.55	81.56	53.61	71.97	69.80	81.71	53.91	72.32	70.23	82.08
20	4	4	8	53.13	71.71	69.30	81.43	53.68	72.05	69.56	81.59	53.98	72.41	69.98	81.95
20	4	5	5	54.61	72.58	69.50	81.54	55.06	72.91	69.72	81.71	55.47	73.39	70.20	82.16
20	4	5	6	54.72	72.70	69.30	81.46	55.15	73.00	69.54	81.63	55.56	73.49	69.99	82.06
20	4	5	7	54.61	72.50	69.04	81.20	55.07	72.85	69.29	81.40	55.45	73.28	69.73	81.80
20	4	5	8	54.68	72.58	68.80	81.08	55.13	72.93	69.05	81.28	55.52	73.36	69.49	81.67
20	4	5	9	54.00	71.40	68.68	80.49	54.50	71.80	68.95	80.71	54.83	72.18	69.35	81.08
20	4	6	6	55.73	73.09	68.15	80.60	56.15	73.42	68.46	80.83	56.63	73.87	68.91	81.21
20	4	6	7	55.41	72.63	67.90	80.25	55.85	72.98	68.20	80.49	56.31	73.42	68.64	80.86
20	4	6	8	55.41	72.63	67.75	80.16	55.85	72.98	68.06	80.40	56.31	73.42	68.49	80.77
20	4	6	9	55.41	72.63	67.60	80.07	55.85	72.98	67.92	80.31	56.31	73.42	68.34	80.67
20	4	6	10	54.96	71.89	67.56	79.71	55.38	72.20	67.89	79.94	55.81	72.64	68.29	80.31
20	4	7	7	55.30	72.21	66.26	78.98	55.77	72.55	66.64	79.25	56.21	72.93	67.07	79.58
20	4	7	8	55.30	72.21	66.17	78.93	55.77	72.55	66.56	79.19	56.21	72.93	66.98	79.52
20	4	7	9	55.30	72.21	66.09	78.87	55.77	72.55	66.47	79.14	56.21	72.93	66.89	79.46
20	4	7	10	55.13	71.92	66.07	78.72	55.62	72.27	66.47	79.00	56.07	72.71	66.87	79.35
20	4	7	11	55.13	71.92	66.02	78.68	55.62	72.27	66.42	78.96	56.07	72.71	66.81	79.31
20	4	8	8	55.79	72.76	64.59	78.13	56.25	73.07	65.06	78.44	56.69	73.51	65.44	78.79
20	4	8	9	55.79	72.76	64.50	78.08	56.25	73.07	64.98	78.39	56.69	73.51	65.35	78.73
20	4	8	10	55.65	72.41	64.50	77.86	56.11	72.74	64.97	78.18	56.56	73.20	65.34	78.53
20	4	8	11	55.65	72.41	64.45	77.83	56.11	72.74	64.92	78.15	56.56	73.20	65.28	78.50
20	4	8	12	55.65	72.41	64.39	77.80	56.11	72.74	64.87	78.12	56.56	73.20	65.22	78.46
20	5	5	5	55.29	71.99	67.73	79.76	55.85	72.36	68.02	79.96	56.35	72.79	68.59	80.41
20	5	5	6	55.37	72.16	67.58	79.75	55.93	72.52	67.87	79.95	56.43	72.97	68.43	80.39
20	5	5	7	55.44	72.33	67.39	79.72	56.00	72.68	67.69	79.92	56.50	73.13	68.24	80.36
20	5	5	8	55.51	72.47	67.17	79.66	56.07	72.83	67.48	79.86	56.57	73.29	68.02	80.30
20	5	5	9	54.84	71.18	66.98	78.90	55.40	71.57	67.29	79.13	55.89	71.99	67.83	79.54
20	5	6	6	55.98	72.26	66.59	78.91	56.51	72.59	66.93	79.13	57.03	73.01	67.46	79.53
20	5	6	7	55.98	72.26	66.47	78.84	56.51	72.59	66.82	79.05	57.03	73.01	67.35	79.46
20	5	6	8	55.98	72.26	66.36	78.76	56.51	72.59	66.71	78.98	57.03	73.01	67.23	79.38
20	5	6	9	55.85	71.93	66.25	78.51	56.38	72.27	66.61	78.74	56.89	72.68	67.12	79.13
20	5	6	10	55.85	71.93	66.16	78.46	56.38	72.27	66.52	78.68	56.89	72.68	67.04	79.07
20	5	7	7	56.43	72.60	65.22	78.09	56.95	72.88	65.62	78.30	57.47	73.31	66.12	78.69
20	5	7	8	56.43	72.60	65.13	78.03	56.95	72.88	65.54	78.25	57.47	73.31	66.03	78.64
20	5	7	9	56.43	72.60	65.05	77.98	56.95	72.88	65.46	78.20	57.47	73.31	65.95	78.59
20	5	7	10	56.43	72.60	64.96	77.92	56.95	72.88	65.38	78.15	57.47	73.31	65.87	78.53
20	5	7	11	56.43	72.60	64.87	77.87	56.95	72.88	65.30	78.10	57.47	73.31	65.78	78.48
20	5	8	8	56.81	72.94	63.75	77.25	57.31	73.25	64.21	77.53	57.85	73.75	64.67	77.94
20	5	8	9	56.81	72.94	63.68	77.20	57.31	73.25	64.14	77.49	57.85	73.75	64.59	77.89
20	5	8	10	56.81	72.94	63.61	77.16	57.31	73.25	64.07	77.44	57.85	73.75	64.51	77.84
20	5	8	11	56.81	72.94	63.53	77.11	57.31	73.25	64.00	77.40	57.85	73.75	64.44	77.79
20	5	8	12	56.63	72.55	63.58	76.90	57.13	72.82	64.04	77.16	57.66	73.28	64.50	77.54
20	5	9	9	56.16	71.88	62.27	75.76	56.72	72.31	62.78	76.15	57.24	72.70	63.22	76.46
20	5	9	10	56.16	71.88	62.20	75.71	56.72	72.31	62.71	76.10	57.24	72.70	63.14	76.41
20	5	9	11	56.16	71.88	62.12	75.66	56.72	72.31	62.64	76.06	57.24	72.70	63.06	76.35
20	5	9	12	56.00	71.47	62.18	75.44	56.54	71.87	62.69	75.81	57.05	72.21	63.14	76.09
20	5	9	13	56.00	71.47	62.15	75.41	56.54	71.87	62.66	75.79	57.05	72.21	63.10	76.07
20	6	6	6	56.56	71.72	64.61	76.95	57.04	72.11	64.94	77.23	57.64	72.52	65.56	77.65
20	6	6	7	56.56	71.72	64.53	76.90	57.04	72.11	64.86	77.17	57.64	72.52	65.48	77.59
20	6	6	8	56.56	71.72	64.44	76.84	57.04	72.11	64.78	77.12	57.64	72.52	65.39	77.54
20	6	6	9	56.56	71.72	64.36	76.78	57.04	72.11	64.70	77.07	57.64	72.52	65.31	77.48
20	6	6	10	56.56	71.72	64.27	76.73	57.04	72.11	64.62	77.02	57.64	72.52	65.23	77.43
20	6	7	7	56.96	72.08	63.55	76.33	57.43	72.50	63.92	76.67	58.05	72.96	64.52	77.11
20	6	7	8	56.96	72.08	63.48	76.29	57.43	72.50	63.85	76.63	58.05	72.96	64.44	77.06

				Blue				Green				Red			
				% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings	
R	k	n	p	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra
20	6	7	9	56.96	72.08	63.41	76.24	57.43	72.50	63.78	76.58	58.05	72.96	64.37	77.01
20	6	7	10	56.96	72.08	63.34	76.19	57.43	72.50	63.71	76.54	58.05	72.96	64.29	76.96
20	6	7	11	56.96	72.08	63.26	76.14	57.43	72.50	63.64	76.49	58.05	72.96	64.21	76.90
20	6	8	8	57.32	72.50	62.38	75.74	57.80	72.93	62.81	76.12	58.44	73.41	63.38	76.55
20	6	8	9	57.32	72.50	62.31	75.69	57.80	72.93	62.74	76.07	58.44	73.41	63.31	76.50
20	6	8	10	57.32	72.50	62.24	75.64	57.80	72.93	62.67	76.03	58.44	73.41	63.23	76.44
20	6	8	11	57.32	72.50	62.17	75.60	57.80	72.93	62.60	75.98	58.44	73.41	63.16	76.39
20	6	8	12	57.32	72.50	62.10	75.55	57.80	72.93	62.53	75.94	58.44	73.41	63.08	76.34
20	6	9	9	57.66	72.80	61.15	75.01	58.11	73.19	61.60	75.40	58.75	73.65	62.15	75.78
20	6	9	10	57.66	72.80	61.09	74.97	58.11	73.19	61.55	75.36	58.75	73.65	62.09	75.74
20	6	9	11	57.66	72.80	61.03	74.93	58.11	73.19	61.49	75.32	58.75	73.65	62.03	75.70
20	6	9	12	57.66	72.80	60.96	74.89	58.11	73.19	61.44	75.29	58.75	73.65	61.97	75.66
20	6	9	13	57.66	72.80	60.90	74.85	58.11	73.19	61.38	75.25	58.75	73.65	61.91	75.62
20	6	10	10	57.55	71.68	59.86	73.19	57.98	72.08	60.36	73.62	58.64	72.51	60.88	73.94
20	6	10	11	57.55	71.68	59.80	73.15	57.98	72.08	60.31	73.59	58.64	72.51	60.82	73.90
20	6	10	12	57.55	71.68	59.74	73.10	57.98	72.08	60.25	73.55	58.64	72.51	60.76	73.86
20	6	10	13	57.55	71.68	59.68	73.06	57.98	72.08	60.20	73.51	58.64	72.51	60.70	73.82
20	6	10	14	57.40	71.22	59.80	72.80	57.82	71.66	60.28	73.28	58.48	72.07	60.81	73.59
50	2	3	7	50.59	75.03	69.58	84.48	51.42	75.37	70.27	84.79	51.49	75.90	70.08	84.96
50	2	4	7	52.48	74.47	70.97	84.29	53.10	74.81	71.50	84.58	53.25	75.35	71.49	84.82
50	2	4	8	53.05	74.87	70.30	83.97	53.69	75.25	70.87	84.30	53.79	75.73	70.80	84.49
50	2	5	7	55.61	75.69	71.30	84.18	56.23	76.02	71.88	84.49	56.47	76.52	71.95	84.72
50	2	5	8	55.87	75.57	70.87	83.75	56.49	75.93	71.46	84.09	56.73	76.39	71.54	84.30
50	2	5	9	54.77	74.54	70.07	83.02	55.55	75.07	70.71	83.44	55.62	75.35	70.74	83.57
50	2	6	6	56.16	75.13	70.58	83.18	56.78	75.62	71.20	83.63	57.13	76.08	71.30	83.81
50	2	6	7	56.39	75.34	70.36	83.10	56.99	75.81	70.97	83.54	57.34	76.29	71.07	83.73
50	2	6	8	56.56	75.56	70.07	83.02	57.17	76.06	70.69	83.47	57.52	76.52	70.78	83.65
50	2	6	9	56.70	75.37	69.84	82.68	57.30	75.83	70.47	83.12	57.66	76.31	70.56	83.31
50	2	6	10	55.46	74.17	69.16	81.95	56.22	74.77	69.84	82.45	56.38	75.09	69.86	82.56
50	3	3	7	52.36	74.70	70.68	84.36	53.06	75.05	71.17	84.60	53.19	75.55	71.24	84.88
50	3	4	7	54.02	74.38	71.65	84.15	54.71	74.79	72.08	84.40	54.89	75.28	72.27	84.73
50	3	4	8	54.30	74.49	71.16	83.83	55.04	74.94	71.62	84.11	55.17	75.40	71.76	84.42
50	3	5	6	55.95	75.10	71.98	84.12	56.50	75.45	72.41	84.37	56.82	75.98	72.65	84.72
50	3	5	7	56.46	75.49	71.74	84.03	57.05	75.86	72.20	84.31	57.29	76.32	72.39	84.61
50	3	5	8	56.42	75.01	71.42	83.55	57.04	75.43	71.89	83.86	57.26	75.87	72.08	84.15
50	3	5	9	55.76	74.27	70.91	83.01	56.52	74.84	71.42	83.38	56.59	75.15	71.58	83.63
50	3	6	6	57.53	75.31	71.09	83.14	58.12	75.71	71.62	83.47	58.38	76.17	71.78	83.75
50	3	6	7	57.71	75.50	70.90	83.08	58.29	75.90	71.42	83.42	58.54	76.35	71.58	83.69
50	3	6	8	57.79	75.61	70.69	82.99	58.36	75.99	71.22	83.33	58.58	76.41	71.37	83.60
50	3	6	9	57.83	75.37	70.47	82.68	58.39	75.72	71.01	83.00	58.62	76.18	71.17	83.29
50	3	6	10	57.01	74.48	70.03	82.13	57.65	74.92	70.58	82.49	57.80	75.29	70.73	82.75
50	3	7	7	58.89	76.06	69.55	82.19	59.48	76.46	70.16	82.58	59.74	76.91	70.29	82.84
50	3	7	8	58.86	75.83	69.43	81.96	59.43	76.18	70.04	82.32	59.70	76.65	70.17	82.59
50	3	7	9	58.93	75.89	69.28	81.89	59.51	76.25	69.89	82.25	59.78	76.72	70.02	82.52
50	3	7	10	58.92	75.78	69.14	81.72	59.48	76.11	69.75	82.07	59.79	76.63	69.88	82.36
50	3	7	11	58.99	75.85	68.98	81.64	59.55	76.19	69.60	82.00	59.87	76.71	69.72	82.29
50	4	4	7	55.65	73.93	71.53	83.24	56.30	74.36	71.86	83.46	56.46	74.69	72.14	83.78
50	4	4	8	55.91	74.05	71.15	82.99	56.58	74.49	71.50	83.22	56.70	74.81	71.77	83.54
50	4	5	6	57.29	74.68	71.68	83.19	57.81	75.06	72.02	83.44	58.10	75.54	72.31	83.80
50	4	5	7	57.41	74.58	71.44	82.93	57.98	75.02	71.80	83.21	58.19	75.41	72.06	83.54
50	4	5	8	57.52	74.60	71.18	82.74	58.09	75.05	71.53	83.02	58.28	75.42	71.80	83.35
50	4	5	9	57.25	74.22	70.88	82.41	57.88	74.74	71.24	82.71	58.01	75.02	71.50	83.00
50	4	6	6	58.65	75.13	70.86	82.44	59.21	75.53	71.29	82.75	59.49	75.97	71.53	83.07
50	4	6	7	58.67	75.14	70.68	82.33	59.24	75.56	71.12	82.65	59.50	75.98	71.34	82.95
50	4	6	8	58.79	75.31	70.49	82.28	59.37	75.75	70.93	82.61	59.60	76.12	71.15	82.90
50	4	6	9	58.74	75.05	70.28	81.99	59.30	75.44	70.72	82.28	59.57	75.89	70.95	82.62
50	4	6	10	58.10	74.05	70.08	81.43	58.68	74.46	70.53	81.74	58.86	74.84	70.74	82.05
50	4	7	7	59.02	74.85	69.37	81.16	59.63	75.28	69.88	81.51	59.84	75.61	70.07	81.77
50	4	7	8	59.07	74.90	69.24	81.10	59.68	75.33	69.75	81.45	59.89	75.67	69.95	81.71
50	4	7	9	59.12	74.95	69.10	81.02	59.73	75.38	69.62	81.38	59.93	75.71	69.82	81.64
50	4	7	10	58.88	74.56	69.00	80.78	59.52	75.01	69.53	81.14	59.76	75.42	69.72	81.44
50	4	7	11	58.93	74.61	68.89	80.73	59.57	75.06	69.42	81.09	59.80	75.47	69.61	81.39
50	4	8	8	59.82	75.42	67.88	80.30	60.45	75.86	68.48	80.70	60.64	76.23	68.64	80.99
50	4	8	9	59.85	75.46	67.78	80.26	60.48	75.90	68.38	80.66	60.67	76.27	68.55	80.94
50	4	8	10	59.71	75.12	67.73	80.02	60.34	75.59	68.32	80.44	60.55	75.96	68.48	80.71
50	4	8	11	59.74	75.16	67.64	79.98	60.37	75.63	68.24	80.40	60.58	75.99	68.40	80.67
50	4	8	12	59.76	75.18	67.55	79.93	60.40	75.66	68.14	80.36	60.60	76.02	68.30	80.63
50	5	5	6	58.28	74.29	70.35	81.72	58.94	74.74	70.78	82.02	59.26	75.13	71.11	82.36
50	5	5	7	58.42	74.42	70.16	81.63	59.08	74.88	70.59	81.93	59.39	75.27	70.92	82.27
50	5	5	8	58.47	74.43	69.93	81.48	59.13	74.89	70.36	81.77	59.43	75.27	70.69	82.11
50	5	5	9	58.08	73.64	69.70	80.93	58.79	74.16	70.13	81.25	59.04	74.48	70.46	81.58
50	5	6	6	59.29	74.72	69.68	81.15	59.94	75.14	70.15	81.46	60.25	75.53	70.44	81.79
50	5	6	7	59.40	74.85	69.55	81.12	60.06	75.28	70.04	81.44	60.35	75.64	70.32	81.75
50	5	6	8	59.42	74.82	69.38	80.98	60.07	75.23	69.86	81.28	60.36	75.62	70.15	81.61
50	5	6	9	59.11	74.30	69.15	80.59	59.78	74.72	69.64	80.90	60.08	75.12	69.94	81.24
50	5	6	10	58.93	74.03	69.00	80.38	59.60	74.45	69.50	80.68	59.89	74.82	69.79	81.01
50	5	7	7	60.17	75.20	68.55	80.39	60.81	75.56	69.09	80.70	61.10	75.96	69.34	81.02
50	5	7	8	60.19	75.22	68.43	80.32	60.84	75.59	68.98	80.63	61.13	75.99	69.23	80.95
50	5	7	9	60.09	75.03	68.30	80.13	60.74	75.42	68.84	80.46	61.02	75.79	69.10	80.77

				Blue				Green				Red			
				% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings	
R	k	n	p	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra
50	5	7	10	60.11	75.06	68.19	80.08	60.77	75.47	68.74	80.42	61.05	75.83	68.99	80.72
50	5	7	11	60.14	75.10	68.08	80.02	60.80	75.51	68.62	80.37	61.07	75.86	68.88	80.66
50	5	8	8	60.71	75.58	67.20	79.57	61.36	76.02	67.80	79.97	61.67	76.43	68.02	80.28
50	5	8	9	60.65	75.48	67.09	79.45	61.31	75.92	67.69	79.85	61.60	76.31	67.91	80.14
50	5	8	10	60.67	75.50	67.01	79.41	61.33	75.95	67.61	79.81	61.62	76.33	67.82	80.10
50	5	8	11	60.69	75.53	66.92	79.37	61.35	75.98	67.52	79.77	61.63	76.35	67.73	80.05
50	5	8	12	60.45	75.07	66.89	79.09	61.10	75.47	67.49	79.46	61.39	75.82	67.72	79.73
50	5	9	9	60.29	74.80	65.65	78.16	61.04	75.38	66.32	78.67	61.25	75.65	66.50	78.89
50	5	9	10	60.31	74.82	65.58	78.12	61.05	75.39	66.24	78.62	61.26	75.66	66.42	78.85
50	5	9	11	60.32	74.83	65.49	78.07	61.06	75.40	66.15	78.58	61.27	75.67	66.33	78.79
50	5	9	12	60.12	74.38	65.50	77.79	60.85	74.92	66.15	78.27	61.04	75.15	66.35	78.47
50	5	9	13	60.13	74.39	65.45	77.76	60.86	74.93	66.10	78.24	61.05	75.16	66.30	78.44
50	6	6	6	60.07	74.20	67.95	79.29	60.68	74.68	68.42	79.66	61.03	75.03	68.76	79.98
50	6	6	7	60.10	74.26	67.83	79.24	60.72	74.75	68.31	79.62	61.06	75.09	68.65	79.94
50	6	6	8	60.13	74.32	67.70	79.19	60.75	74.80	68.19	79.57	61.10	75.16	68.53	79.89
50	6	6	9	60.11	74.27	67.55	79.06	60.73	74.74	68.04	79.43	61.09	75.12	68.39	79.78
50	6	6	10	59.85	73.72	67.40	78.65	60.47	74.22	67.88	79.05	60.82	74.56	68.24	79.36
50	6	7	7	60.69	74.63	67.01	78.70	61.31	75.17	67.53	79.15	61.66	75.56	67.86	79.50
50	6	7	8	60.71	74.68	66.92	78.67	61.34	75.22	67.45	79.12	61.69	75.60	67.77	79.46
50	6	7	9	60.74	74.72	66.83	78.63	61.36	75.27	67.35	79.09	61.71	75.65	67.67	79.42
50	6	7	10	60.60	74.46	66.70	78.39	61.23	75.02	67.22	78.86	61.57	75.36	67.54	79.16
50	6	7	11	60.61	74.48	66.61	78.35	61.23	75.04	67.13	78.82	61.58	75.37	67.45	79.11
50	6	8	8	61.22	75.12	65.93	78.12	61.86	75.69	66.51	78.63	62.21	76.06	66.80	78.94
50	6	8	9	61.24	75.14	65.84	78.07	61.89	75.72	66.43	78.59	62.23	76.08	66.72	78.89
50	6	8	10	61.15	74.98	65.73	77.90	61.79	75.53	66.31	78.40	62.14	75.91	66.60	78.71
50	6	8	11	61.16	74.99	65.65	77.85	61.80	75.54	66.23	78.35	62.15	75.92	66.52	78.66
50	6	8	12	61.16	75.00	65.56	77.80	61.81	75.55	66.15	78.30	62.16	75.92	66.44	78.61
50	6	9	9	61.67	75.38	64.74	77.32	62.30	75.90	65.36	77.82	62.63	76.26	65.61	78.11
50	6	9	10	61.62	75.28	64.65	77.20	62.24	75.80	65.27	77.70	62.57	76.16	65.52	77.99
50	6	9	11	61.63	75.31	64.58	77.17	62.26	75.82	65.21	77.68	62.58	76.18	65.46	77.96
50	6	9	12	61.64	75.33	64.52	77.14	62.27	75.85	65.15	77.65	62.59	76.19	65.40	77.93
50	6	9	13	61.64	75.32	64.45	77.09	62.27	75.84	65.08	77.60	62.59	76.19	65.34	77.88
50	6	10	10	61.09	74.34	63.20	75.69	61.72	74.90	63.84	76.26	62.03	75.18	64.10	76.48
50	6	10	11	61.09	74.34	63.14	75.65	61.72	74.90	63.79	76.22	62.03	75.18	64.04	76.44
50	6	10	12	61.09	74.34	63.08	75.62	61.72	74.90	63.74	76.19	62.03	75.18	63.99	76.40
50	6	10	13	61.09	74.34	63.02	75.58	61.72	74.90	63.69	76.15	62.03	75.18	63.93	76.36
50	6	10	14	60.91	73.83	63.10	75.27	61.52	74.43	63.74	75.87	61.85	74.71	64.01	76.09
255	2	5	9	55.13	74.77	70.26	83.14	55.93	75.29	70.89	83.55	55.88	75.53	70.88	83.66
255	2	6	9	57.10	75.66	70.08	82.87	57.72	76.10	70.72	83.29	57.91	76.51	70.72	83.44
255	2	6	10	55.89	74.51	69.36	82.13	56.68	75.13	70.05	82.64	56.66	75.35	70.00	82.71
255	3	5	9	56.12	74.51	71.09	83.14	56.90	75.06	71.60	83.49	56.85	75.33	71.72	83.73
255	3	6	9	58.24	75.70	70.72	82.89	58.83	76.04	71.27	83.20	58.89	76.42	71.33	83.45
255	3	6	10	57.44	74.84	70.24	82.33	58.14	75.30	70.81	82.69	58.09	75.56	70.87	82.90
255	3	7	9	59.40	76.23	69.63	82.13	60.02	76.59	70.26	82.50	60.09	76.98	70.24	82.71
255	3	7	10	59.39	76.05	69.46	81.90	60.01	76.39	70.10	82.25	60.12	76.81	70.10	82.49
255	3	7	11	59.49	76.15	69.29	81.83	60.12	76.50	69.94	82.18	60.20	76.90	69.94	82.41
255	4	5	9	57.60	74.46	71.07	82.54	58.26	74.97	71.43	82.83	58.25	75.19	71.64	83.10
255	4	6	9	59.17	75.41	70.56	82.23	59.78	75.81	71.02	82.52	59.87	76.15	71.14	82.80
255	4	6	10	58.56	74.45	70.32	81.66	59.19	74.88	70.79	81.97	59.17	75.13	70.91	82.23
255	4	7	9	59.60	75.32	69.46	81.30	60.26	75.76	70.01	81.66	60.25	75.98	70.05	81.84
255	4	7	10	59.35	74.83	69.33	80.97	60.05	75.28	69.90	81.33	60.07	75.60	69.95	81.57
255	4	7	11	59.42	74.91	69.22	80.92	60.13	75.36	69.78	81.28	60.13	75.65	69.84	81.52
255	4	8	8	60.35	75.75	68.31	80.57	61.05	76.20	68.96	80.98	61.00	76.47	68.93	81.18
255	4	8	9	60.40	75.82	68.20	80.53	61.10	76.28	68.86	80.95	61.04	76.51	68.83	81.13
255	4	8	10	60.27	75.51	68.14	80.30	60.98	75.99	68.78	80.73	60.93	76.21	68.76	80.90
255	4	8	11	60.31	75.55	68.03	80.26	61.02	76.04	68.67	80.68	60.95	76.25	68.66	80.85
255	4	8	12	60.29	75.38	67.96	80.08	61.01	75.85	68.61	80.49	60.95	76.17	68.58	80.74
255	5	5	9	58.45	73.97	69.92	81.14	59.20	74.49	70.37	81.46	59.29	74.72	70.62	81.74
255	5	6	9	59.61	74.72	69.49	80.88	60.33	75.16	70.01	81.20	60.42	75.41	70.17	81.44
255	5	6	10	59.46	74.48	69.30	80.66	60.19	74.93	69.83	80.98	60.25	75.15	70.00	81.22
255	5	7	9	60.58	75.42	68.69	80.44	61.30	75.84	69.28	80.79	61.36	76.08	69.36	81.00
255	5	7	10	60.55	75.32	68.55	80.29	61.27	75.72	69.15	80.62	61.34	75.98	69.24	80.85
255	5	7	11	60.60	75.37	68.44	80.23	61.33	75.78	69.03	80.57	61.36	76.02	69.13	80.80
255	5	8	8	61.28	75.89	67.68	79.83	62.01	76.33	68.34	80.24	62.06	76.64	68.35	80.46
255	5	8	9	61.24	75.81	67.57	79.72	61.98	76.26	68.24	80.13	62.00	76.53	68.23	80.32
255	5	8	10	61.27	75.85	67.48	79.68	62.02	76.31	68.15	80.09	62.02	76.55	68.14	80.27
255	5	8	11	61.30	75.89	67.38	79.63	62.04	76.34	68.04	80.03	62.04	76.56	68.05	80.21
255	5	8	12	61.01	75.28	67.35	79.25	61.75	75.68	68.01	79.62	61.76	75.98	68.03	79.86
255	5	9	9	60.94	75.17	66.16	78.45	61.78	75.76	66.90	78.97	61.67	75.90	66.84	79.09
255	5	9	10	60.95	75.19	66.08	78.40	61.80	75.78	66.82	78.92	61.69	75.92	66.76	79.05
255	5	9	11	60.97	75.21	66.00	78.36	61.82	75.81	66.74	78.88	61.70	75.93	66.67	79.00
255	5	9	12	60.78	74.77	66.00	78.08	61.61	75.33	66.73	78.57	61.48	75.42	66.69	78.68
255	5	9	13	60.76	74.73	65.94	78.02	61.59	75.28	66.67	78.50	61.48	75.40	66.64	78.64
255	6	6	9	60.55	74.58	67.93	79.33	61.23	75.07	68.47	79.71	61.39	75.34	68.65	79.97
255	6	6	10	60.31	74.06	67.77	78.92	60.99	74.57	68.30	79.33	61.13	74.78	68.49	79.55
255	6	7	9	61.28	75.03	67.31	78.91	61.97	75.58	67.90	79.37	62.08	75.85	67.99	79.60
255	6	7	10	61.11	74.68	67.16	78.60	61.80	75.23	67.74	79.07	61.90	75.50	67.84	79.30
255	6	7	11	61.13	74.71	67.07	78.56	61.83	75.26	67.66	79.02	61.92	75.52	67.76	79.25
255	6	8	8	61.83	75.47	66.47	78.43	62.56	76.04	67.13	78.95	62.62	76.29	67.17	79.15

				Blue				Green				Red			
				% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings	
R	k	n	p	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra
255	6	8	9	61.84	75.48	66.38	78.37	62.58	76.06	67.05	78.89	62.63	76.31	67.08	79.09
255	6	8	10	61.76	75.33	66.26	78.21	62.50	75.89	66.93	78.72	62.55	76.14	66.96	78.92
255	6	8	11	61.78	75.34	66.18	78.16	62.51	75.91	66.84	78.66	62.56	76.15	66.88	78.87
255	6	8	12	61.74	75.27	66.09	78.05	62.48	75.83	66.75	78.56	62.55	76.14	66.79	78.80
255	6	9	9	62.27	75.73	65.28	77.63	63.00	76.27	65.99	78.15	63.00	76.50	65.95	78.33
255	6	9	10	62.22	75.63	65.19	77.51	62.95	76.16	65.90	78.03	62.94	76.39	65.86	78.20
255	6	9	11	62.23	75.65	65.12	77.48	62.96	76.19	65.84	78.00	62.95	76.40	65.80	78.17
255	6	9	12	62.23	75.65	65.05	77.43	62.97	76.19	65.77	77.96	62.96	76.41	65.75	78.13
255	6	9	13	62.23	75.65	64.98	77.38	62.96	76.18	65.70	77.90	62.97	76.41	65.68	78.09
255	6	10	10	61.77	74.79	63.78	76.08	62.52	75.39	64.54	76.68	62.47	75.49	64.49	76.76
255	6	10	11	61.78	74.80	63.72	76.05	62.53	75.40	64.48	76.65	62.48	75.50	64.43	76.72
255	6	10	12	61.78	74.81	63.66	76.01	62.53	75.41	64.42	76.61	62.48	75.51	64.37	76.68
255	6	10	13	61.79	74.82	63.60	75.97	62.54	75.42	64.36	76.58	62.49	75.52	64.31	76.65
255	6	10	14	61.58	74.29	63.65	75.64	62.32	74.92	64.38	76.26	62.27	75.01	64.36	76.34

APPENDIX B

RESULTS OF IVTM OPTIMIZED FOR ENERGY MINIMIZATION

The EDP and energy savings of the IVTM scheme (optimized for energy minimization), for various values of codeword lengths (*k*, *n* and *p*) and range (*R*), averaged over 10 images of the SIPI database [21], have been presented below.

				Blue				Green				Red			
				% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings	
R	k	n	p	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra
10	2	2	4	38.84	67.57	64.66	81.02	40.84	68.69	65.95	81.73	39.94	68.05	65.22	81.22
10	2	2	5	39.88	67.45	63.58	80.01	41.86	68.58	64.96	80.80	41.01	67.94	64.13	80.18
10	2	2	6	40.42	67.66	62.23	79.20	42.36	68.75	63.70	80.04	41.54	68.09	62.74	79.31
10	2	3	4	41.62	67.37	65.61	80.58	43.47	68.53	66.82	81.33	42.66	67.95	66.23	80.89
10	2	3	5	42.06	67.50	64.85	80.07	43.91	68.67	66.12	80.86	43.12	68.09	65.45	80.35
10	2	3	6	42.43	67.82	64.07	79.69	44.25	68.94	65.38	80.49	43.47	68.35	64.63	79.91
10	2	3	7	42.79	68.19	63.26	79.33	44.57	69.27	64.62	80.15	43.82	68.71	63.81	79.54
10	2	4	4	43.73	67.57	64.93	79.60	45.54	68.71	66.22	80.40	44.79	68.17	65.65	79.96
10	2	4	5	44.03	67.89	64.52	79.45	45.82	69.00	65.84	80.26	45.11	68.50	65.23	79.80
10	2	4	6	44.03	67.57	63.93	78.89	45.82	68.70	65.28	79.74	45.11	68.16	64.62	79.21
10	2	4	7	44.03	67.57	63.33	78.54	45.82	68.70	64.73	79.41	45.11	68.16	64.01	78.84
10	2	4	8	44.03	67.57	62.73	78.18	45.82	68.70	64.17	79.08	45.11	68.16	63.39	78.47
10	2	5	5	44.63	66.61	62.66	77.30	46.35	67.79	64.06	78.23	45.66	67.18	63.41	77.63
10	2	5	6	44.63	66.61	62.50	77.20	46.35	67.79	63.91	78.14	45.66	67.18	63.24	77.53
10	2	5	7	44.63	66.61	62.34	77.10	46.35	67.79	63.76	78.05	45.66	67.18	63.08	77.43
10	2	5	8	44.63	66.61	62.18	77.00	46.35	67.79	63.61	77.95	45.66	67.18	62.92	77.33
10	2	5	9	44.63	66.61	62.01	76.90	46.35	67.79	63.46	77.86	45.66	67.18	62.76	77.22
10	2	6	6	45.17	67.49	60.12	76.18	46.91	68.65	61.72	77.21	46.22	68.11	60.93	76.57
10	2	6	7	45.17	67.49	59.96	76.08	46.91	68.65	61.57	77.12	46.22	68.11	60.77	76.47
10	2	6	8	45.17	67.49	59.80	75.99	46.91	68.65	61.43	77.03	46.22	68.11	60.61	76.37
10	2	6	9	45.17	67.49	59.65	75.89	46.91	68.65	61.28	76.95	46.22	68.11	60.45	76.28
10	2	6	10	45.17	67.49	59.49	75.80	46.91	68.65	61.13	76.86	46.22	68.11	60.29	76.18
10	3	3	3	42.94	66.59	65.70	79.79	44.79	67.78	66.81	80.50	44.03	67.13	66.43	80.14
10	3	3	4	43.22	66.96	65.31	79.69	45.05	68.11	66.44	80.39	44.30	67.49	66.02	80.02
10	3	3	5	43.44	67.22	64.74	79.43	45.25	68.39	65.91	80.18	44.52	67.81	65.43	79.78
10	3	3	6	43.74	67.54	64.10	79.14	45.54	68.68	65.31	79.91	44.84	68.14	64.76	79.47
10	3	3	7	43.74	67.22	63.40	78.52	45.54	68.38	64.66	79.32	44.84	67.81	64.04	78.81
10	3	4	4	44.47	66.39	64.39	78.32	46.26	67.59	65.59	79.12	45.57	66.99	65.16	78.71
10	3	4	5	44.47	66.39	64.08	78.13	46.26	67.59	65.31	78.95	45.57	66.99	64.84	78.51
10	3	4	6	44.47	66.39	63.78	77.94	46.26	67.59	65.03	78.77	45.57	66.99	64.53	78.31
10	3	4	7	44.47	66.39	63.48	77.76	46.26	67.59	64.74	78.60	45.57	66.99	64.21	78.12
10	3	4	8	44.47	66.39	63.17	77.57	46.26	67.59	64.46	78.42	45.57	66.99	63.90	77.92
10	3	5	5	45.16	66.72	62.51	77.13	46.93	67.87	63.85	77.99	46.24	67.26	63.32	77.49
10	3	5	6	45.16	66.72	62.36	77.03	46.93	67.87	63.71	77.90	46.24	67.26	63.16	77.39
10	3	5	7	45.16	66.72	62.20	76.93	46.93	67.87	63.56	77.81	46.24	67.26	63.00	77.29
10	3	5	8	45.16	66.72	62.04	76.84	46.93	67.87	63.41	77.72	46.24	67.26	62.84	77.19
10	3	5	9	45.16	66.72	61.88	76.74	46.93	67.87	63.26	77.63	46.24	67.26	62.68	77.09
10	3	6	6	45.73	67.28	60.61	76.13	47.47	68.42	62.06	77.06	46.80	67.85	61.43	76.52
10	3	6	7	45.73	67.28	60.48	76.05	47.47	68.42	61.93	76.98	46.80	67.85	61.30	76.44
10	3	6	8	45.73	67.28	60.35	75.98	47.47	68.42	61.81	76.91	46.80	67.85	61.16	76.36
10	3	6	9	45.73	67.28	60.22	75.90	47.47	68.42	61.68	76.83	46.80	67.85	61.03	76.27
10	3	6	10	45.73	67.28	60.09	75.82	47.47	68.42	61.56	76.76	46.80	67.85	60.90	76.19
10	3	7	7	46.25	67.67	58.63	75.00	48.00	68.82	60.21	76.01	47.35	68.29	59.50	75.44
10	3	7	8	46.25	67.67	58.50	74.92	48.00	68.82	60.09	75.94	47.35	68.29	59.37	75.35
10	3	7	9	46.25	67.67	58.38	74.85	48.00	68.82	59.97	75.86	47.35	68.29	59.24	75.27
10	3	7	10	46.25	67.67	58.25	74.77	48.00	68.82	59.85	75.79	47.35	68.29	59.11	75.19
10	3	7	11	46.25	67.67	58.13	74.69	48.00	68.82	59.73	75.71	47.35	68.29	58.98	75.11
10	4	4	4	45.43	65.82	62.85	76.65	47.14	66.95	64.01	77.41	46.51	66.31	63.65	77.00
10	4	4	5	45.43	65.82	62.70	76.55	47.14	66.95	63.86	77.32	46.51	66.31	63.49	76.90
10	4	4	6	45.43	65.82	62.54	76.45	47.14	66.95	63.71	77.22	46.51	66.31	63.33	76.80
10	4	4	7	45.43	65.82	62.38	76.35	47.14	66.95	63.57	77.13	46.51	66.31	63.17	76.70
10	4	4	8	45.43	65.82	62.22	76.25	47.14	66.95	63.42	77.04	46.51	66.31	63.01	76.59
10	4	5	5	46.08	66.09	61.56	75.75	47.75	67.27	62.79	76.61	47.12	66.66	62.37	76.17
10	4	5	6	46.08	66.09	61.44	75.67	47.75	67.27	62.67	76.53	47.12	66.66	62.24	76.08
10	4	5	7	46.08	66.09	61.31	75.58	47.75	67.27	62.54	76.45	47.12	66.66	62.10	76.00
10	4	5	8	46.08	66.09	61.18	75.50	47.75	67.27	62.42	76.37	47.12	66.66	61.97	75.91
10	4	5	9	46.08	66.09	61.05	75.42	47.75	67.27	62.30	76.29	47.12	66.66	61.83	75.82
10	4	6	6	46.67	66.25	60.18	74.72	48.33	67.44	61.50	75.65	47.74	66.82	61.03	75.15
10	4	6	7	46.67	66.25	60.05	74.64	48.33	67.44	61.38	75.57	47.74	66.82	60.90	75.06
10	4	6	8	46.67	66.25	59.93	74.56	48.33	67.44	61.26	75.49	47.74	66.82	60.77	74.98
10	4	6	9	46.67	66.25	59.80	74.48	48.33	67.44	61.14	75.42	47.74	66.82	60.64	74.89

				Blue				Green				Red			
				% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings	
R	k	n	p	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra
10	4	6	10	46.67	66.25	59.68	74.40	48.33	67.44	61.02	75.34	47.74	66.82	60.51	74.80
10	4	7	7	47.19	66.25	58.71	73.53	48.83	67.41	60.11	74.51	48.27	66.75	59.61	73.92
10	4	7	8	47.19	66.25	58.60	73.46	48.83	67.41	60.01	74.44	48.27	66.75	59.50	73.85
10	4	7	9	47.19	66.25	58.49	73.39	48.83	67.41	59.91	74.38	48.27	66.75	59.40	73.78
10	4	7	10	47.19	66.25	58.38	73.32	48.83	67.41	59.81	74.31	48.27	66.75	59.29	73.71
10	4	7	11	47.19	66.25	58.28	73.25	48.83	67.41	59.71	74.25	48.27	66.75	59.18	73.63
10	4	8	8	47.68	66.39	57.17	72.40	49.32	67.53	58.68	73.44	48.78	66.88	58.15	72.81
10	4	8	9	47.68	66.39	57.06	72.33	49.32	67.53	58.59	73.38	48.78	66.88	58.05	72.74
10	4	8	10	47.68	66.39	56.96	72.26	49.32	67.53	58.49	73.32	48.78	66.88	57.94	72.67
10	4	8	11	47.68	66.39	56.85	72.20	49.32	67.53	58.40	73.25	48.78	66.88	57.84	72.60
10	4	8	12	47.68	66.39	56.74	72.13	49.32	67.53	58.30	73.19	48.78	66.88	57.74	72.53
10	5	5	5	46.55	64.72	59.36	73.11	48.35	66.00	60.71	74.07	47.83	65.32	60.38	73.58
10	5	5	6	46.55	64.72	59.23	73.02	48.35	66.00	60.59	73.99	47.83	65.32	60.25	73.49
10	5	5	7	46.55	64.72	59.11	72.94	48.35	66.00	60.47	73.91	47.83	65.32	60.12	73.40
10	5	5	8	46.55	64.72	58.99	72.86	48.35	66.00	60.35	73.83	47.83	65.32	59.99	73.31
10	5	5	9	46.55	64.72	58.86	72.77	48.35	66.00	60.24	73.75	47.83	65.32	59.86	73.22
10	5	6	6	46.93	64.84	58.17	72.22	48.72	66.10	59.59	73.22	48.20	65.38	59.20	72.65
10	5	6	7	46.93	64.84	58.06	72.15	48.72	66.10	59.49	73.15	48.20	65.38	59.09	72.57
10	5	6	8	46.93	64.84	57.95	72.07	48.72	66.10	59.39	73.09	48.20	65.38	58.99	72.50
10	5	6	9	46.93	64.84	57.84	72.00	48.72	66.10	59.29	73.02	48.20	65.38	58.88	72.42
10	5	6	10	46.93	64.84	57.73	71.93	48.72	66.10	59.19	72.95	48.20	65.38	58.77	72.35
10	5	7	7	47.30	65.05	56.77	71.26	49.07	66.27	58.28	72.30	48.55	65.53	57.83	71.65
10	5	7	8	47.30	65.05	56.67	71.19	49.07	66.27	58.19	72.24	48.55	65.53	57.72	71.58
10	5	7	9	47.30	65.05	56.56	71.12	49.07	66.27	58.09	72.17	48.55	65.53	57.62	71.51
10	5	7	10	47.30	65.05	56.45	71.04	49.07	66.27	57.99	72.11	48.55	65.53	57.52	71.44
10	5	7	11	47.30	65.05	56.35	70.97	49.07	66.27	57.90	72.04	48.55	65.53	57.41	71.36
10	5	8	8	47.62	65.41	55.19	70.34	49.38	66.65	56.80	71.46	48.87	65.96	56.26	70.78
10	5	8	9	47.62	65.41	55.10	70.28	49.38	66.65	56.71	71.41	48.87	65.96	56.16	70.71
10	5	8	10	47.62	65.41	55.01	70.21	49.38	66.65	56.63	71.35	48.87	65.96	56.07	70.65
10	5	8	11	47.62	65.41	54.92	70.15	49.38	66.65	56.54	71.29	48.87	65.96	55.97	70.58
10	5	8	12	47.62	65.41	54.83	70.09	49.38	66.65	56.46	71.23	48.87	65.96	55.87	70.51
10	5	9	9	47.92	65.86	53.44	69.40	49.68	67.09	55.16	70.59	49.18	66.44	54.52	69.84
10	5	9	10	47.92	65.86	53.35	69.33	49.68	67.09	55.08	70.54	49.18	66.44	54.42	69.78
10	5	9	11	47.92	65.86	53.26	69.27	49.68	67.09	54.99	70.48	49.18	66.44	54.32	69.71
10	5	9	12	47.92	65.86	53.17	69.21	49.68	67.09	54.91	70.42	49.18	66.44	54.23	69.65
10	5	9	13	47.92	65.86	53.08	69.15	49.68	67.09	54.82	70.37	49.18	66.44	54.13	69.58
10	6	6	6	47.05	64.69	55.52	70.30	48.81	65.97	56.98	71.36	48.33	65.26	56.62	70.78
10	6	6	7	47.05	64.69	55.41	70.22	48.81	65.97	56.88	71.30	48.33	65.26	56.52	70.70
10	6	6	8	47.05	64.69	55.30	70.15	48.81	65.97	56.79	71.23	48.33	65.26	56.41	70.63
10	6	6	9	47.05	64.69	55.20	70.08	48.81	65.97	56.69	71.17	48.33	65.26	56.31	70.56
10	6	6	10	47.05	64.69	55.09	70.01	48.81	65.97	56.59	71.10	48.33	65.26	56.20	70.48
10	6	7	7	47.41	65.06	54.33	69.61	49.15	66.35	55.86	70.76	48.68	65.69	55.44	70.15
10	6	7	8	47.41	65.06	54.24	69.55	49.15	66.35	55.78	70.70	48.68	65.69	55.35	70.09
10	6	7	9	47.41	65.06	54.15	69.49	49.15	66.35	55.69	70.64	48.68	65.69	55.25	70.02
10	6	7	10	47.41	65.06	54.06	69.43	49.15	66.35	55.61	70.58	48.68	65.69	55.15	69.95
10	6	7	11	47.41	65.06	53.97	69.37	49.15	66.35	55.52	70.52	48.68	65.69	55.06	69.88
10	6	8	8	47.73	65.50	52.96	68.90	49.48	66.79	54.59	70.11	49.02	66.16	54.09	69.46
10	6	8	9	47.73	65.50	52.87	68.84	49.48	66.79	54.51	70.05	49.02	66.16	54.00	69.39
10	6	8	10	47.73	65.50	52.78	68.78	49.48	66.79	54.42	69.99	49.02	66.16	53.90	69.33
10	6	8	11	47.73	65.50	52.69	68.72	49.48	66.79	54.34	69.94	49.02	66.16	53.80	69.26
10	6	8	12	47.73	65.50	52.60	68.66	49.48	66.79	54.25	69.88	49.02	66.16	53.71	69.20
10	6	9	9	48.03	65.83	51.44	68.01	49.75	67.06	53.16	69.25	49.29	66.42	52.57	68.51
10	6	9	10	48.03	65.83	51.36	67.96	49.75	67.06	53.09	69.20	49.29	66.42	52.49	68.45
10	6	9	11	48.03	65.83	51.28	67.91	49.75	67.06	53.03	69.15	49.29	66.42	52.41	68.40
10	6	9	12	48.03	65.83	51.20	67.85	49.75	67.06	52.96	69.11	49.29	66.42	52.34	68.35
10	6	9	13	48.03	65.83	51.13	67.80	49.75	67.06	52.89	69.06	49.29	66.42	52.26	68.30
10	6	10	10	48.31	66.20	49.76	67.09	50.02	67.39	51.62	68.38	49.57	66.78	50.91	67.58
10	6	10	11	48.31	66.20	49.69	67.04	50.02	67.39	51.55	68.33	49.57	66.78	50.83	67.52
10	6	10	12	48.31	66.20	49.61	66.99	50.02	67.39	51.48	68.29	49.57	66.78	50.76	67.47
10	6	10	13	48.31	66.20	49.53	66.94	50.02	67.39	51.41	68.24	49.57	66.78	50.68	67.42
10	6	10	14	48.31	66.20	49.46	66.89	50.02	67.39	51.35	68.20	49.57	66.78	50.61	67.37
20	2	2	6	45.97	72.90	67.23	83.36	46.91	73.22	67.92	83.63	46.89	73.57	67.70	83.70
20	2	3	5	47.27	72.83	70.09	84.47	48.13	73.22	70.59	84.69	48.14	73.64	70.65	84.95
20	2	3	6	48.49	73.30	69.27	83.92	49.29	73.62	69.81	84.15	49.35	74.07	69.78	84.36
20	2	3	7	49.34	74.19	68.23	83.66	50.10	74.49	68.86	83.92	50.18	74.95	68.73	84.09
20	2	4	5	50.35	73.14	70.72	84.06	51.08	73.49	71.18	84.28	51.27	73.98	71.39	84.59
20	2	4	6	51.03	73.83	70.14	83.93	51.73	74.13	70.65	84.16	51.91	74.62	70.78	84.44
20	2	4	7	51.38	73.65	69.38	83.27	52.04	73.95	69.93	83.52	52.24	74.44	70.00	83.77
20	2	4	8	51.68	73.87	68.60	82.86	52.32	74.17	69.18	83.14	52.57	74.69	69.21	83.37
20	2	5	5	52.68	73.04	69.98	82.79	53.22	73.35	70.43	83.04	53.53	73.82	70.67	83.33
20	2	5	6	52.94	73.27	69.68	82.66	53.46	73.55	70.14	82.91	53.79	74.05	70.37	83.20
20	2	5	7	53.17	73.46	69.34	82.50	53.67	73.73	69.82	82.75	54.02	74.24	70.03	83.03
20	2	5	8	53.39	73.65	68.96	82.32	53.86	73.91	69.46	82.59	54.25	74.43	69.65	82.85
20	2	5	9	53.58	73.80	68.56	82.10	54.04	74.05	69.08	82.39	54.45	74.60	69.24	82.64
20	2	6	6	54.49	74.01	68.17	81.70	54.90	74.32	68.68	82.03	55.37	74.88	68.94	82.33
20	2	6	7	54.64	74.11	67.96	81.59	55.04	74.42	68.48	81.93	55.52	74.98	68.72	82.21
20	2	6	8	54.78	74.22	67.71	81.45	55.17	74.53	68.24	81.81	55.66	75.09	68.47	82.08
20	2	6	9	54.90	74.31	67.41	81.29	55.29	74.62	67.96	81.66	55.79	75.19	68.17	81.92
20	2	6	10	55.02	74.41	67.08	81.11	55.40	74.72	67.64	81.49	55.92	75.29	67.83	81.74

				Blue				Green				Red			
				% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings	
R	k	n	p	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra
20	3	3	5	49.56	72.81	70.66	84.12	50.33	73.19	71.01	84.28	50.47	73.66	71.28	84.66
20	3	3	6	50.37	73.27	70.00	83.77	51.13	73.64	70.41	83.96	51.29	74.11	70.59	84.28
20	3	3	7	50.86	73.41	69.15	83.21	51.57	73.73	69.62	83.42	51.75	74.19	69.73	83.69
20	3	4	5	51.88	72.92	71.02	83.64	52.53	73.28	71.35	83.81	52.76	73.74	71.70	84.20
20	3	4	6	52.26	73.03	70.54	83.29	52.89	73.37	70.89	83.48	53.14	73.86	71.20	83.85
20	3	4	7	52.48	73.14	69.97	82.95	53.08	73.46	70.35	83.15	53.36	73.95	70.62	83.49
20	3	4	8	52.71	73.35	69.38	82.66	53.28	73.64	69.80	82.87	53.58	74.16	70.02	83.20
20	3	5	5	53.63	72.98	70.20	82.57	54.16	73.29	70.55	82.76	54.50	73.77	70.91	83.15
20	3	5	6	53.78	73.13	69.95	82.46	54.31	73.43	70.32	82.66	54.67	73.93	70.67	83.04
20	3	5	7	53.95	73.37	69.67	82.38	54.45	73.65	70.04	82.59	54.84	74.17	70.37	82.96
20	3	5	8	54.09	73.59	69.32	82.27	54.58	73.86	69.72	82.48	54.98	74.38	70.03	82.83
20	3	5	9	54.24	73.80	68.93	82.13	54.70	74.05	69.35	82.35	55.13	74.59	69.63	82.69
20	3	6	6	55.02	73.59	68.65	81.52	55.47	73.92	69.05	81.79	55.94	74.41	69.41	82.13
20	3	6	7	55.13	73.69	68.47	81.43	55.58	74.01	68.87	81.70	56.05	74.51	69.22	82.03
20	3	6	8	55.22	73.77	68.24	81.31	55.66	74.09	68.65	81.59	56.14	74.59	68.99	81.91
20	3	6	9	55.32	73.86	67.99	81.18	55.75	74.17	68.40	81.46	56.24	74.68	68.74	81.78
20	3	6	10	55.40	73.94	67.70	81.03	55.83	74.25	68.12	81.31	56.32	74.76	68.45	81.62
20	3	7	7	55.88	73.75	66.72	80.10	56.32	74.09	67.21	80.44	56.82	74.59	67.54	80.75
20	3	7	8	55.88	73.75	66.56	80.01	56.32	74.09	67.05	80.35	56.82	74.59	67.37	80.65
20	3	7	9	55.88	73.75	66.40	79.91	56.32	74.09	66.90	80.25	56.82	74.59	67.20	80.55
20	3	7	10	55.88	73.75	66.24	79.81	56.32	74.09	66.74	80.15	56.82	74.59	67.04	80.45
20	3	7	11	55.88	73.75	66.08	79.71	56.32	74.09	66.58	80.05	56.82	74.59	66.87	80.34
20	4	4	4	53.29	72.32	70.60	82.56	53.84	72.59	70.80	82.64	54.15	73.05	71.29	83.10
20	4	4	5	53.45	72.25	70.29	82.26	53.97	72.52	70.50	82.36	54.30	72.97	70.97	82.80
20	4	4	6	53.58	72.44	69.95	82.12	54.09	72.70	70.17	82.22	54.44	73.16	70.62	82.65
20	4	4	7	53.71	72.58	69.58	81.94	54.21	72.84	69.82	82.06	54.58	73.32	70.24	82.47
20	4	4	8	53.84	72.73	69.19	81.76	54.32	72.97	69.46	81.88	54.71	73.49	69.85	82.30
20	4	5	5	54.61	72.58	69.50	81.54	55.06	72.91	69.72	81.71	55.47	73.39	70.20	82.16
20	4	5	6	54.72	72.70	69.30	81.46	55.15	73.00	69.54	81.63	55.56	73.49	69.99	82.06
20	4	5	7	54.81	72.82	69.06	81.35	55.24	73.13	69.30	81.53	55.66	73.61	69.75	81.95
20	4	5	8	54.90	72.91	68.78	81.21	55.32	73.22	69.04	81.40	55.76	73.71	69.47	81.80
20	4	5	9	54.98	73.02	68.47	81.05	55.40	73.33	68.73	81.25	55.84	73.82	69.14	81.65
20	4	6	6	55.73	73.09	68.15	80.60	56.15	73.42	68.46	80.83	56.63	73.87	68.91	81.21
20	4	6	7	55.81	73.24	67.97	80.56	56.23	73.57	68.27	80.79	56.71	74.02	68.72	81.17
20	4	6	8	55.81	73.16	67.75	80.36	56.23	73.49	68.06	80.60	56.71	73.94	68.49	80.97
20	4	6	9	55.81	73.16	67.53	80.23	56.23	73.49	67.85	80.47	56.71	73.94	68.27	80.83
20	4	6	10	55.81	73.16	67.32	80.09	56.23	73.49	67.63	80.34	56.71	73.94	68.05	80.70
20	4	7	7	56.23	72.94	66.41	79.18	56.63	73.23	66.78	79.43	57.12	73.66	67.19	79.77
20	4	7	8	56.23	72.94	66.32	79.12	56.63	73.23	66.70	79.38	57.12	73.66	67.10	79.71
20	4	7	9	56.23	72.94	66.23	79.07	56.63	73.23	66.62	79.32	57.12	73.66	67.02	79.66
20	4	7	10	56.23	72.94	66.14	79.01	56.63	73.23	66.53	79.27	57.12	73.66	66.93	79.60
20	4	7	11	56.23	72.94	66.06	78.95	56.63	73.23	66.45	79.22	57.12	73.66	66.84	79.55
20	4	8	8	56.62	73.47	64.57	78.27	57.02	73.70	65.05	78.54	57.50	74.17	65.41	78.88
20	4	8	9	56.62	73.47	64.49	78.22	57.02	73.70	64.97	78.49	57.50	74.17	65.33	78.83
20	4	8	10	56.62	73.47	64.40	78.16	57.02	73.70	64.89	78.44	57.50	74.17	65.24	78.77
20	4	8	11	56.62	73.47	64.32	78.11	57.02	73.70	64.81	78.39	57.50	74.17	65.16	78.72
20	4	8	12	56.62	73.47	64.23	78.06	57.02	73.70	64.73	78.34	57.50	74.17	65.07	78.67
20	5	5	5	55.29	71.99	67.73	79.76	55.85	72.36	68.02	79.96	56.35	72.79	68.59	80.41
20	5	5	6	55.37	72.16	67.58	79.75	55.93	72.52	67.87	79.95	56.43	72.97	68.43	80.39
20	5	5	7	55.44	72.33	67.39	79.72	56.00	72.68	67.69	79.92	56.50	73.13	68.24	80.36
20	5	5	8	55.51	72.47	67.17	79.66	56.07	72.83	67.48	79.86	56.57	73.29	68.02	80.30
20	5	5	9	55.51	72.40	66.93	79.45	56.07	72.75	67.25	79.66	56.57	73.21	67.78	80.09
20	5	6	6	55.98	72.26	66.59	78.91	56.51	72.59	66.93	79.13	57.03	73.01	67.46	79.53
20	5	6	7	55.98	72.26	66.47	78.84	56.51	72.59	66.82	79.05	57.03	73.01	67.35	79.46
20	5	6	8	55.98	72.26	66.36	78.76	56.51	72.59	66.71	78.98	57.03	73.01	67.23	79.38
20	5	6	9	55.98	72.26	66.24	78.69	56.51	72.59	66.60	78.91	57.03	73.01	67.12	79.31
20	5	6	10	55.98	72.26	66.13	78.61	56.51	72.59	66.49	78.84	57.03	73.01	67.00	79.23
20	5	7	7	56.43	72.60	65.22	78.09	56.95	72.88	65.62	78.30	57.47	73.31	66.12	78.69
20	5	7	8	56.43	72.60	65.13	78.03	56.95	72.88	65.54	78.25	57.47	73.31	66.03	78.64
20	5	7	9	56.43	72.60	65.05	77.98	56.95	72.88	65.46	78.20	57.47	73.31	65.95	78.59
20	5	7	10	56.43	72.60	64.96	77.92	56.95	72.88	65.38	78.15	57.47	73.31	65.87	78.53
20	5	7	11	56.43	72.60	64.87	77.87	56.95	72.88	65.30	78.10	57.47	73.31	65.78	78.48
20	5	8	8	56.81	72.94	63.75	77.25	57.31	73.25	64.21	77.53	57.85	73.75	64.67	77.94
20	5	8	9	56.81	72.94	63.68	77.20	57.31	73.25	64.14	77.49	57.85	73.75	64.59	77.89
20	5	8	10	56.81	72.94	63.61	77.16	57.31	73.25	64.07	77.44	57.85	73.75	64.51	77.84
20	5	8	11	56.81	72.94	63.53	77.11	57.31	73.25	64.00	77.40	57.85	73.75	64.44	77.79
20	5	8	12	56.81	72.94	63.46	77.06	57.31	73.25	63.93	77.35	57.85	73.75	64.36	77.74
20	5	9	9	57.16	73.35	62.22	76.45	57.66	73.67	62.74	76.77	58.22	74.20	63.15	77.17
20	5	9	10	57.16	73.35	62.15	76.40	57.66	73.67	62.67	76.73	58.22	74.20	63.08	77.12
20	5	9	11	57.16	73.35	62.08	76.36	57.66	73.67	62.60	76.68	58.22	74.20	63.00	77.07
20	5	9	12	57.16	73.35	62.01	76.31	57.66	73.67	62.53	76.64	58.22	74.20	62.92	77.02
20	5	9	13	57.16	73.35	61.93	76.26	57.66	73.67	62.46	76.59	58.22	74.20	62.85	76.97
20	6	6	6	56.56	71.72	64.61	76.95	57.04	72.11	64.94	77.23	57.64	72.52	65.56	77.65
20	6	6	7	56.56	71.72	64.53	76.90	57.04	72.11	64.86	77.17	57.64	72.52	65.48	77.59
20	6	6	8	56.56	71.72	64.44	76.84	57.04	72.11	64.78	77.12	57.64	72.52	65.39	77.54
20	6	6	9	56.56	71.72	64.36	76.78	57.04	72.11	64.70	77.07	57.64	72.52	65.31	77.48
20	6	6	10	56.56	71.72	64.27	76.73	57.04	72.11	64.62	77.02	57.64	72.52	65.23	77.43
20	6	7	7	56.96	72.08	63.55	76.33	57.43	72.50	63.92	76.67	58.05	72.96	64.52	77.11
20	6	7	8	56.96	72.08	63.48	76.29	57.43	72.50	63.85	76.63	58.05	72.96	64.44	77.06

				Blue				Green				Red			
				% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings	
R	k	n	p	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra
20	6	7	9	56.96	72.08	63.41	76.24	57.43	72.50	63.78	76.58	58.05	72.96	64.37	77.01
20	6	7	10	56.96	72.08	63.34	76.19	57.43	72.50	63.71	76.54	58.05	72.96	64.29	76.96
20	6	7	11	56.96	72.08	63.26	76.14	57.43	72.50	63.64	76.49	58.05	72.96	64.21	76.90
20	6	8	8	57.32	72.50	62.38	75.74	57.80	72.93	62.81	76.12	58.44	73.41	63.38	76.55
20	6	8	9	57.32	72.50	62.31	75.69	57.80	72.93	62.74	76.07	58.44	73.41	63.31	76.50
20	6	8	10	57.32	72.50	62.24	75.64	57.80	72.93	62.67	76.03	58.44	73.41	63.23	76.44
20	6	8	11	57.32	72.50	62.17	75.60	57.80	72.93	62.60	75.98	58.44	73.41	63.16	76.39
20	6	8	12	57.32	72.50	62.10	75.55	57.80	72.93	62.53	75.94	58.44	73.41	63.08	76.34
20	6	9	9	57.66	72.80	61.15	75.01	58.11	73.19	61.60	75.40	58.75	73.65	62.15	75.78
20	6	9	10	57.66	72.80	61.09	74.97	58.11	73.19	61.55	75.36	58.75	73.65	62.09	75.74
20	6	9	11	57.66	72.80	61.03	74.93	58.11	73.19	61.49	75.32	58.75	73.65	62.03	75.70
20	6	9	12	57.66	72.80	60.96	74.89	58.11	73.19	61.44	75.29	58.75	73.65	61.97	75.66
20	6	9	13	57.66	72.80	60.90	74.85	58.11	73.19	61.38	75.25	58.75	73.65	61.91	75.62
20	6	10	10	57.95	73.00	59.81	74.16	58.40	73.37	60.33	74.56	59.04	73.84	60.83	74.93
20	6	10	11	57.95	73.00	59.75	74.12	58.40	73.37	60.28	74.53	59.04	73.84	60.77	74.89
20	6	10	12	57.95	73.00	59.69	74.08	58.40	73.37	60.22	74.49	59.04	73.84	60.71	74.85
20	6	10	13	57.95	73.00	59.63	74.04	58.40	73.37	60.17	74.46	59.04	73.84	60.65	74.81
20	6	10	14	57.95	73.00	59.57	74.00	58.40	73.37	60.11	74.42	59.04	73.84	60.59	74.77
50	2	3	7	51.02	75.40	69.62	84.59	51.75	75.73	70.24	84.89	51.82	76.22	70.07	85.05
50	2	4	7	53.42	75.62	71.02	84.71	54.10	75.94	71.59	84.99	54.26	76.49	71.60	85.24
50	2	4	8	54.08	76.08	70.23	84.36	54.79	76.44	70.86	84.68	54.91	76.96	70.79	84.90
50	2	5	7	55.67	75.72	71.32	84.19	56.24	76.06	71.87	84.51	56.47	76.55	71.95	84.74
50	2	5	8	56.00	75.95	70.79	83.92	56.57	76.29	71.36	84.25	56.80	76.79	71.43	84.48
50	2	5	9	56.28	76.24	70.22	83.68	56.84	76.59	70.81	84.03	57.08	77.08	70.86	84.25
50	2	6	6	57.17	75.76	70.59	83.25	57.70	76.16	71.20	83.66	58.02	76.68	71.29	83.89
50	2	6	7	57.40	75.97	70.36	83.16	57.91	76.35	70.96	83.57	58.23	76.89	71.05	83.80
50	2	6	8	57.60	76.21	70.07	83.08	58.12	76.63	70.69	83.51	58.43	77.14	70.76	83.73
50	2	6	9	57.80	76.46	69.73	82.98	58.32	76.89	70.35	83.42	58.62	77.36	70.42	83.62
50	2	6	10	57.97	76.63	69.33	82.80	58.50	77.07	69.96	83.25	58.79	77.52	70.03	83.44
50	3	3	7	52.71	75.13	70.63	84.48	53.44	75.48	71.13	84.72	53.59	76.00	71.17	85.00
50	3	4	7	54.69	75.23	71.69	84.46	55.34	75.59	72.13	84.71	55.55	76.10	72.30	85.03
50	3	4	8	55.22	75.60	71.07	84.17	55.87	75.96	71.54	84.42	56.03	76.47	71.66	84.74
50	3	5	6	56.03	75.19	71.99	84.15	56.58	75.54	72.41	84.41	56.90	76.07	72.66	84.75
50	3	5	7	56.57	75.62	71.75	84.08	57.16	75.98	72.21	84.36	57.41	76.47	72.39	84.67
50	3	5	8	56.82	75.80	71.30	83.85	57.41	76.17	71.77	84.13	57.65	76.64	71.95	84.43
50	3	5	9	57.06	76.07	70.82	83.67	57.63	76.44	71.30	83.96	57.88	76.90	71.46	84.24
50	3	6	6	57.83	75.48	71.13	83.16	58.40	75.88	71.65	83.50	58.70	76.36	71.82	83.78
50	3	6	7	58.01	75.68	70.94	83.11	58.58	76.09	71.45	83.45	58.87	76.56	71.61	83.72
50	3	6	8	58.18	75.90	70.70	83.05	58.75	76.32	71.22	83.40	59.02	76.76	71.37	83.66
50	3	6	9	58.34	76.11	70.41	82.96	58.92	76.55	70.93	83.32	59.17	76.95	71.08	83.56
50	3	6	10	58.46	76.21	70.08	82.78	59.04	76.63	70.59	83.13	59.29	77.04	70.77	83.38
50	3	7	7	59.19	76.27	69.54	82.21	59.78	76.68	70.16	82.61	60.07	77.15	70.28	82.87
50	3	7	8	59.28	76.29	69.38	82.09	59.86	76.70	69.99	82.49	60.16	77.19	70.12	82.76
50	3	7	9	59.36	76.36	69.21	82.00	59.93	76.76	69.82	82.39	60.23	77.25	69.95	82.67
50	3	7	10	59.43	76.43	69.01	81.90	60.01	76.83	69.62	82.30	60.31	77.32	69.75	82.57
50	3	7	11	59.49	76.48	68.80	81.79	60.08	76.89	69.42	82.19	60.38	77.37	69.55	82.46
50	4	4	7	56.26	74.85	71.57	83.62	56.83	75.19	71.89	83.82	57.09	75.65	72.18	84.18
50	4	4	8	56.57	75.05	71.08	83.35	57.16	75.38	71.43	83.54	57.39	75.87	71.68	83.92
50	4	5	6	57.32	74.71	71.69	83.21	57.83	75.09	72.02	83.45	58.13	75.58	72.32	83.83
50	4	5	7	57.64	74.96	71.47	83.11	58.19	75.37	71.83	83.37	58.44	75.81	72.09	83.72
50	4	5	8	57.84	75.15	71.16	82.97	58.40	75.56	71.52	83.23	58.63	76.00	71.77	83.58
50	4	5	9	58.02	75.36	70.81	82.83	58.58	75.79	71.17	83.11	58.79	76.21	71.42	83.45
50	4	6	6	58.70	75.17	70.87	82.46	59.26	75.57	71.31	82.77	59.53	76.01	71.54	83.09
50	4	6	7	58.84	75.37	70.71	82.44	59.41	75.79	71.16	82.76	59.67	76.20	71.38	83.06
50	4	6	8	58.97	75.55	70.51	82.39	59.54	75.99	70.95	82.72	59.79	76.37	71.17	83.01
50	4	6	9	59.09	75.67	70.27	82.28	59.66	76.11	70.69	82.60	59.90	76.48	70.92	82.89
50	4	6	10	59.16	75.70	70.00	82.10	59.73	76.12	70.42	82.41	59.98	76.53	70.66	82.73
50	4	7	7	59.81	75.65	69.52	81.49	60.35	76.01	70.02	81.81	60.61	76.42	70.20	82.10
50	4	7	8	59.87	75.71	69.38	81.42	60.42	76.08	69.89	81.75	60.68	76.49	70.08	82.05
50	4	7	9	59.93	75.77	69.24	81.35	60.47	76.14	69.75	81.68	60.73	76.54	69.93	81.97
50	4	7	10	59.98	75.83	69.08	81.27	60.52	76.19	69.59	81.60	60.78	76.60	69.78	81.89
50	4	7	11	60.03	75.87	68.91	81.18	60.58	76.25	69.43	81.52	60.83	76.65	69.61	81.80
50	4	8	8	60.59	76.18	67.94	80.56	61.15	76.53	68.54	80.93	61.40	76.93	68.70	81.21
50	4	8	9	60.63	76.22	67.84	80.52	61.19	76.57	68.45	80.89	61.44	76.97	68.60	81.16
50	4	8	10	60.66	76.26	67.72	80.46	61.23	76.62	68.34	80.84	61.47	77.01	68.49	81.11
50	4	8	11	60.69	76.31	67.60	80.40	61.26	76.66	68.22	80.78	61.51	77.05	68.36	81.05
50	4	8	12	60.73	76.35	67.47	80.34	61.30	76.71	68.09	80.72	61.54	77.09	68.24	80.98
50	5	5	6	58.28	74.29	70.35	81.72	58.94	74.74	70.78	82.02	59.26	75.13	71.11	82.36
50	5	5	7	58.44	74.44	70.16	81.64	59.11	74.90	70.59	81.94	59.41	75.28	70.93	82.28
50	5	5	8	58.59	74.62	69.95	81.57	59.27	75.10	70.39	81.88	59.55	75.46	70.71	82.21
50	5	5	9	58.72	74.79	69.68	81.46	59.42	75.28	70.11	81.77	59.68	75.62	70.44	82.11
50	5	6	6	59.29	74.72	69.68	81.15	59.94	75.14	70.15	81.46	60.25	75.53	70.44	81.79
50	5	6	7	59.40	74.85	69.55	81.12	60.06	75.28	70.04	81.44	60.35	75.64	70.32	81.75
50	5	6	8	59.48	74.93	69.39	81.04	60.14	75.35	69.87	81.35	60.42	75.72	70.16	81.67
50	5	6	9	59.53	74.97	69.20	80.92	60.19	75.39	69.68	81.24	60.47	75.76	69.97	81.56
50	5	6	10	59.58	75.03	69.00	80.82	60.24	75.46	69.49	81.14	60.52	75.83	69.78	81.46
50	5	7	7	60.17	75.20	68.55	80.39	60.81	75.56	69.09	80.70	61.10	75.96	69.34	81.02
50	5	7	8	60.20	75.24	68.44	80.33	60.85	75.61	68.98	80.65	61.14	76.00	69.23	80.96
50	5	7	9	60.24	75.29	68.32	80.28	60.89	75.66	68.87	80.59	61.17	76.06	69.11	80.91

				Blue				Green				Red			
				% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings	
R	k	n	p	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra
50	5	7	10	60.27	75.33	68.18	80.21	60.92	75.71	68.74	80.54	61.21	76.10	68.99	80.85
50	5	7	11	60.30	75.38	68.04	80.14	60.95	75.77	68.60	80.48	61.24	76.15	68.85	80.78
50	5	8	8	60.79	75.64	67.23	79.60	61.45	76.08	67.83	80.00	61.74	76.48	68.04	80.31
50	5	8	9	60.82	75.68	67.14	79.56	61.48	76.12	67.74	79.96	61.77	76.52	67.95	80.26
50	5	8	10	60.84	75.71	67.04	79.51	61.51	76.16	67.64	79.92	61.79	76.55	67.86	80.21
50	5	8	11	60.86	75.75	66.93	79.46	61.53	76.20	67.54	79.87	61.81	76.58	67.75	80.16
50	5	8	12	60.88	75.77	66.83	79.41	61.56	76.24	67.43	79.82	61.84	76.61	67.64	80.10
50	5	9	9	61.33	76.07	65.80	78.79	62.02	76.54	66.48	79.24	62.29	76.93	66.65	79.52
50	5	9	10	61.34	76.09	65.72	78.74	62.04	76.56	66.40	79.20	62.31	76.95	66.56	79.48
50	5	9	11	61.36	76.11	65.64	78.69	62.06	76.58	66.31	79.15	62.33	76.96	66.48	79.42
50	5	9	12	61.38	76.13	65.55	78.64	62.07	76.60	66.22	79.10	62.34	76.98	66.38	79.37
50	5	9	13	61.40	76.14	65.45	78.59	62.09	76.62	66.12	79.04	62.36	77.00	66.29	79.31
50	6	6	6	60.07	74.20	67.95	79.29	60.68	74.68	68.42	79.66	61.03	75.03	68.76	79.98
50	6	6	7	60.10	74.26	67.83	79.24	60.72	74.75	68.31	79.62	61.06	75.09	68.65	79.94
50	6	6	8	60.13	74.32	67.70	79.19	60.75	74.80	68.19	79.57	61.10	75.16	68.53	79.89
50	6	6	9	60.16	74.36	67.56	79.12	60.79	74.85	68.06	79.50	61.13	75.20	68.40	79.83
50	6	6	10	60.19	74.41	67.42	79.05	60.82	74.90	67.92	79.43	61.16	75.26	68.26	79.77
50	6	7	7	60.69	74.63	67.01	78.70	61.31	75.17	67.53	79.15	61.66	75.56	67.86	79.50
50	6	7	8	60.71	74.68	66.92	78.67	61.34	75.22	67.45	79.12	61.69	75.60	67.77	79.46
50	6	7	9	60.74	74.72	66.83	78.63	61.36	75.27	67.35	79.09	61.71	75.65	67.67	79.42
50	6	7	10	60.76	74.76	66.72	78.58	61.38	75.31	67.24	79.04	61.73	75.69	67.56	79.37
50	6	7	11	60.78	74.80	66.61	78.53	61.41	75.36	67.13	78.99	61.75	75.73	67.45	79.31
50	6	8	8	61.22	75.12	65.93	78.12	61.86	75.69	66.51	78.63	62.21	76.06	66.80	78.94
50	6	8	9	61.24	75.14	65.84	78.07	61.89	75.72	66.43	78.59	62.23	76.08	66.72	78.89
50	6	8	10	61.26	75.17	65.76	78.03	61.91	75.74	66.34	78.54	62.25	76.10	66.63	78.84
50	6	8	11	61.27	75.19	65.66	77.97	61.92	75.77	66.24	78.49	62.26	76.12	66.53	78.79
50	6	8	12	61.29	75.22	65.56	77.92	61.94	75.79	66.14	78.43	62.27	76.15	66.43	78.73
50	6	9	9	61.69	75.42	64.75	77.35	62.33	75.95	65.37	77.86	62.64	76.30	65.61	78.14
50	6	9	10	61.71	75.44	64.68	77.31	62.34	75.96	65.30	77.82	62.66	76.31	65.55	78.10
50	6	9	11	61.72	75.46	64.60	77.27	62.35	75.99	65.23	77.79	62.67	76.33	65.48	78.06
50	6	9	12	61.73	75.47	64.52	77.23	62.37	76.01	65.16	77.75	62.68	76.34	65.41	78.02
50	6	9	13	61.74	75.49	64.44	77.18	62.38	76.03	65.07	77.70	62.70	76.36	65.33	77.98
50	6	10	10	62.09	75.77	63.42	76.57	62.74	76.26	64.11	77.09	63.03	76.63	64.31	77.38
50	6	10	11	62.10	75.78	63.35	76.53	62.75	76.28	64.05	77.05	63.04	76.65	64.25	77.34
50	6	10	12	62.11	75.79	63.28	76.49	62.76	76.29	63.98	77.01	63.05	76.66	64.18	77.30
50	6	10	13	62.12	75.81	63.21	76.45	62.78	76.31	63.90	76.98	63.06	76.67	64.11	77.27
50	6	10	14	62.13	75.83	63.13	76.41	62.79	76.34	63.83	76.95	63.07	76.69	64.04	77.23
255	2	5	9	56.63	76.47	70.42	83.81	57.22	76.82	71.00	84.15	57.33	77.26	71.00	84.35
255	2	6	9	58.21	76.67	70.00	83.11	58.75	77.08	70.62	83.54	58.89	77.50	70.60	83.71
255	2	6	10	58.41	76.86	69.61	82.94	58.96	77.29	70.24	83.38	59.07	77.68	70.22	83.55
255	3	5	9	57.42	76.31	71.02	83.80	58.01	76.67	71.49	84.08	58.13	77.08	71.60	84.35
255	3	6	9	58.74	76.32	70.68	83.10	59.34	76.74	71.20	83.44	59.43	77.09	71.27	83.66
255	3	6	10	58.90	76.49	70.35	82.95	59.51	76.92	70.87	83.30	59.58	77.24	70.95	83.52
255	3	7	9	59.83	76.70	69.56	82.25	60.44	77.10	70.19	82.65	60.54	77.50	70.17	82.86
255	3	7	10	59.92	76.81	69.34	82.17	60.55	77.23	69.97	82.57	60.63	77.61	69.97	82.77
255	3	7	11	60.00	76.92	69.10	82.07	60.64	77.36	69.73	82.48	60.71	77.69	69.74	82.67
255	4	5	9	58.37	75.61	71.01	82.97	58.96	76.02	71.38	83.24	59.04	76.38	71.56	83.55
255	4	6	9	59.48	75.92	70.55	82.46	60.08	76.34	71.00	82.77	60.16	76.65	71.12	83.02
255	4	6	10	59.61	76.05	70.27	82.33	60.22	76.49	70.72	82.64	60.27	76.79	70.84	82.90
255	4	7	9	60.41	76.14	69.59	81.63	61.00	76.52	70.14	81.97	61.05	76.82	70.17	82.18
255	4	7	10	60.48	76.24	69.41	81.56	61.09	76.63	69.96	81.91	61.12	76.91	70.00	82.11
255	4	7	11	60.55	76.33	69.22	81.47	61.17	76.75	69.76	81.83	61.18	76.98	69.82	82.02
255	4	8	8	61.12	76.51	68.37	80.84	61.74	76.87	69.03	81.21	61.75	77.17	68.98	81.40
255	4	8	9	61.17	76.58	68.27	80.80	61.80	76.95	68.93	81.19	61.80	77.22	68.88	81.36
255	4	8	10	61.22	76.65	68.14	80.76	61.86	77.03	68.80	81.15	61.84	77.27	68.76	81.30
255	4	8	11	61.26	76.72	68.00	80.70	61.91	77.10	68.66	81.09	61.88	77.31	68.63	81.24
255	4	8	12	61.31	76.77	67.84	80.63	61.96	77.16	68.51	81.02	61.92	77.35	68.49	81.17
255	5	5	9	59.06	75.02	69.92	81.62	59.79	75.50	70.36	81.92	59.91	75.79	70.61	82.22
255	5	6	9	59.95	75.31	69.52	81.19	60.66	75.74	70.04	81.50	60.76	76.01	70.19	81.75
255	5	6	10	60.05	75.42	69.31	81.09	60.76	75.87	69.83	81.42	60.84	76.11	70.00	81.66
255	5	7	9	60.75	75.70	68.71	80.60	61.46	76.10	69.31	80.93	61.52	76.36	69.38	81.15
255	5	7	10	60.80	75.78	68.56	80.53	61.53	76.21	69.16	80.89	61.57	76.43	69.24	81.08
255	5	7	11	60.86	75.86	68.39	80.47	61.59	76.29	68.98	80.82	61.62	76.49	69.08	81.01
255	5	8	8	61.35	75.96	67.70	79.87	62.08	76.40	68.37	80.27	62.12	76.70	68.37	80.49
255	5	8	9	61.39	76.02	67.61	79.84	62.13	76.48	68.28	80.25	62.16	76.75	68.28	80.45
255	5	8	10	61.42	76.07	67.50	79.80	62.18	76.54	68.17	80.21	62.19	76.78	68.17	80.40
255	5	8	11	61.46	76.12	67.39	79.75	62.22	76.60	68.06	80.16	62.22	76.82	68.06	80.34
255	5	8	12	61.49	76.16	67.26	79.68	62.26	76.64	67.93	80.10	62.24	76.84	67.94	80.28
255	5	9	9	61.94	76.42	66.31	79.07	62.73	76.90	67.06	79.52	62.70	77.16	66.98	79.71
255	5	9	10	61.97	76.45	66.23	79.03	62.76	76.93	66.98	79.48	62.72	77.19	66.90	79.67
255	5	9	11	62.00	76.47	66.14	78.98	62.79	76.96	66.89	79.44	62.74	77.21	66.81	79.62
255	5	9	12	62.02	76.50	66.04	78.93	62.82	76.99	66.80	79.39	62.76	77.23	66.72	79.57
255	5	9	13	62.04	76.52	65.94	78.87	62.84	77.02	66.70	79.34	62.78	77.25	66.62	79.52
255	6	6	9	60.66	74.76	67.96	79.44	61.35	75.27	68.50	79.84	61.47	75.49	68.68	80.06
255	6	6	10	60.72	74.85	67.80	79.37	61.43	75.37	68.35	79.77	61.53	75.58	68.53	80.00
255	6	7	9	61.31	75.09	67.32	78.94	62.01	75.65	67.91	79.42	62.10	75.90	68.00	79.63
255	6	7	10	61.35	75.16	67.20	78.90	62.06	75.73	67.79	79.38	62.14	75.95	67.89	79.58
255	6	7	11	61.40	75.22	67.08	78.85	62.11	75.80	67.66	79.33	62.17	75.99	67.77	79.52
255	6	8	8	61.83	75.47	66.47	78.43	62.57	76.05	67.14	78.95	62.62	76.30	67.17	79.15

				Blue				Green				Red			
				% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings	
R	k	n	p	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra
255	6	8	9	61.86	75.52	66.39	78.40	62.61	76.11	67.06	78.93	62.65	76.33	67.08	79.11
255	6	8	10	61.90	75.57	66.30	78.36	62.64	76.16	66.97	78.89	62.67	76.36	66.99	79.06
255	6	8	11	61.92	75.60	66.20	78.31	62.67	76.20	66.86	78.84	62.69	76.39	66.89	79.01
255	6	8	12	61.95	75.63	66.09	78.26	62.70	76.23	66.75	78.78	62.70	76.42	66.79	78.96
255	6	9	9	62.36	75.83	65.32	77.69	63.10	76.38	66.03	78.22	63.08	76.58	65.98	78.38
255	6	9	10	62.37	75.86	65.24	77.66	63.12	76.41	65.97	78.19	63.09	76.60	65.92	78.35
255	6	9	11	62.39	75.87	65.17	77.62	63.14	76.44	65.89	78.16	63.11	76.62	65.85	78.31
255	6	9	12	62.41	75.90	65.09	77.58	63.16	76.46	65.82	78.12	63.12	76.64	65.78	78.27
255	6	9	13	62.42	75.92	65.01	77.53	63.18	76.49	65.73	78.08	63.13	76.66	65.70	78.23
255	6	10	10	62.76	76.22	64.01	76.97	63.54	76.76	64.81	77.52	63.47	76.96	64.70	77.67
255	6	10	11	62.77	76.24	63.95	76.94	63.55	76.78	64.75	77.49	63.48	76.97	64.64	77.64
255	6	10	12	62.79	76.25	63.88	76.90	63.57	76.80	64.68	77.46	63.49	76.98	64.58	77.60
255	6	10	13	62.80	76.27	63.81	76.86	63.58	76.82	64.62	77.43	63.50	76.99	64.51	77.56
255	6	10	14	62.81	76.28	63.74	76.82	63.60	76.84	64.55	77.39	63.51	77.01	64.45	77.52

APPENDIX C

RESULTS OF IVPA OPTIMIZED FOR EDP MINIMIZATION

The EDP and energy savings of the IVPA scheme (optimized for EDP minimization), for various values of codeword lengths (*k*, *n* and *p*) and range (*R*), averaged over 10 images of the SIPI database [21], have been presented below.

				Blue				Green				Red			
				% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings	
R	k	n	p	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra
10	2	2	4	39.04	67.57	64.76	81.02	40.98	68.69	66.02	81.73	40.08	68.05	65.29	81.22
10	2	2	5	40.07	67.45	63.68	80.01	42.00	68.58	65.03	80.80	41.15	67.94	64.20	80.18
10	2	2	6	40.28	67.31	62.39	79.13	42.34	68.48	63.88	79.99	41.49	67.83	62.91	79.26
10	2	3	4	41.62	67.37	65.61	80.58	43.47	68.53	66.82	81.33	42.66	67.95	66.23	80.89
10	2	3	5	42.06	67.50	64.85	80.07	43.91	68.67	66.12	80.86	43.12	68.09	65.45	80.35
10	2	3	6	42.09	67.57	64.03	79.63	43.97	68.63	65.39	80.40	43.22	68.07	64.65	79.84
10	2	3	7	42.39	67.83	63.27	79.25	44.27	68.91	64.70	80.07	43.53	68.39	63.88	79.48
10	2	4	4	43.73	67.57	64.93	79.60	45.54	68.71	66.22	80.40	44.79	68.17	65.65	79.96
10	2	4	5	44.03	67.89	64.52	79.45	45.82	69.00	65.84	80.26	45.11	68.50	65.23	79.80
10	2	4	6	43.98	67.40	64.00	78.85	45.68	68.53	65.32	79.71	45.00	68.03	64.65	79.19
10	2	4	7	43.98	67.40	63.43	78.51	45.68	68.53	64.79	79.39	45.00	68.03	64.06	78.83
10	2	4	8	42.50	65.55	63.25	77.78	44.29	66.78	64.60	78.68	43.51	66.15	63.89	78.08
10	2	5	5	44.63	66.61	62.66	77.30	46.35	67.79	64.06	78.23	45.66	67.18	63.41	77.63
10	2	5	6	44.59	66.60	62.49	77.20	46.37	67.78	63.93	78.13	45.68	67.17	63.26	77.53
10	2	5	7	44.59	66.60	62.33	77.10	46.37	67.78	63.78	78.04	45.68	67.17	63.10	77.42
10	2	5	8	44.59	66.60	62.17	77.00	46.37	67.78	63.63	77.95	45.68	67.17	62.93	77.32
10	2	5	9	44.59	66.60	62.01	76.90	46.37	67.78	63.48	77.86	45.68	67.17	62.77	77.22
10	2	6	6	44.90	67.34	60.17	76.20	46.44	68.53	61.81	77.35	46.03	67.99	61.00	76.59
10	2	6	7	44.90	67.34	60.04	76.12	46.44	68.53	61.68	77.28	46.03	67.99	60.86	76.51
10	2	6	8	44.90	67.34	59.91	76.05	46.44	68.53	61.55	77.20	46.03	67.99	60.72	76.42
10	2	6	9	44.90	67.34	59.78	75.97	46.44	68.53	61.43	77.12	46.03	67.99	60.59	76.34
10	2	6	10	44.90	67.34	59.65	75.89	46.44	68.53	61.30	77.05	46.03	67.99	60.45	76.25
10	3	3	3	43.45	66.32	65.99	79.64	45.24	67.82	67.06	80.52	44.34	66.93	66.60	80.03
10	3	3	4	43.72	66.70	65.60	79.53	45.49	68.15	66.69	80.42	44.61	67.29	66.19	79.90
10	3	3	5	43.94	66.96	65.03	79.28	45.74	68.43	66.20	80.20	44.83	67.62	65.60	79.67
10	3	3	6	43.49	66.07	64.50	78.56	45.25	67.55	65.66	79.51	44.39	66.67	65.08	78.91
10	3	3	7	43.49	66.07	63.99	78.25	45.25	67.55	65.19	79.23	44.39	66.67	64.56	78.59
10	3	4	4	44.47	66.39	64.39	78.32	46.26	67.59	65.59	79.12	45.57	66.99	65.16	78.71
10	3	4	5	44.47	66.39	64.08	78.13	46.26	67.59	65.31	78.95	45.57	66.99	64.84	78.51
10	3	4	6	44.19	66.07	63.80	77.86	45.99	67.28	65.05	78.69	45.27	66.64	64.56	78.23
10	3	4	7	44.01	65.80	63.62	77.65	45.82	67.03	64.87	78.49	45.08	66.37	64.38	78.02
10	3	4	8	43.95	65.72	63.48	77.54	45.65	66.81	64.79	78.36	45.03	66.29	64.25	77.90
10	3	5	5	45.16	66.72	62.51	77.13	46.93	67.87	63.85	77.99	46.24	67.26	63.32	77.49
10	3	5	6	45.16	66.72	62.36	77.03	46.93	67.87	63.71	77.90	46.24	67.26	63.16	77.39
10	3	5	7	45.16	66.72	62.20	76.93	46.93	67.87	63.56	77.81	46.24	67.26	63.00	77.29
10	3	5	8	44.96	66.32	62.14	76.70	46.76	67.52	63.51	77.61	46.05	66.89	62.95	77.09
10	3	5	9	44.96	66.32	62.02	76.63	46.76	67.52	63.41	77.54	46.05	66.89	62.83	77.01
10	3	6	6	45.38	67.15	60.64	76.22	47.14	68.29	62.08	77.13	46.45	67.72	61.47	76.62
10	3	6	7	45.38	67.15	60.51	76.14	47.14	68.29	61.96	77.05	46.45	67.72	61.34	76.53
10	3	6	8	45.31	67.04	60.42	76.04	47.05	68.14	61.89	76.95	46.35	67.58	61.27	76.43
10	3	6	9	45.31	67.04	60.31	75.97	47.05	68.14	61.79	76.89	46.35	67.58	61.16	76.36
10	3	6	10	45.31	67.04	60.20	75.90	47.05	68.14	61.69	76.82	46.35	67.58	61.05	76.29
10	3	7	7	45.94	67.23	58.76	74.89	47.69	68.38	60.33	75.89	47.03	67.82	59.66	75.32
10	3	7	8	45.84	66.97	58.73	74.71	47.58	68.09	60.29	75.70	46.93	67.54	59.61	75.13
10	3	7	9	45.84	66.97	58.63	74.66	47.58	68.09	60.20	75.65	46.93	67.54	59.51	75.06
10	3	7	10	45.84	66.97	58.54	74.60	47.58	68.09	60.11	75.59	46.93	67.54	59.41	75.00
10	3	7	11	45.84	66.97	58.44	74.54	47.58	68.09	60.02	75.54	46.93	67.54	59.31	74.93
10	4	4	4	45.88	66.00	63.14	76.76	47.78	67.16	64.42	77.54	46.95	66.48	63.93	77.11
10	4	4	5	45.88	66.00	62.98	76.66	47.78	67.16	64.28	77.45	46.95	66.48	63.77	77.01
10	4	4	6	45.88	66.00	62.83	76.56	47.78	67.16	64.13	77.36	46.95	66.48	63.61	76.90
10	4	4	7	45.88	66.00	62.67	76.46	47.78	67.16	63.98	77.27	46.95	66.48	63.45	76.80
10	4	4	8	45.88	66.00	62.52	76.36	47.78	67.16	63.84	77.17	46.95	66.48	63.29	76.70
10	4	5	5	46.08	66.09	61.56	75.75	47.75	67.27	62.79	76.61	47.12	66.66	62.37	76.17
10	4	5	6	46.08	66.09	61.44	75.67	47.75	67.27	62.67	76.53	47.12	66.66	62.24	76.08
10	4	5	7	46.08	66.09	61.31	75.58	47.75	67.27	62.54	76.45	47.12	66.66	62.10	76.00
10	4	5	8	46.08	66.09	61.18	75.50	47.75	67.27	62.42	76.37	47.12	66.66	61.97	75.91
10	4	5	9	46.08	66.09	61.05	75.42	47.75	67.27	62.30	76.29	47.12	66.66	61.83	75.82
10	4	6	6	46.67	66.25	60.18	74.72	48.33	67.44	61.50	75.65	47.74	66.82	61.03	75.15
10	4	6	7	46.67	66.25	60.05	74.64	48.33	67.44	61.38	75.57	47.74	66.82	60.90	75.06
10	4	6	8	46.67	66.25	59.93	74.56	48.33	67.44	61.26	75.49	47.74	66.82	60.77	74.98
10	4	6	9	46.67	66.25	59.80	74.48	48.33	67.44	61.14	75.42	47.74	66.82	60.64	74.89

				Blue				Green				Red			
				% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings	
R	k	n	p	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra
10	4	6	10	46.65	66.21	59.70	74.39	48.15	66.98	61.18	75.19	47.73	66.78	60.53	74.80
10	4	7	7	47.00	65.61	58.75	73.16	48.64	66.80	60.14	74.15	48.07	66.08	59.67	73.54
10	4	7	8	47.00	65.61	58.64	73.09	48.64	66.80	60.04	74.08	48.07	66.08	59.56	73.46
10	4	7	9	47.00	65.61	58.53	73.01	48.64	66.80	59.94	74.02	48.07	66.08	59.45	73.39
10	4	7	10	46.97	65.57	58.45	72.94	48.50	66.52	59.96	73.88	48.05	66.03	59.37	73.31
10	4	7	11	46.84	65.31	58.49	72.83	48.50	66.52	59.90	73.84	47.94	65.86	59.38	73.24
10	4	8	8	47.68	66.39	57.17	72.40	49.32	67.53	58.68	73.44	48.78	66.88	58.15	72.81
10	4	8	9	47.68	66.39	57.06	72.33	49.32	67.53	58.59	73.38	48.78	66.88	58.05	72.74
10	4	8	10	47.56	66.04	57.09	72.13	49.19	67.20	58.60	73.18	48.66	66.57	58.05	72.55
10	4	8	11	47.56	66.04	57.03	72.09	49.19	67.20	58.54	73.14	48.66	66.57	57.98	72.50
10	4	8	12	47.56	66.04	56.96	72.04	49.19	67.20	58.48	73.10	48.66	66.57	57.91	72.45
10	5	5	5	47.40	64.90	59.99	73.23	49.35	66.32	61.45	74.31	48.51	65.78	60.88	73.91
10	5	5	6	47.40	64.90	59.86	73.15	49.35	66.32	61.33	74.24	48.51	65.78	60.75	73.82
10	5	5	7	47.40	64.90	59.74	73.07	49.35	66.32	61.22	74.16	48.51	65.78	60.62	73.73
10	5	5	8	47.40	64.90	59.62	72.98	49.35	66.32	61.10	74.08	48.51	65.78	60.49	73.64
10	5	5	9	47.40	64.90	59.50	72.90	49.35	66.32	60.98	74.00	48.51	65.78	60.36	73.55
10	5	6	6	46.93	64.84	58.17	72.22	48.72	66.10	59.59	73.22	48.20	65.38	59.20	72.65
10	5	6	7	46.93	64.84	58.06	72.15	48.72	66.10	59.49	73.15	48.20	65.38	59.09	72.57
10	5	6	8	46.93	64.84	57.95	72.07	48.72	66.10	59.39	73.09	48.20	65.38	58.99	72.50
10	5	6	9	46.93	64.84	57.84	72.00	48.72	66.10	59.29	73.02	48.20	65.38	58.88	72.42
10	5	6	10	46.93	64.84	57.73	71.93	48.72	66.10	59.19	72.95	48.20	65.38	58.77	72.35
10	5	7	7	47.30	65.05	56.77	71.26	49.07	66.27	58.28	72.30	48.55	65.53	57.83	71.65
10	5	7	8	47.30	65.05	56.67	71.19	49.07	66.27	58.19	72.24	48.55	65.53	57.72	71.58
10	5	7	9	47.30	65.05	56.56	71.12	49.07	66.27	58.09	72.17	48.55	65.53	57.62	71.51
10	5	7	10	47.30	65.05	56.45	71.04	49.07	66.27	57.99	72.11	48.55	65.53	57.52	71.44
10	5	7	11	47.30	65.05	56.35	70.97	49.07	66.27	57.90	72.04	48.55	65.53	57.41	71.36
10	5	8	8	47.62	65.41	55.19	70.34	49.38	66.65	56.80	71.46	48.87	65.96	56.26	70.78
10	5	8	9	47.62	65.41	55.10	70.28	49.38	66.65	56.71	71.41	48.87	65.96	56.16	70.71
10	5	8	10	47.62	65.41	55.01	70.21	49.38	66.65	56.63	71.35	48.87	65.96	56.07	70.65
10	5	8	11	47.62	65.41	54.92	70.15	49.38	66.65	56.54	71.29	48.87	65.96	55.97	70.58
10	5	8	12	47.56	65.25	54.90	70.04	49.32	66.49	56.54	71.19	48.81	65.81	55.95	70.46
10	5	9	9	47.92	65.86	53.44	69.40	49.68	67.09	55.16	70.59	49.18	66.44	54.52	69.84
10	5	9	10	47.92	65.86	53.35	69.33	49.68	67.09	55.08	70.54	49.18	66.44	54.42	69.78
10	5	9	11	47.92	65.86	53.26	69.27	49.68	67.09	54.99	70.48	49.18	66.44	54.32	69.71
10	5	9	12	47.87	65.70	53.25	69.16	49.38	66.21	55.23	70.04	49.13	66.28	54.30	69.59
10	5	9	13	47.62	64.97	53.53	68.84	49.38	66.21	55.23	70.04	48.87	65.50	54.62	69.26
10	6	6	6	48.08	65.21	56.36	70.72	50.03	66.46	57.99	71.77	49.18	65.86	57.32	71.27
10	6	6	7	48.08	65.21	56.25	70.64	50.03	66.46	57.90	71.70	49.18	65.86	57.21	71.20
10	6	6	8	48.08	65.21	56.15	70.57	50.03	66.46	57.80	71.64	49.18	65.86	57.11	71.13
10	6	6	9	48.08	65.21	56.04	70.50	50.03	66.46	57.71	71.57	49.18	65.86	57.01	71.05
10	6	6	10	48.08	65.21	55.94	70.43	50.03	66.46	57.61	71.51	49.18	65.86	56.90	70.98
10	6	7	7	47.41	65.06	54.33	69.61	49.15	66.35	55.86	70.76	48.68	65.69	55.44	70.15
10	6	7	8	47.41	65.06	54.24	69.55	49.15	66.35	55.78	70.70	48.68	65.69	55.35	70.09
10	6	7	9	47.41	65.06	54.15	69.49	49.15	66.35	55.69	70.64	48.68	65.69	55.25	70.02
10	6	7	10	47.41	65.06	54.06	69.43	49.15	66.35	55.61	70.58	48.68	65.69	55.15	69.95
10	6	7	11	47.41	65.06	53.97	69.37	49.15	66.35	55.52	70.52	48.68	65.69	55.06	69.88
10	6	8	8	47.73	65.50	52.96	68.90	49.48	66.79	54.59	70.11	49.02	66.16	54.09	69.46
10	6	8	9	47.73	65.50	52.87	68.84	49.48	66.79	54.51	70.05	49.02	66.16	54.00	69.39
10	6	8	10	47.73	65.50	52.78	68.78	49.48	66.79	54.42	69.99	49.02	66.16	53.90	69.33
10	6	8	11	47.73	65.50	52.69	68.72	49.48	66.79	54.34	69.94	49.02	66.16	53.80	69.26
10	6	8	12	47.73	65.50	52.60	68.66	49.48	66.79	54.25	69.88	49.02	66.16	53.71	69.20
10	6	9	9	48.03	65.83	51.44	68.01	49.75	67.06	53.16	69.25	49.29	66.42	52.57	68.51
10	6	9	10	48.03	65.83	51.36	67.96	49.75	67.06	53.09	69.20	49.29	66.42	52.49	68.45
10	6	9	11	48.03	65.83	51.28	67.91	49.75	67.06	53.03	69.15	49.29	66.42	52.41	68.40
10	6	9	12	48.03	65.83	51.20	67.85	49.75	67.06	52.96	69.11	49.29	66.42	52.34	68.35
10	6	9	13	48.03	65.83	51.13	67.80	49.75	67.06	52.89	69.06	49.29	66.42	52.26	68.30
10	6	10	10	48.31	66.20	49.76	67.09	50.02	67.39	51.62	68.38	49.57	66.78	50.91	67.58
10	6	10	11	48.31	66.20	49.69	67.04	50.02	67.39	51.55	68.33	49.57	66.78	50.83	67.52
10	6	10	12	48.31	66.20	49.61	66.99	50.02	67.39	51.48	68.29	49.57	66.78	50.76	67.47
10	6	10	13	48.31	66.20	49.53	66.94	50.02	67.39	51.41	68.24	49.57	66.78	50.68	67.42
10	6	10	14	48.26	66.06	49.53	66.84	49.97	67.26	51.42	68.15	49.52	66.64	50.68	67.32
20	2	2	6	45.85	72.56	67.38	83.28	46.90	72.94	68.09	83.57	46.86	73.30	67.86	83.64
20	2	3	5	47.27	72.83	70.09	84.47	48.13	73.22	70.59	84.69	48.14	73.64	70.65	84.95
20	2	3	6	48.13	73.05	69.20	83.85	48.99	73.31	69.80	84.06	49.06	73.80	69.76	84.28
20	2	3	7	48.91	73.83	68.20	83.55	49.77	74.13	68.90	83.82	49.85	74.63	68.75	84.00
20	2	4	5	50.35	73.14	70.72	84.06	51.08	73.49	71.18	84.28	51.27	73.98	71.39	84.59
20	2	4	6	50.87	73.36	70.23	83.74	51.50	73.69	70.69	83.98	51.70	74.19	70.82	84.26
20	2	4	7	51.23	73.30	69.53	83.17	51.81	73.62	70.02	83.44	52.05	74.13	70.09	83.69
20	2	4	8	50.63	72.64	68.72	82.51	51.21	72.95	69.25	82.80	51.44	73.44	69.28	83.00
20	2	5	5	52.68	73.04	69.98	82.79	53.22	73.35	70.43	83.04	53.53	73.82	70.67	83.33
20	2	5	6	52.91	73.26	69.67	82.66	53.47	73.54	70.16	82.91	53.81	74.04	70.39	83.19
20	2	5	7	53.14	73.45	69.33	82.50	53.68	73.71	69.84	82.75	54.04	74.23	70.04	83.03
20	2	5	8	53.26	73.48	68.98	82.26	53.77	73.73	69.51	82.53	54.17	74.26	69.70	82.79
20	2	5	9	52.19	72.39	68.38	81.60	52.85	72.80	68.97	81.95	53.12	73.17	69.10	82.12
20	2	6	6	54.21	73.85	68.19	81.70	54.43	74.20	68.72	82.14	55.19	74.75	68.98	82.33
20	2	6	7	54.36	73.96	68.00	81.60	54.56	74.30	68.53	82.05	55.34	74.86	68.79	82.23
20	2	6	8	54.50	74.06	67.77	81.48	54.70	74.41	68.31	81.94	55.48	74.97	68.55	82.10
20	2	6	9	54.63	74.16	67.49	81.33	54.82	74.50	68.04	81.79	55.61	75.06	68.27	81.95
20	2	6	10	54.75	74.25	67.18	81.16	54.93	74.60	67.74	81.63	55.74	75.16	67.95	81.78

				Blue				Green				Red			
				% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings	
R	k	n	p	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra
20	3	3	5	50.05	72.55	70.93	83.97	50.77	73.24	71.25	84.31	50.75	73.46	71.43	84.55
20	3	3	6	50.54	72.63	70.26	83.49	51.19	73.25	70.63	83.83	51.20	73.42	70.75	84.00
20	3	3	7	50.98	72.71	69.48	82.94	51.62	73.35	69.91	83.34	51.65	73.54	69.96	83.47
20	3	4	5	51.88	72.92	71.02	83.64	52.53	73.28	71.35	83.81	52.76	73.74	71.70	84.20
20	3	4	6	52.05	72.67	70.53	83.13	52.69	73.01	70.88	83.32	52.91	73.44	71.19	83.67
20	3	4	7	51.88	72.39	69.95	82.68	52.53	72.75	70.34	82.90	52.76	73.21	70.62	83.24
20	3	4	8	51.91	72.38	69.48	82.39	52.44	72.61	69.93	82.59	52.80	73.19	70.14	82.94
20	3	5	5	53.63	72.98	70.20	82.57	54.16	73.29	70.55	82.76	54.50	73.77	70.91	83.15
20	3	5	6	53.71	73.04	69.95	82.43	54.23	73.34	70.31	82.63	54.59	73.84	70.67	83.01
20	3	5	7	53.85	73.26	69.67	82.36	54.37	73.56	70.05	82.56	54.74	74.05	70.38	82.92
20	3	5	8	53.79	73.08	69.41	82.10	54.31	73.40	69.81	82.34	54.69	73.90	70.13	82.69
20	3	5	9	52.90	71.81	69.05	81.39	53.55	72.26	69.49	81.69	53.80	72.63	69.78	81.99
20	3	6	6	54.73	73.42	68.62	81.50	55.19	73.75	69.02	81.77	55.62	74.22	69.38	82.11
20	3	6	7	54.82	73.50	68.43	81.41	55.28	73.83	68.84	81.68	55.72	74.30	69.19	82.01
20	3	6	8	54.83	73.48	68.24	81.27	55.27	73.76	68.67	81.53	55.70	74.25	69.00	81.86
20	3	6	9	54.92	73.56	68.01	81.15	55.35	73.84	68.44	81.42	55.78	74.33	68.78	81.75
20	3	6	10	55.00	73.63	67.75	81.01	55.42	73.91	68.19	81.28	55.87	74.40	68.52	81.61
20	3	7	7	55.51	73.49	66.73	80.09	55.95	73.81	67.22	80.41	56.42	74.29	67.55	80.72
20	3	7	8	55.40	73.23	66.64	79.89	55.83	73.52	67.13	80.20	56.31	74.01	67.45	80.50
20	3	7	9	55.40	73.23	66.52	79.81	55.83	73.52	67.01	80.12	56.31	74.01	67.32	80.42
20	3	7	10	55.40	73.23	66.40	79.74	55.83	73.52	66.90	80.05	56.31	74.01	67.20	80.34
20	3	7	11	55.40	73.23	66.28	79.66	55.83	73.52	66.78	79.98	56.31	74.01	67.07	80.27
20	4	4	4	53.72	72.49	70.87	82.66	54.44	72.80	71.17	82.77	54.56	73.22	71.54	83.21
20	4	4	5	53.88	72.42	70.56	82.37	54.57	72.73	70.88	82.49	54.71	73.14	71.22	82.90
20	4	4	6	53.92	72.51	70.20	82.18	54.61	72.80	70.53	82.31	54.76	73.23	70.85	82.72
20	4	4	7	53.48	71.79	69.83	81.67	54.22	72.17	70.19	81.84	54.32	72.49	70.49	82.19
20	4	4	8	53.57	71.89	69.58	81.54	54.29	72.26	69.95	81.72	54.40	72.58	70.24	82.06
20	4	5	5	54.61	72.58	69.50	81.54	55.06	72.91	69.72	81.71	55.47	73.39	70.20	82.16
20	4	5	6	54.72	72.70	69.30	81.46	55.15	73.00	69.54	81.63	55.56	73.49	69.99	82.06
20	4	5	7	54.78	72.75	69.06	81.32	55.07	72.85	69.29	81.40	55.63	73.55	69.75	81.92
20	4	5	8	54.68	72.58	68.80	81.08	55.13	72.93	69.05	81.28	55.52	73.36	69.49	81.67
20	4	5	9	54.00	71.40	68.68	80.49	54.50	71.80	68.95	80.71	54.83	72.18	69.35	81.08
20	4	6	6	55.73	73.09	68.15	80.60	56.15	73.42	68.46	80.83	56.63	73.87	68.91	81.21
20	4	6	7	55.73	73.13	67.96	80.50	55.85	72.98	68.20	80.49	56.63	73.92	68.70	81.12
20	4	6	8	55.41	72.63	67.75	80.16	55.85	72.98	68.06	80.40	56.31	73.42	68.49	80.77
20	4	6	9	55.41	72.63	67.60	80.07	55.85	72.98	67.92	80.31	56.31	73.42	68.34	80.67
20	4	6	10	55.20	72.36	67.49	79.89	55.40	72.22	67.88	79.95	56.09	73.14	68.22	80.49
20	4	7	7	55.30	72.21	66.26	78.98	55.77	72.55	66.64	79.25	56.21	72.93	67.07	79.58
20	4	7	8	55.30	72.21	66.17	78.93	55.77	72.55	66.56	79.19	56.21	72.93	66.98	79.52
20	4	7	9	55.30	72.21	66.09	78.87	55.77	72.55	66.47	79.14	56.21	72.93	66.89	79.46
20	4	7	10	55.28	72.17	66.01	78.80	55.62	72.27	66.47	79.00	56.18	72.89	66.81	79.40
20	4	7	11	55.13	71.92	66.02	78.68	55.62	72.27	66.42	78.96	56.07	72.71	66.81	79.31
20	4	8	8	55.79	72.76	64.59	78.13	56.25	73.07	65.06	78.44	56.69	73.51	65.44	78.79
20	4	8	9	55.79	72.76	64.50	78.08	56.25	73.07	64.98	78.39	56.69	73.51	65.35	78.73
20	4	8	10	55.65	72.41	64.50	77.86	56.11	72.74	64.97	78.18	56.56	73.20	65.34	78.53
20	4	8	11	55.65	72.41	64.45	77.83	56.11	72.74	64.92	78.15	56.56	73.20	65.28	78.50
20	4	8	12	55.65	72.41	64.39	77.80	56.11	72.74	64.87	78.12	56.56	73.20	65.22	78.46
20	5	5	5	56.12	72.16	68.32	79.89	56.81	72.68	68.71	80.19	57.02	73.25	69.07	80.73
20	5	5	6	56.20	72.34	68.17	79.88	56.89	72.85	68.56	80.18	57.10	73.43	68.91	80.72
20	5	5	7	56.27	72.50	67.98	79.85	56.96	73.01	68.38	80.15	57.17	73.59	68.72	80.69
20	5	5	8	56.34	72.65	67.77	79.79	57.03	73.16	68.18	80.10	57.24	73.75	68.51	80.63
20	5	5	9	55.67	71.35	67.59	79.03	56.38	71.90	67.99	79.36	56.57	72.44	68.31	79.87
20	5	6	6	55.98	72.26	66.59	78.91	56.51	72.59	66.93	79.13	57.03	73.01	67.46	79.53
20	5	6	7	55.98	72.26	66.47	78.84	56.51	72.59	66.82	79.05	57.03	73.01	67.35	79.46
20	5	6	8	55.98	72.26	66.36	78.76	56.51	72.59	66.71	78.98	57.03	73.01	67.23	79.38
20	5	6	9	55.85	71.93	66.25	78.51	56.38	72.27	66.61	78.74	56.89	72.68	67.12	79.13
20	5	6	10	55.85	71.93	66.16	78.46	56.38	72.27	66.52	78.68	56.89	72.68	67.04	79.07
20	5	7	7	56.43	72.60	65.22	78.09	56.95	72.88	65.62	78.30	57.47	73.31	66.12	78.69
20	5	7	8	56.43	72.60	65.13	78.03	56.95	72.88	65.54	78.25	57.47	73.31	66.03	78.64
20	5	7	9	56.43	72.60	65.05	77.98	56.95	72.88	65.46	78.20	57.47	73.31	65.95	78.59
20	5	7	10	56.43	72.60	64.96	77.92	56.95	72.88	65.38	78.15	57.47	73.31	65.87	78.53
20	5	7	11	56.43	72.60	64.87	77.87	56.95	72.88	65.30	78.10	57.47	73.31	65.78	78.48
20	5	8	8	56.81	72.94	63.75	77.25	57.31	73.25	64.21	77.53	57.85	73.75	64.67	77.94
20	5	8	9	56.81	72.94	63.68	77.20	57.31	73.25	64.14	77.49	57.85	73.75	64.59	77.89
20	5	8	10	56.81	72.94	63.61	77.16	57.31	73.25	64.07	77.44	57.85	73.75	64.51	77.84
20	5	8	11	56.81	72.94	63.53	77.11	57.31	73.25	64.00	77.40	57.85	73.75	64.44	77.79
20	5	8	12	56.78	72.88	63.48	77.04	57.28	73.19	63.95	77.33	57.82	73.68	64.38	77.72
20	5	9	9	56.16	71.88	62.27	75.76	56.72	72.31	62.78	76.15	57.24	72.70	63.22	76.46
20	5	9	10	56.16	71.88	62.20	75.71	56.72	72.31	62.71	76.10	57.24	72.70	63.14	76.41
20	5	9	11	56.16	71.88	62.12	75.66	56.72	72.31	62.64	76.06	57.24	72.70	63.06	76.35
20	5	9	12	56.14	71.81	62.08	75.59	56.54	71.87	62.69	75.81	57.21	72.63	63.01	76.28
20	5	9	13	56.00	71.47	62.15	75.41	56.54	71.87	62.66	75.79	57.05	72.21	63.10	76.07
20	6	6	6	57.54	72.23	65.41	77.37	58.24	72.60	65.91	77.62	58.47	73.13	66.24	78.14
20	6	6	7	57.54	72.23	65.33	77.31	58.24	72.60	65.84	77.57	58.47	73.13	66.15	78.08
20	6	6	8	57.54	72.23	65.24	77.26	58.24	72.60	65.76	77.52	58.47	73.13	66.07	78.03
20	6	6	9	57.54	72.23	65.16	77.20	58.24	72.60	65.68	77.47	58.47	73.13	65.99	77.97
20	6	6	10	57.54	72.23	65.07	77.14	58.24	72.60	65.60	77.41	58.47	73.13	65.91	77.92
20	6	7	7	56.96	72.08	63.55	76.33	57.43	72.50	63.92	76.67	58.05	72.96	64.52	77.11
20	6	7	8	56.96	72.08	63.48	76.29	57.43	72.50	63.85	76.63	58.05	72.96	64.44	77.06

				Blue				Green				Red			
				% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings	
R	k	n	p	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra
20	6	7	9	56.96	72.08	63.41	76.24	57.43	72.50	63.78	76.58	58.05	72.96	64.37	77.01
20	6	7	10	56.96	72.08	63.34	76.19	57.43	72.50	63.71	76.54	58.05	72.96	64.29	76.96
20	6	7	11	56.96	72.08	63.26	76.14	57.43	72.50	63.64	76.49	58.05	72.96	64.21	76.90
20	6	8	8	57.32	72.50	62.38	75.74	57.80	72.93	62.81	76.12	58.44	73.41	63.38	76.55
20	6	8	9	57.32	72.50	62.31	75.69	57.80	72.93	62.74	76.07	58.44	73.41	63.31	76.50
20	6	8	10	57.32	72.50	62.24	75.64	57.80	72.93	62.67	76.03	58.44	73.41	63.23	76.44
20	6	8	11	57.32	72.50	62.17	75.60	57.80	72.93	62.60	75.98	58.44	73.41	63.16	76.39
20	6	8	12	57.32	72.50	62.10	75.55	57.80	72.93	62.53	75.94	58.44	73.41	63.08	76.34
20	6	9	9	57.66	72.80	61.15	75.01	58.11	73.19	61.60	75.40	58.75	73.65	62.15	75.78
20	6	9	10	57.66	72.80	61.09	74.97	58.11	73.19	61.55	75.36	58.75	73.65	62.09	75.74
20	6	9	11	57.66	72.80	61.03	74.93	58.11	73.19	61.49	75.32	58.75	73.65	62.03	75.70
20	6	9	12	57.66	72.80	60.96	74.89	58.11	73.19	61.44	75.29	58.75	73.65	61.97	75.66
20	6	9	13	57.66	72.80	60.90	74.85	58.11	73.19	61.38	75.25	58.75	73.65	61.91	75.62
20	6	10	10	57.55	71.68	59.86	73.19	57.98	72.08	60.36	73.62	58.64	72.51	60.88	73.94
20	6	10	11	57.55	71.68	59.80	73.15	57.98	72.08	60.31	73.59	58.64	72.51	60.82	73.90
20	6	10	12	57.55	71.68	59.74	73.10	57.98	72.08	60.25	73.55	58.64	72.51	60.76	73.86
20	6	10	13	57.55	71.68	59.68	73.06	57.98	72.08	60.20	73.51	58.64	72.51	60.70	73.82
20	6	10	14	57.52	71.60	59.66	72.99	57.95	71.99	60.18	73.44	58.61	72.42	60.68	73.74
50	2	3	7	50.59	75.03	69.58	84.48	51.42	75.37	70.27	84.79	51.49	75.90	70.08	84.96
50	2	4	7	53.34	75.30	71.15	84.62	53.93	75.64	71.68	84.91	54.12	76.21	71.68	85.16
50	2	4	8	53.05	74.87	70.30	83.97	53.69	75.25	70.87	84.30	53.79	75.73	70.80	84.49
50	2	5	7	55.61	75.69	71.30	84.18	56.23	76.02	71.88	84.49	56.47	76.52	71.95	84.72
50	2	5	8	55.87	75.57	70.87	83.75	56.49	75.93	71.46	84.09	56.73	76.39	71.54	84.30
50	2	5	9	54.77	74.54	70.07	83.02	55.55	75.07	70.71	83.44	55.62	75.35	70.74	83.57
50	2	6	6	56.90	75.61	70.60	83.25	57.23	76.03	71.23	83.76	57.84	76.56	71.33	83.89
50	2	6	7	57.13	75.81	70.39	83.17	57.44	76.23	71.01	83.67	58.05	76.76	71.10	83.81
50	2	6	8	57.33	76.05	70.12	83.10	57.66	76.50	70.74	83.62	58.25	77.01	70.83	83.75
50	2	6	9	57.44	75.84	69.88	82.76	57.76	76.25	70.51	83.26	58.37	76.78	70.60	83.39
50	2	6	10	57.59	75.96	69.57	82.60	57.90	76.36	70.20	83.10	58.52	76.91	70.30	83.24
50	3	3	7	52.82	74.44	70.94	84.20	53.47	75.09	71.41	84.63	53.47	75.35	71.39	84.77
50	3	4	7	54.13	74.50	71.66	84.19	54.81	74.91	72.10	84.45	54.99	75.39	72.29	84.77
50	3	4	8	54.44	74.65	71.12	83.87	55.04	74.94	71.62	84.11	55.28	75.52	71.74	84.44
50	3	5	6	55.95	75.10	71.98	84.12	56.50	75.45	72.41	84.37	56.82	75.98	72.65	84.72
50	3	5	7	56.46	75.49	71.74	84.03	57.05	75.86	72.20	84.31	57.29	76.32	72.39	84.61
50	3	5	8	56.42	75.01	71.42	83.55	57.04	75.43	71.89	83.86	57.26	75.87	72.08	84.15
50	3	5	9	55.76	74.27	70.91	83.01	56.52	74.84	71.42	83.38	56.59	75.15	71.58	83.63
50	3	6	6	57.53	75.31	71.09	83.14	58.12	75.71	71.62	83.47	58.38	76.17	71.78	83.75
50	3	6	7	57.71	75.50	70.90	83.08	58.29	75.90	71.42	83.42	58.54	76.35	71.58	83.69
50	3	6	8	57.79	75.61	70.69	82.99	58.36	75.99	71.22	83.33	58.58	76.41	71.37	83.60
50	3	6	9	57.83	75.37	70.47	82.68	58.39	75.72	71.01	83.00	58.62	76.18	71.17	83.29
50	3	6	10	57.93	75.48	70.22	82.56	58.49	75.82	70.76	82.88	58.74	76.30	70.92	83.18
50	3	7	7	58.89	76.06	69.55	82.19	59.48	76.46	70.16	82.58	59.74	76.91	70.29	82.84
50	3	7	8	58.86	75.83	69.43	81.96	59.43	76.18	70.04	82.32	59.70	76.65	70.17	82.59
50	3	7	9	58.93	75.89	69.28	81.89	59.51	76.25	69.89	82.25	59.78	76.72	70.02	82.52
50	3	7	10	58.92	75.78	69.14	81.72	59.48	76.11	69.75	82.07	59.79	76.63	69.88	82.36
50	3	7	11	58.99	75.85	68.98	81.64	59.55	76.19	69.60	82.00	59.87	76.71	69.72	82.29
50	4	4	7	56.07	74.11	71.79	83.35	56.90	74.56	72.24	83.59	56.86	74.86	72.39	83.88
50	4	4	8	56.33	74.23	71.42	83.10	57.18	74.70	71.88	83.35	57.10	74.98	72.02	83.64
50	4	5	6	57.31	74.71	71.69	83.20	57.81	75.06	72.02	83.44	58.13	75.57	72.32	83.82
50	4	5	7	57.56	74.84	71.46	83.05	57.98	75.02	71.80	83.21	58.37	75.69	72.09	83.67
50	4	5	8	57.52	74.60	71.18	82.74	58.09	75.05	71.53	83.02	58.28	75.42	71.80	83.35
50	4	5	9	57.25	74.22	70.88	82.41	57.88	74.74	71.24	82.71	58.01	75.02	71.50	83.00
50	4	6	6	58.69	75.17	70.87	82.46	59.21	75.53	71.29	82.75	59.52	76.00	71.54	83.08
50	4	6	7	58.80	75.31	70.71	82.42	59.25	75.56	71.12	82.65	59.63	76.14	71.37	83.04
50	4	6	8	58.81	75.33	70.50	82.29	59.37	75.75	70.93	82.61	59.63	76.14	71.16	82.91
50	4	6	9	58.76	75.07	70.29	82.00	59.31	75.44	70.72	82.29	59.59	75.91	70.95	82.63
50	4	6	10	58.37	74.56	70.03	81.64	58.76	74.56	70.54	81.78	59.18	75.36	70.68	82.25
50	4	7	7	59.02	74.85	69.37	81.16	59.63	75.28	69.88	81.51	59.84	75.61	70.07	81.77
50	4	7	8	59.07	74.90	69.24	81.10	59.68	75.33	69.75	81.45	59.89	75.67	69.95	81.71
50	4	7	9	59.12	74.95	69.10	81.02	59.73	75.38	69.62	81.38	59.93	75.71	69.82	81.64
50	4	7	10	59.08	74.89	68.96	80.91	59.58	75.10	69.53	81.18	59.90	75.66	69.67	81.53
50	4	7	11	58.93	74.61	68.89	80.73	59.57	75.06	69.42	81.09	59.80	75.47	69.61	81.39
50	4	8	8	59.82	75.42	67.88	80.30	60.45	75.86	68.48	80.70	60.64	76.23	68.64	80.99
50	4	8	9	59.85	75.46	67.78	80.26	60.48	75.90	68.38	80.66	60.67	76.27	68.55	80.94
50	4	8	10	59.71	75.12	67.73	80.02	60.34	75.59	68.32	80.44	60.55	75.96	68.48	80.71
50	4	8	11	59.74	75.16	67.64	79.98	60.37	75.63	68.24	80.40	60.58	75.99	68.40	80.67
50	4	8	12	59.76	75.18	67.55	79.93	60.40	75.66	68.14	80.36	60.60	76.02	68.30	80.63
50	5	5	6	59.08	74.47	70.92	81.85	59.89	75.06	71.45	82.25	59.92	75.59	71.58	82.69
50	5	5	7	59.23	74.59	70.73	81.75	60.04	75.20	71.27	82.16	60.06	75.73	71.39	82.60
50	5	5	8	59.28	74.61	70.51	81.60	60.09	75.21	71.05	82.01	60.09	75.73	71.16	82.44
50	5	5	9	58.88	73.81	70.28	81.06	59.75	74.48	70.82	81.49	59.69	74.94	70.93	81.91
50	5	6	6	59.29	74.72	69.68	81.15	59.94	75.14	70.15	81.46	60.25	75.53	70.44	81.79
50	5	6	7	59.40	74.85	69.55	81.12	60.06	75.28	70.04	81.44	60.35	75.64	70.32	81.75
50	5	6	8	59.42	74.82	69.38	80.98	60.07	75.23	69.86	81.28	60.36	75.62	70.15	81.61
50	5	6	9	59.11	74.30	69.15	80.59	59.78	74.72	69.64	80.90	60.08	75.12	69.94	81.24
50	5	6	10	58.93	74.03	69.00	80.38	59.60	74.45	69.50	80.68	59.89	74.82	69.79	81.01
50	5	7	7	60.17	75.20	68.55	80.39	60.81	75.56	69.09	80.70	61.10	75.96	69.34	81.02
50	5	7	8	60.19	75.22	68.43	80.32	60.84	75.59	68.98	80.63	61.13	75.99	69.23	80.95
50	5	7	9	60.09	75.03	68.30	80.13	60.74	75.42	68.84	80.46	61.02	75.79	69.10	80.77

				Blue				Green				Red			
				% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings	
R	k	n	p	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra
50	5	7	10	60.11	75.06	68.19	80.08	60.77	75.47	68.74	80.42	61.05	75.83	68.99	80.72
50	5	7	11	60.14	75.10	68.08	80.02	60.80	75.51	68.62	80.37	61.07	75.86	68.88	80.66
50	5	8	8	60.71	75.58	67.20	79.57	61.36	76.02	67.80	79.97	61.67	76.43	68.02	80.28
50	5	8	9	60.65	75.48	67.09	79.45	61.31	75.92	67.69	79.85	61.60	76.31	67.91	80.14
50	5	8	10	60.67	75.50	67.01	79.41	61.33	75.95	67.61	79.81	61.62	76.33	67.82	80.10
50	5	8	11	60.69	75.53	66.92	79.37	61.35	75.98	67.52	79.77	61.63	76.35	67.73	80.05
50	5	8	12	60.60	75.40	66.82	79.24	61.26	75.84	67.42	79.64	61.55	76.22	67.64	79.92
50	5	9	9	60.29	74.80	65.65	78.16	61.04	75.38	66.32	78.67	61.25	75.65	66.50	78.89
50	5	9	10	60.31	74.82	65.58	78.12	61.05	75.39	66.24	78.62	61.26	75.66	66.42	78.85
50	5	9	11	60.32	74.83	65.49	78.07	61.06	75.40	66.15	78.58	61.27	75.67	66.33	78.79
50	5	9	12	60.26	74.73	65.42	77.96	60.85	74.92	66.15	78.27	61.21	75.56	66.25	78.68
50	5	9	13	60.13	74.39	65.45	77.76	60.86	74.93	66.10	78.24	61.05	75.16	66.30	78.44
50	6	6	6	61.03	74.71	68.72	79.70	61.87	75.17	69.37	80.06	61.86	75.64	69.43	80.47
50	6	6	7	61.06	74.77	68.60	79.65	61.91	75.24	69.27	80.02	61.89	75.69	69.32	80.43
50	6	6	8	61.10	74.83	68.48	79.60	61.94	75.29	69.15	79.96	61.93	75.76	69.20	80.38
50	6	6	9	61.07	74.78	68.33	79.47	61.92	75.23	69.00	79.83	61.92	75.73	69.06	80.27
50	6	6	10	60.82	74.24	68.18	79.07	61.66	74.71	68.85	79.44	61.65	75.16	68.91	79.85
50	6	7	7	60.69	74.63	67.01	78.70	61.31	75.17	67.53	79.15	61.66	75.56	67.86	79.50
50	6	7	8	60.71	74.68	66.92	78.67	61.34	75.22	67.45	79.12	61.69	75.60	67.77	79.46
50	6	7	9	60.74	74.72	66.83	78.63	61.36	75.27	67.35	79.09	61.71	75.65	67.67	79.42
50	6	7	10	60.73	74.71	66.72	78.55	61.23	75.02	67.22	78.86	61.70	75.63	67.56	79.33
50	6	7	11	60.61	74.48	66.61	78.35	61.23	75.04	67.13	78.82	61.58	75.37	67.45	79.11
50	6	8	8	61.22	75.12	65.93	78.12	61.86	75.69	66.51	78.63	62.21	76.06	66.80	78.94
50	6	8	9	61.24	75.14	65.84	78.07	61.89	75.72	66.43	78.59	62.23	76.08	66.72	78.89
50	6	8	10	61.24	75.13	65.75	78.00	61.79	75.53	66.31	78.40	62.23	76.07	66.62	78.82
50	6	8	11	61.16	74.99	65.65	77.85	61.80	75.54	66.23	78.35	62.15	75.92	66.52	78.66
50	6	8	12	61.16	75.00	65.56	77.80	61.81	75.55	66.15	78.30	62.16	75.92	66.44	78.61
50	6	9	9	61.67	75.38	64.74	77.32	62.30	75.90	65.36	77.82	62.63	76.26	65.61	78.11
50	6	9	10	61.68	75.39	64.67	77.27	62.24	75.80	65.27	77.70	62.63	76.26	65.54	78.06
50	6	9	11	61.63	75.31	64.58	77.17	62.26	75.82	65.21	77.68	62.58	76.18	65.46	77.96
50	6	9	12	61.64	75.33	64.52	77.14	62.27	75.85	65.15	77.65	62.59	76.19	65.40	77.93
50	6	9	13	61.64	75.32	64.45	77.09	62.27	75.84	65.08	77.60	62.59	76.19	65.34	77.88
50	6	10	10	61.44	74.57	63.29	75.75	61.72	74.90	63.84	76.26	62.03	75.18	64.10	76.48
50	6	10	11	61.37	74.49	63.21	75.67	61.72	74.90	63.79	76.22	62.03	75.18	64.04	76.44
50	6	10	12	61.37	74.49	63.15	75.63	61.72	74.90	63.74	76.19	62.03	75.18	63.99	76.40
50	6	10	13	61.37	74.49	63.10	75.59	61.72	74.90	63.69	76.15	62.03	75.18	63.93	76.36
50	6	10	14	61.32	74.37	63.06	75.48	61.66	74.76	63.66	76.04	61.99	75.06	63.90	76.26
255	2	5	9	55.13	74.77	70.26	83.14	55.93	75.29	70.89	83.55	55.88	75.53	70.88	83.66
255	2	6	9	57.84	76.13	70.13	82.95	58.18	76.52	70.76	83.43	58.62	76.98	70.77	83.53
255	2	6	10	58.04	76.31	69.81	82.80	58.39	76.72	70.44	83.30	58.81	77.16	70.45	83.40
255	3	5	9	56.12	74.51	71.09	83.14	56.90	75.06	71.60	83.49	56.85	75.33	71.72	83.73
255	3	6	9	58.24	75.70	70.72	82.89	58.83	76.04	71.27	83.20	58.89	76.42	71.33	83.45
255	3	6	10	58.39	75.84	70.45	82.76	58.99	76.20	71.01	83.09	59.03	76.56	71.08	83.34
255	3	7	9	59.40	76.23	69.63	82.13	60.02	76.59	70.26	82.50	60.09	76.98	70.24	82.71
255	3	7	10	59.39	76.05	69.46	81.90	60.01	76.39	70.10	82.25	60.12	76.81	70.10	82.49
255	3	7	11	59.49	76.15	69.29	81.83	60.12	76.50	69.94	82.18	60.20	76.90	69.94	82.41
255	4	5	9	57.60	74.46	71.07	82.54	58.26	74.97	71.43	82.83	58.25	75.19	71.64	83.10
255	4	6	9	59.20	75.43	70.57	82.24	59.78	75.81	71.02	82.53	59.89	76.17	71.14	82.80
255	4	6	10	58.83	74.95	70.26	81.87	59.27	74.98	70.80	82.02	59.49	75.65	70.85	82.43
255	4	7	9	59.60	75.32	69.46	81.30	60.26	75.76	70.01	81.66	60.25	75.98	70.05	81.84
255	4	7	10	59.55	75.25	69.27	81.16	60.11	75.49	69.87	81.45	60.23	75.94	69.89	81.72
255	4	7	11	59.42	74.91	69.22	80.92	60.13	75.36	69.78	81.28	60.13	75.65	69.84	81.52
255	4	8	8	60.35	75.75	68.31	80.57	61.05	76.20	68.96	80.98	61.00	76.47	68.93	81.18
255	4	8	9	60.40	75.82	68.20	80.53	61.10	76.28	68.86	80.95	61.04	76.51	68.83	81.13
255	4	8	10	60.27	75.51	68.14	80.30	60.98	75.99	68.78	80.73	60.93	76.21	68.76	80.90
255	4	8	11	60.31	75.55	68.03	80.26	61.02	76.04	68.67	80.68	60.95	76.25	68.66	80.85
255	4	8	12	60.29	75.38	67.96	80.08	61.01	75.85	68.61	80.49	60.95	76.17	68.58	80.74
255	5	5	9	59.25	74.15	70.50	81.27	60.15	74.81	71.05	81.69	59.95	75.18	71.09	82.07
255	5	6	9	59.61	74.72	69.49	80.88	60.33	75.16	70.01	81.20	60.42	75.41	70.17	81.44
255	5	6	10	59.46	74.48	69.30	80.66	60.19	74.93	69.83	80.98	60.25	75.15	70.00	81.22
255	5	7	9	60.58	75.42	68.69	80.44	61.30	75.84	69.28	80.79	61.36	76.08	69.36	81.00
255	5	7	10	60.60	75.44	68.55	80.36	61.33	75.88	69.14	80.72	61.38	76.10	69.24	80.92
255	5	7	11	60.60	75.37	68.44	80.23	61.33	75.78	69.03	80.57	61.36	76.02	69.13	80.80
255	5	8	8	61.28	75.89	67.68	79.83	62.01	76.33	68.34	80.24	62.06	76.64	68.35	80.46
255	5	8	9	61.24	75.81	67.57	79.72	61.98	76.26	68.24	80.13	62.00	76.53	68.23	80.32
255	5	8	10	61.27	75.85	67.48	79.68	62.02	76.31	68.15	80.09	62.02	76.55	68.14	80.27
255	5	8	11	61.30	75.89	67.38	79.63	62.04	76.34	68.04	80.03	62.04	76.56	68.05	80.21
255	5	8	12	61.16	75.61	67.28	79.41	61.90	76.04	67.95	79.80	61.93	76.38	67.95	80.05
255	5	9	9	60.94	75.17	66.16	78.45	61.78	75.76	66.90	78.97	61.67	75.90	66.84	79.09
255	5	9	10	60.95	75.19	66.08	78.40	61.80	75.78	66.82	78.92	61.69	75.92	66.76	79.05
255	5	9	11	60.97	75.21	66.00	78.36	61.82	75.81	66.74	78.88	61.70	75.93	66.67	79.00
255	5	9	12	60.92	75.11	65.92	78.25	61.61	75.33	66.73	78.57	61.64	75.83	66.59	78.89
255	5	9	13	60.76	74.73	65.94	78.02	61.59	75.28	66.67	78.50	61.48	75.40	66.64	78.64
255	6	6	9	61.51	75.09	68.71	79.74	62.41	75.56	69.43	80.11	62.22	75.94	69.32	80.45
255	6	6	10	61.28	74.57	68.55	79.33	62.19	75.06	69.26	79.72	61.96	75.38	69.16	80.04
255	6	7	9	61.28	75.03	67.31	78.91	61.97	75.58	67.90	79.37	62.08	75.85	67.99	79.60
255	6	7	10	61.29	75.03	67.20	78.83	61.86	75.35	67.76	79.15	62.07	75.84	67.88	79.51
255	6	7	11	61.13	74.71	67.07	78.56	61.83	75.26	67.66	79.02	61.92	75.52	67.76	79.25
255	6	8	8	61.83	75.47	66.47	78.43	62.56	76.04	67.13	78.95	62.62	76.30	67.17	79.15

				Blue				Green				Red			
				% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings	
R	k	n	p	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra
255	6	8	9	61.84	75.48	66.38	78.38	62.58	76.06	67.05	78.89	62.63	76.31	67.08	79.09
255	6	8	10	61.85	75.49	66.29	78.31	62.50	75.89	66.93	78.72	62.63	76.30	66.98	79.03
255	6	8	11	61.78	75.35	66.18	78.16	62.51	75.91	66.84	78.66	62.56	76.15	66.88	78.87
255	6	8	12	61.75	75.28	66.09	78.06	62.48	75.83	66.75	78.56	62.56	76.14	66.80	78.81
255	6	9	9	62.27	75.73	65.28	77.63	63.00	76.27	65.99	78.15	63.00	76.50	65.95	78.33
255	6	9	10	62.27	75.74	65.20	77.58	62.95	76.16	65.90	78.03	63.00	76.49	65.88	78.28
255	6	9	11	62.23	75.65	65.12	77.48	62.96	76.19	65.84	78.00	62.95	76.40	65.80	78.17
255	6	9	12	62.23	75.65	65.05	77.43	62.97	76.19	65.77	77.96	62.96	76.41	65.75	78.13
255	6	9	13	62.23	75.65	64.98	77.38	62.96	76.18	65.70	77.90	62.97	76.41	65.68	78.09
255	6	10	10	62.06	74.96	63.86	76.11	62.52	75.39	64.54	76.68	62.47	75.49	64.49	76.76
255	6	10	11	62.05	74.95	63.80	76.06	62.53	75.40	64.48	76.65	62.48	75.50	64.43	76.72
255	6	10	12	62.06	74.97	63.74	76.03	62.53	75.41	64.42	76.61	62.48	75.51	64.37	76.68
255	6	10	13	62.07	74.98	63.67	75.99	62.54	75.42	64.36	76.58	62.49	75.52	64.31	76.65
255	6	10	14	62.00	74.83	63.62	75.87	62.47	75.27	64.31	76.45	62.41	75.37	64.26	76.52

APPENDIX D

RESULTS OF IVPA OPTIMIZED FOR ENERGY MINIMIZATION

The EDP and energy savings of the IVPA scheme (optimized for energy minimization), for various values of codeword lengths (*k*, *n* and *p*) and range (*R*), averaged over 10 images of the SIPI database [21], have been presented below.

				Blue				Green				Red			
				% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings	
R	k	n	p	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra
10	2	2	4	39.04	67.57	64.76	81.02	40.98	68.69	66.02	81.73	40.08	68.05	65.29	81.22
10	2	2	5	40.07	67.45	63.68	80.01	42.00	68.58	65.03	80.80	41.15	67.94	64.20	80.18
10	2	2	6	40.62	67.66	62.33	79.20	42.50	68.75	63.77	80.04	41.67	68.09	62.81	79.31
10	2	3	4	41.77	67.37	65.68	80.58	43.64	68.53	66.90	81.32	42.82	67.95	66.30	80.88
10	2	3	5	42.21	67.50	64.92	80.06	44.08	68.67	66.20	80.85	43.29	68.09	65.51	80.34
10	2	3	6	42.57	67.82	64.14	79.69	44.42	68.94	65.46	80.48	43.63	68.35	64.70	79.90
10	2	3	7	42.94	68.19	63.33	79.33	44.75	69.27	64.70	80.14	43.98	68.71	63.88	79.53
10	2	4	4	43.93	67.57	65.03	79.60	45.69	68.71	66.27	80.39	44.93	68.17	65.69	79.94
10	2	4	5	44.24	67.89	64.63	79.45	45.97	69.00	65.89	80.25	45.24	68.50	65.28	79.78
10	2	4	6	44.24	67.57	64.03	78.89	45.97	68.70	65.34	79.72	45.24	68.16	64.66	79.19
10	2	4	7	44.24	67.57	63.43	78.53	45.97	68.70	64.79	79.39	45.24	68.16	64.05	78.82
10	2	4	8	44.24	67.57	62.84	78.17	45.97	68.70	64.23	79.06	45.24	68.16	63.44	78.45
10	2	5	5	44.81	66.61	62.75	77.29	46.51	67.79	64.12	78.20	45.81	67.18	63.45	77.60
10	2	5	6	44.81	66.61	62.59	77.19	46.51	67.79	63.96	78.11	45.81	67.18	63.29	77.50
10	2	5	7	44.81	66.61	62.43	77.09	46.51	67.79	63.81	78.02	45.81	67.18	63.12	77.40
10	2	5	8	44.81	66.61	62.27	76.99	46.51	67.79	63.66	77.93	45.81	67.18	62.96	77.30
10	2	5	9	44.81	66.61	62.11	76.89	46.51	67.79	63.51	77.84	45.81	67.18	62.80	77.20
10	2	6	6	45.38	67.49	60.23	76.16	47.05	68.65	61.76	77.18	46.34	68.11	60.95	76.54
10	2	6	7	45.38	67.49	60.07	76.07	47.05	68.65	61.61	77.09	46.34	68.11	60.79	76.44
10	2	6	8	45.38	67.49	59.92	75.97	47.05	68.65	61.46	77.00	46.34	68.11	60.63	76.34
10	2	6	9	45.38	67.49	59.76	75.88	47.05	68.65	61.32	76.91	46.34	68.11	60.47	76.24
10	2	6	10	45.38	67.49	59.60	75.78	47.05	68.65	61.17	76.82	46.34	68.11	60.31	76.14
10	3	3	3	43.45	66.32	65.99	79.64	45.24	67.82	67.06	80.52	44.34	66.93	66.60	80.03
10	3	3	4	43.72	66.70	65.60	79.53	45.49	68.15	66.69	80.42	44.61	67.29	66.19	79.90
10	3	3	5	43.94	66.96	65.03	79.28	45.74	68.43	66.20	80.20	44.83	67.62	65.60	79.67
10	3	3	6	44.25	67.28	64.39	78.98	45.98	68.73	65.57	79.93	45.15	67.94	64.94	79.35
10	3	3	7	44.25	66.96	63.70	78.36	45.98	68.43	64.93	79.35	45.15	67.61	64.22	78.69
10	3	4	4	44.93	66.12	64.52	78.08	46.72	67.64	65.77	79.09	45.86	66.79	65.19	78.51
10	3	4	5	44.93	66.12	64.21	77.89	46.72	67.64	65.49	78.92	45.86	66.79	64.87	78.31
10	3	4	6	44.93	66.12	63.91	77.70	46.72	67.64	65.21	78.75	45.86	66.79	64.56	78.11
10	3	4	7	44.93	66.12	63.61	77.51	46.72	67.64	64.93	78.57	45.86	66.79	64.24	77.91
10	3	4	8	44.93	66.12	63.31	77.32	46.72	67.64	64.65	78.40	45.86	66.79	63.93	77.71
10	3	5	5	45.62	66.46	62.53	76.79	47.36	67.92	63.95	77.91	46.51	67.06	63.21	77.21
10	3	5	6	45.62	66.46	62.38	76.70	47.36	67.92	63.80	77.82	46.51	67.06	63.05	77.10
10	3	5	7	45.62	66.46	62.22	76.60	47.36	67.92	63.66	77.73	46.51	67.06	62.89	77.00
10	3	5	8	45.62	66.46	62.06	76.50	47.36	67.92	63.51	77.64	46.51	67.06	62.73	76.90
10	3	5	9	45.62	66.46	61.91	76.40	47.36	67.92	63.37	77.55	46.51	67.06	62.57	76.80
10	3	6	6	46.19	67.02	60.52	75.71	47.91	68.46	62.09	76.94	47.06	67.65	61.19	76.15
10	3	6	7	46.19	67.02	60.39	75.63	47.91	68.46	61.96	76.86	47.06	67.65	61.06	76.07
10	3	6	8	46.19	67.02	60.26	75.55	47.91	68.46	61.84	76.79	47.06	67.65	60.92	75.98
10	3	6	9	46.19	67.02	60.13	75.47	47.91	68.46	61.72	76.71	47.06	67.65	60.79	75.90
10	3	6	10	46.19	67.02	60.01	75.39	47.91	68.46	61.59	76.64	47.06	67.65	60.65	75.81
10	3	7	7	46.69	67.41	58.41	74.49	48.41	68.86	60.16	75.84	47.59	68.10	59.13	74.98
10	3	7	8	46.69	67.41	58.29	74.41	48.41	68.86	60.04	75.77	47.59	68.10	59.00	74.90
10	3	7	9	46.69	67.41	58.16	74.34	48.41	68.86	59.92	75.69	47.59	68.10	58.87	74.81
10	3	7	10	46.69	67.41	58.04	74.26	48.41	68.86	59.80	75.62	47.59	68.10	58.73	74.73
10	3	7	11	46.69	67.41	57.91	74.18	48.41	68.86	59.68	75.55	47.59	68.10	58.60	74.65
10	4	4	4	45.88	66.00	63.14	76.76	47.78	67.16	64.42	77.54	46.95	66.48	63.93	77.11
10	4	4	5	45.88	66.00	62.98	76.66	47.78	67.16	64.28	77.45	46.95	66.48	63.77	77.01
10	4	4	6	45.88	66.00	62.83	76.56	47.78	67.16	64.13	77.36	46.95	66.48	63.61	76.90
10	4	4	7	45.88	66.00	62.67	76.46	47.78	67.16	63.98	77.27	46.95	66.48	63.45	76.80
10	4	4	8	45.88	66.00	62.52	76.36	47.78	67.16	63.84	77.17	46.95	66.48	63.29	76.70
10	4	5	5	46.51	66.26	61.66	75.75	48.41	67.47	63.10	76.66	47.54	66.83	62.44	76.16
10	4	5	6	46.51	66.26	61.54	75.67	48.41	67.47	62.97	76.58	47.54	66.83	62.31	76.07
10	4	5	7	46.51	66.26	61.41	75.58	48.41	67.47	62.85	76.51	47.54	66.83	62.18	75.98
10	4	5	8	46.51	66.26	61.28	75.50	48.41	67.47	62.73	76.43	47.54	66.83	62.04	75.90
10	4	5	9	46.51	66.26	61.15	75.42	48.41	67.47	62.61	76.35	47.54	66.83	61.91	75.81
10	4	6	6	47.09	66.42	60.10	74.61	48.96	67.64	61.67	75.62	48.13	66.99	60.90	75.02
10	4	6	7	47.09	66.42	59.97	74.53	48.96	67.64	61.55	75.55	48.13	66.99	60.77	74.93
10	4	6	8	47.09	66.42	59.85	74.45	48.96	67.64	61.43	75.47	48.13	66.99	60.64	74.85
10	4	6	9	47.09	66.42	59.73	74.37	48.96	67.64	61.31	75.40	48.13	66.99	60.51	74.76

				Blue				Green				Red			
				% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings	
R	k	n	p	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra
10	4	6	10	47.09	66.42	59.60	74.29	48.96	67.64	61.19	75.32	48.13	66.99	60.38	74.68
10	4	7	7	47.60	66.43	58.44	73.31	49.47	67.61	60.17	74.41	48.65	66.92	59.28	73.67
10	4	7	8	47.60	66.43	58.34	73.24	49.47	67.61	60.08	74.34	48.65	66.92	59.18	73.60
10	4	7	9	47.60	66.43	58.23	73.17	49.47	67.61	59.98	74.28	48.65	66.92	59.07	73.53
10	4	7	10	47.60	66.43	58.12	73.10	49.47	67.61	59.88	74.21	48.65	66.92	58.96	73.46
10	4	7	11	47.60	66.43	58.01	73.03	49.47	67.61	59.78	74.15	48.65	66.92	58.85	73.39
10	4	8	8	48.08	66.57	56.73	72.08	49.93	67.74	58.62	73.27	49.14	67.05	57.63	72.45
10	4	8	9	48.08	66.57	56.62	72.01	49.93	67.74	58.53	73.20	49.14	67.05	57.52	72.38
10	4	8	10	48.08	66.57	56.52	71.94	49.93	67.74	58.43	73.14	49.14	67.05	57.42	72.31
10	4	8	11	48.08	66.57	56.41	71.87	49.93	67.74	58.34	73.08	49.14	67.05	57.32	72.24
10	4	8	12	48.08	66.57	56.31	71.80	49.93	67.74	58.24	73.02	49.14	67.05	57.21	72.17
10	5	5	5	47.40	64.90	59.99	73.23	49.35	66.32	61.45	74.31	48.51	65.78	60.88	73.91
10	5	5	6	47.40	64.90	59.86	73.15	49.35	66.32	61.33	74.24	48.51	65.78	60.75	73.82
10	5	5	7	47.40	64.90	59.74	73.07	49.35	66.32	61.22	74.16	48.51	65.78	60.62	73.73
10	5	5	8	47.40	64.90	59.62	72.98	49.35	66.32	61.10	74.08	48.51	65.78	60.49	73.64
10	5	5	9	47.40	64.90	59.50	72.90	49.35	66.32	60.98	74.00	48.51	65.78	60.36	73.55
10	5	6	6	47.76	65.02	58.50	72.16	49.72	66.42	60.15	73.33	48.86	65.84	59.43	72.83
10	5	6	7	47.76	65.02	58.39	72.09	49.72	66.42	60.05	73.27	48.86	65.84	59.33	72.75
10	5	6	8	47.76	65.02	58.28	72.02	49.72	66.42	59.95	73.20	48.86	65.84	59.22	72.68
10	5	6	9	47.76	65.02	58.18	71.94	49.72	66.42	59.85	73.13	48.86	65.84	59.11	72.60
10	5	6	10	47.76	65.02	58.07	71.87	49.72	66.42	59.75	73.06	48.86	65.84	59.00	72.53
10	5	7	7	48.11	65.23	56.82	71.02	50.04	66.60	58.63	72.29	49.19	65.99	57.80	71.68
10	5	7	8	48.11	65.23	56.71	70.95	50.04	66.60	58.54	72.22	49.19	65.99	57.70	71.61
10	5	7	9	48.11	65.23	56.61	70.87	50.04	66.60	58.44	72.16	49.19	65.99	57.59	71.53
10	5	7	10	48.11	65.23	56.50	70.80	50.04	66.60	58.35	72.09	49.19	65.99	57.49	71.46
10	5	7	11	48.11	65.23	56.40	70.73	50.04	66.60	58.25	72.03	49.19	65.99	57.39	71.39
10	5	8	8	48.40	65.59	54.95	69.92	50.34	66.98	56.97	71.33	49.49	66.42	55.97	70.65
10	5	8	9	48.40	65.59	54.86	69.85	50.34	66.98	56.89	71.27	49.49	66.42	55.87	70.59
10	5	8	10	48.40	65.59	54.77	69.79	50.34	66.98	56.80	71.21	49.49	66.42	55.78	70.52
10	5	8	11	48.40	65.59	54.68	69.73	50.34	66.98	56.72	71.16	49.49	66.42	55.68	70.46
10	5	8	12	48.40	65.59	54.59	69.67	50.34	66.98	56.63	71.10	49.49	66.42	55.59	70.39
10	5	9	9	48.68	66.03	52.93	68.80	50.62	67.41	55.14	70.34	49.78	66.90	53.97	69.58
10	5	9	10	48.68	66.03	52.84	68.74	50.62	67.41	55.06	70.28	49.78	66.90	53.88	69.51
10	5	9	11	48.68	66.03	52.75	68.68	50.62	67.41	54.97	70.23	49.78	66.90	53.78	69.44
10	5	9	12	48.68	66.03	52.66	68.62	50.62	67.41	54.89	70.17	49.78	66.90	53.68	69.38
10	5	9	13	48.68	66.03	52.57	68.56	50.62	67.41	54.81	70.11	49.78	66.90	53.59	69.31
10	6	6	6	48.08	65.21	56.36	70.72	50.03	66.46	57.99	71.77	49.18	65.86	57.32	71.27
10	6	6	7	48.08	65.21	56.25	70.64	50.03	66.46	57.90	71.70	49.18	65.86	57.21	71.20
10	6	6	8	48.08	65.21	56.15	70.57	50.03	66.46	57.80	71.64	49.18	65.86	57.11	71.13
10	6	6	9	48.08	65.21	56.04	70.50	50.03	66.46	57.71	71.57	49.18	65.86	57.01	71.05
10	6	6	10	48.08	65.21	55.94	70.43	50.03	66.46	57.61	71.51	49.18	65.86	56.90	70.98
10	6	7	7	48.39	65.57	54.81	69.82	50.36	66.84	56.64	71.00	49.50	66.29	55.83	70.47
10	6	7	8	48.39	65.57	54.73	69.76	50.36	66.84	56.56	70.94	49.50	66.29	55.74	70.40
10	6	7	9	48.39	65.57	54.64	69.70	50.36	66.84	56.47	70.88	49.50	66.29	55.64	70.33
10	6	7	10	48.39	65.57	54.55	69.64	50.36	66.84	56.39	70.83	49.50	66.29	55.55	70.27
10	6	7	11	48.39	65.57	54.46	69.57	50.36	66.84	56.31	70.77	49.50	66.29	55.45	70.20
10	6	8	8	48.71	66.01	53.11	68.90	50.67	67.28	55.12	70.20	49.82	66.77	54.18	69.60
10	6	8	9	48.71	66.01	53.02	68.84	50.67	67.28	55.03	70.14	49.82	66.77	54.08	69.53
10	6	8	10	48.71	66.01	52.93	68.78	50.67	67.28	54.95	70.08	49.82	66.77	53.99	69.47
10	6	8	11	48.71	66.01	52.84	68.72	50.67	67.28	54.87	70.03	49.82	66.77	53.89	69.40
10	6	8	12	48.71	66.01	52.76	68.66	50.67	67.28	54.78	69.97	49.82	66.77	53.79	69.34
10	6	9	9	48.99	66.34	51.26	67.81	50.93	67.55	53.46	69.18	50.08	67.02	52.35	68.47
10	6	9	10	48.99	66.34	51.18	67.76	50.93	67.55	53.39	69.14	50.08	67.02	52.28	68.42
10	6	9	11	48.99	66.34	51.10	67.71	50.93	67.55	53.32	69.09	50.08	67.02	52.20	68.37
10	6	9	12	48.99	66.34	51.03	67.65	50.93	67.55	53.26	69.05	50.08	67.02	52.13	68.31
10	6	9	13	48.99	66.34	50.95	67.60	50.93	67.55	53.19	69.00	50.08	67.02	52.05	68.26
10	6	10	10	49.25	66.71	49.26	66.69	51.17	67.88	51.66	68.17	50.33	67.39	50.40	67.37
10	6	10	11	49.25	66.71	49.19	66.64	51.17	67.88	51.60	68.12	50.33	67.39	50.32	67.32
10	6	10	12	49.25	66.71	49.11	66.59	51.17	67.88	51.53	68.08	50.33	67.39	50.25	67.27
10	6	10	13	49.25	66.71	49.04	66.54	51.17	67.88	51.47	68.03	50.33	67.39	50.17	67.22
10	6	10	14	49.25	66.71	48.96	66.49	51.17	67.88	51.40	67.99	50.33	67.39	50.10	67.16
20	2	2	6	46.18	72.90	67.33	83.36	47.05	73.22	67.99	83.63	47.02	73.57	67.76	83.70
20	2	3	5	47.42	72.83	70.16	84.47	48.30	73.22	70.66	84.68	48.30	73.64	70.71	84.94
20	2	3	6	48.64	73.30	69.34	83.92	49.46	73.62	69.88	84.14	49.51	74.07	69.85	84.35
20	2	3	7	49.49	74.19	68.31	83.66	50.27	74.49	68.94	83.92	50.33	74.95	68.80	84.08
20	2	4	5	50.56	73.14	70.82	84.05	51.23	73.49	71.23	84.26	51.40	73.98	71.43	84.58
20	2	4	6	51.23	73.83	70.24	83.92	51.87	74.13	70.70	84.14	52.04	74.62	70.82	84.42
20	2	4	7	51.59	73.65	69.49	83.26	52.18	73.95	69.98	83.51	52.38	74.44	70.05	83.76
20	2	4	8	51.89	73.87	68.70	82.85	52.46	74.17	69.23	83.13	52.70	74.69	69.25	83.35
20	2	5	5	52.87	73.04	70.07	82.78	53.37	73.35	70.48	83.02	53.67	73.82	70.71	83.31
20	2	5	6	53.13	73.27	69.78	82.65	53.60	73.55	70.19	82.89	53.93	74.05	70.41	83.18
20	2	5	7	53.36	73.46	69.43	82.49	53.81	73.73	69.87	82.73	54.16	74.24	70.07	83.01
20	2	5	8	53.58	73.65	69.06	82.31	54.01	73.91	69.51	82.57	54.39	74.43	69.70	82.83
20	2	5	9	53.77	73.80	68.65	82.09	54.18	74.05	69.13	82.37	54.59	74.60	69.29	82.62
20	2	6	6	54.70	74.01	68.28	81.68	55.03	74.32	68.71	82.00	55.49	74.88	68.96	82.30
20	2	6	7	54.85	74.11	68.07	81.57	55.16	74.42	68.51	81.90	55.64	74.98	68.75	82.19
20	2	6	8	54.99	74.22	67.82	81.44	55.30	74.53	68.27	81.78	55.78	75.09	68.49	82.05
20	2	6	9	55.12	74.31	67.52	81.28	55.42	74.62	67.99	81.63	55.91	75.19	68.19	81.89
20	2	6	10	55.24	74.41	67.19	81.10	55.53	74.72	67.67	81.46	56.04	75.29	67.86	81.71

				Blue				Green				Red			
				% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings	
R	k	n	p	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra
20	3	3	5	50.05	72.55	70.93	83.97	50.77	73.24	71.25	84.31	50.75	73.46	71.43	84.55
20	3	3	6	50.85	73.01	70.27	83.61	51.54	73.69	70.64	83.98	51.57	73.91	70.74	84.17
20	3	3	7	51.35	73.15	69.44	83.06	52.00	73.78	69.86	83.45	52.03	73.99	69.88	83.58
20	3	4	5	52.32	72.66	71.15	83.42	52.97	73.33	71.52	83.80	53.03	73.54	71.72	84.02
20	3	4	6	52.68	72.77	70.66	83.06	53.32	73.42	71.07	83.46	53.40	73.66	71.22	83.67
20	3	4	7	52.91	72.88	70.10	82.72	53.52	73.51	70.53	83.13	53.63	73.75	70.65	83.30
20	3	4	8	53.13	73.09	69.51	82.43	53.72	73.69	69.98	82.85	53.85	73.96	70.05	83.01
20	3	5	5	54.07	72.72	70.23	82.27	54.58	73.33	70.64	82.70	54.75	73.57	70.81	82.89
20	3	5	6	54.23	72.87	69.99	82.16	54.72	73.48	70.42	82.61	54.92	73.73	70.58	82.78
20	3	5	7	54.39	73.11	69.70	82.08	54.86	73.69	70.15	82.53	55.08	73.97	70.28	82.70
20	3	5	8	54.54	73.32	69.36	81.96	54.99	73.90	69.82	82.43	55.23	74.18	69.93	82.57
20	3	5	9	54.68	73.54	68.98	81.82	55.11	74.10	69.45	82.29	55.38	74.39	69.54	82.42
20	3	6	6	55.48	73.33	68.60	81.14	55.89	73.96	69.10	81.69	56.18	74.21	69.21	81.79
20	3	6	7	55.59	73.42	68.42	81.05	56.00	74.06	68.92	81.60	56.28	74.31	69.01	81.70
20	3	6	8	55.68	73.51	68.20	80.93	56.08	74.14	68.70	81.49	56.38	74.39	68.79	81.58
20	3	6	9	55.78	73.60	67.95	80.80	56.17	74.22	68.46	81.36	56.48	74.48	68.54	81.44
20	3	6	10	55.86	73.68	67.66	80.64	56.24	74.30	68.18	81.22	56.56	74.56	68.25	81.29
20	3	7	7	56.32	73.49	66.57	79.64	56.72	74.13	67.19	80.30	57.05	74.39	67.22	80.34
20	3	7	8	56.32	73.49	66.41	79.54	56.72	74.13	67.04	80.21	57.05	74.39	67.06	80.24
20	3	7	9	56.32	73.49	66.25	79.44	56.72	74.13	66.88	80.11	57.05	74.39	66.89	80.14
20	3	7	10	56.32	73.49	66.09	79.35	56.72	74.13	66.72	80.01	57.05	74.39	66.73	80.04
20	3	7	11	56.32	73.49	65.93	79.25	56.72	74.13	66.56	79.92	57.05	74.39	66.56	79.94
20	4	4	4	53.72	72.49	70.87	82.66	54.44	72.80	71.17	82.77	54.56	73.22	71.54	83.21
20	4	4	5	53.88	72.42	70.56	82.37	54.57	72.73	70.88	82.49	54.71	73.14	71.22	82.90
20	4	4	6	54.02	72.61	70.22	82.23	54.70	72.90	70.55	82.35	54.86	73.34	70.88	82.76
20	4	4	7	54.15	72.75	69.85	82.05	54.81	73.05	70.21	82.19	55.00	73.49	70.51	82.58
20	4	4	8	54.27	72.91	69.47	81.87	54.93	73.18	69.85	82.02	55.13	73.67	70.11	82.40
20	4	5	5	55.04	72.76	69.61	81.56	55.68	73.11	70.01	81.78	55.87	73.56	70.28	82.16
20	4	5	6	55.14	72.88	69.41	81.48	55.77	73.21	69.82	81.69	55.96	73.66	70.07	82.07
20	4	5	7	55.24	72.99	69.17	81.37	55.86	73.33	69.59	81.60	56.06	73.79	69.83	81.96
20	4	5	8	55.33	73.09	68.90	81.23	55.94	73.43	69.33	81.46	56.15	73.89	69.55	81.81
20	4	5	9	55.41	73.19	68.59	81.07	56.01	73.53	69.02	81.32	56.24	74.00	69.23	81.66
20	4	6	6	56.14	73.26	68.11	80.53	56.74	73.63	68.63	80.84	57.00	74.04	68.81	81.12
20	4	6	7	56.22	73.41	67.93	80.49	56.82	73.77	68.44	80.79	57.08	74.20	68.62	81.08
20	4	6	8	56.22	73.33	67.71	80.29	56.82	73.70	68.23	80.61	57.08	74.12	68.40	80.89
20	4	6	9	56.22	73.33	67.50	80.16	56.82	73.70	68.02	80.47	57.08	74.12	68.18	80.75
20	4	6	10	56.22	73.33	67.28	80.02	56.82	73.70	67.81	80.34	57.08	74.12	67.96	80.61
20	4	7	7	56.63	73.12	66.21	79.01	57.22	73.43	66.86	79.37	57.48	73.83	66.92	79.58
20	4	7	8	56.63	73.12	66.13	78.96	57.22	73.43	66.78	79.32	57.48	73.83	66.84	79.53
20	4	7	9	56.63	73.12	66.04	78.90	57.22	73.43	66.70	79.26	57.48	73.83	66.75	79.47
20	4	7	10	56.63	73.12	65.95	78.85	57.22	73.43	66.62	79.21	57.48	73.83	66.66	79.41
20	4	7	11	56.63	73.12	65.86	78.79	57.22	73.43	66.53	79.16	57.48	73.83	66.58	79.36
20	4	8	8	57.01	73.64	64.23	78.02	57.60	73.91	65.03	78.42	57.85	74.34	64.97	78.60
20	4	8	9	57.01	73.64	64.15	77.97	57.60	73.91	64.95	78.37	57.85	74.34	64.89	78.55
20	4	8	10	57.01	73.64	64.06	77.92	57.60	73.91	64.87	78.32	57.85	74.34	64.81	78.50
20	4	8	11	57.01	73.64	63.98	77.86	57.60	73.91	64.79	78.27	57.85	74.34	64.72	78.44
20	4	8	12	57.01	73.64	63.89	77.81	57.60	73.91	64.71	78.22	57.85	74.34	64.64	78.39
20	5	5	5	56.12	72.16	68.32	79.89	56.81	72.68	68.71	80.19	57.02	73.25	69.07	80.73
20	5	5	6	56.20	72.34	68.17	79.88	56.89	72.85	68.56	80.18	57.10	73.43	68.91	80.72
20	5	5	7	56.27	72.50	67.98	79.85	56.96	73.01	68.38	80.15	57.17	73.59	68.72	80.69
20	5	5	8	56.34	72.65	67.77	79.79	57.03	73.16	68.18	80.10	57.24	73.75	68.51	80.63
20	5	5	9	56.34	72.57	67.54	79.58	57.03	73.08	67.95	79.89	57.24	73.67	68.27	80.42
20	5	6	6	56.78	72.43	66.93	78.89	57.48	72.91	67.47	79.26	57.67	73.47	67.71	79.74
20	5	6	7	56.78	72.43	66.81	78.81	57.48	72.91	67.36	79.19	57.67	73.47	67.60	79.66
20	5	6	8	56.78	72.43	66.70	78.74	57.48	72.91	67.25	79.11	57.67	73.47	67.48	79.59
20	5	6	9	56.78	72.43	66.58	78.66	57.48	72.91	67.14	79.04	57.67	73.47	67.37	79.51
20	5	6	10	56.78	72.43	66.47	78.59	57.48	72.91	67.03	78.97	57.67	73.47	67.25	79.44
20	5	7	7	57.21	72.77	65.31	77.91	57.88	73.20	65.98	78.33	58.09	73.77	66.14	78.78
20	5	7	8	57.21	72.77	65.23	77.86	57.88	73.20	65.90	78.28	58.09	73.77	66.06	78.72
20	5	7	9	57.21	72.77	65.14	77.80	57.88	73.20	65.83	78.23	58.09	73.77	65.98	78.67
20	5	7	10	57.21	72.77	65.06	77.75	57.88	73.20	65.75	78.18	58.09	73.77	65.89	78.61
20	5	7	11	57.21	72.77	64.97	77.69	57.88	73.20	65.67	78.13	58.09	73.77	65.81	78.56
20	5	8	8	57.56	73.12	63.61	76.93	58.25	73.58	64.43	77.46	58.45	74.21	64.47	77.90
20	5	8	9	57.56	73.12	63.54	76.88	58.25	73.58	64.36	77.42	58.45	74.21	64.39	77.85
20	5	8	10	57.56	73.12	63.47	76.84	58.25	73.58	64.29	77.37	58.45	74.21	64.32	77.80
20	5	8	11	57.56	73.12	63.39	76.79	58.25	73.58	64.23	77.33	58.45	74.21	64.24	77.75
20	5	8	12	57.56	73.12	63.32	76.74	58.25	73.58	64.16	77.28	58.45	74.21	64.16	77.71
20	5	9	9	57.89	73.53	61.84	75.99	58.58	73.99	62.80	76.61	58.80	74.66	62.74	77.02
20	5	9	10	57.89	73.53	61.77	75.94	58.58	73.99	62.73	76.57	58.80	74.66	62.66	76.97
20	5	9	11	57.89	73.53	61.70	75.90	58.58	73.99	62.66	76.52	58.80	74.66	62.58	76.93
20	5	9	12	57.89	73.53	61.63	75.85	58.58	73.99	62.59	76.48	58.80	74.66	62.51	76.88
20	5	9	13	57.89	73.53	61.56	75.80	58.58	73.99	62.53	76.43	58.80	74.66	62.43	76.83
20	6	6	6	57.54	72.23	65.41	77.37	58.24	72.60	65.91	77.62	58.47	73.13	66.24	78.14
20	6	6	7	57.54	72.23	65.33	77.31	58.24	72.60	65.84	77.57	58.47	73.13	66.15	78.08
20	6	6	8	57.54	72.23	65.24	77.26	58.24	72.60	65.76	77.52	58.47	73.13	66.07	78.03
20	6	6	9	57.54	72.23	65.16	77.20	58.24	72.60	65.68	77.47	58.47	73.13	65.99	77.97
20	6	6	10	57.54	72.23	65.07	77.14	58.24	72.60	65.60	77.41	58.47	73.13	65.91	77.92
20	6	7	7	57.90	72.59	64.04	76.58	58.62	72.99	64.69	76.94	58.86	73.56	64.93	77.45
20	6	7	8	57.90	72.59	63.97	76.53	58.62	72.99	64.62	76.89	58.86	73.56	64.86	77.40

				Blue				Green				Red			
				% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings	
R	k	n	p	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra
20	6	7	9	57.90	72.59	63.90	76.48	58.62	72.99	64.55	76.85	58.86	73.56	64.78	77.35
20	6	7	10	57.90	72.59	63.83	76.43	58.62	72.99	64.49	76.80	58.86	73.56	64.71	77.30
20	6	7	11	57.90	72.59	63.76	76.39	58.62	72.99	64.42	76.76	58.86	73.56	64.63	77.25
20	6	8	8	58.25	73.01	62.59	75.81	58.97	73.42	63.37	76.26	59.22	74.02	63.54	76.75
20	6	8	9	58.25	73.01	62.52	75.76	58.97	73.42	63.30	76.21	59.22	74.02	63.46	76.70
20	6	8	10	58.25	73.01	62.45	75.72	58.97	73.42	63.24	76.17	59.22	74.02	63.39	76.65
20	6	8	11	58.25	73.01	62.38	75.67	58.97	73.42	63.17	76.12	59.22	74.02	63.31	76.60
20	6	8	12	58.25	73.01	62.31	75.62	58.97	73.42	63.10	76.08	59.22	74.02	63.24	76.55
20	6	9	9	58.57	73.31	61.07	74.92	59.27	73.68	61.98	75.41	59.51	74.26	62.05	75.84
20	6	9	10	58.57	73.31	61.01	74.88	59.27	73.68	61.93	75.38	59.51	74.26	61.99	75.80
20	6	9	11	58.57	73.31	60.95	74.84	59.27	73.68	61.87	75.34	59.51	74.26	61.93	75.76
20	6	9	12	58.57	73.31	60.89	74.80	59.27	73.68	61.82	75.30	59.51	74.26	61.87	75.73
20	6	9	13	58.57	73.31	60.83	74.76	59.27	73.68	61.76	75.27	59.51	74.26	61.81	75.69
20	6	10	10	58.85	73.52	59.47	73.90	59.53	73.85	60.50	74.46	59.78	74.45	60.48	74.85
20	6	10	11	58.85	73.52	59.41	73.86	59.53	73.85	60.44	74.42	59.78	74.45	60.42	74.81
20	6	10	12	58.85	73.52	59.35	73.82	59.53	73.85	60.39	74.39	59.78	74.45	60.36	74.78
20	6	10	13	58.85	73.52	59.30	73.79	59.53	73.85	60.34	74.35	59.78	74.45	60.30	74.74
20	6	10	14	58.85	73.52	59.24	73.75	59.53	73.85	60.28	74.32	59.78	74.45	60.24	74.70
50	2	3	7	51.16	75.40	69.68	84.59	51.93	75.73	70.32	84.89	51.97	76.22	70.14	85.04
50	2	4	7	53.63	75.62	71.12	84.70	54.25	75.94	71.65	84.98	54.40	76.49	71.64	85.23
50	2	4	8	54.29	76.08	70.34	84.35	54.93	76.44	70.91	84.67	55.04	76.96	70.84	84.88
50	2	5	7	55.85	75.72	71.42	84.18	56.39	76.06	71.93	84.49	56.62	76.55	72.00	84.72
50	2	5	8	56.18	75.95	70.89	83.91	56.71	76.29	71.41	84.23	56.95	76.79	71.47	84.46
50	2	5	9	56.46	76.24	70.32	83.67	56.99	76.59	70.86	84.01	57.22	77.08	70.91	84.23
50	2	6	6	57.38	75.76	70.70	83.24	57.83	76.16	71.24	83.63	58.14	76.68	71.31	83.86
50	2	6	7	57.61	75.97	70.46	83.15	58.04	76.35	70.99	83.54	58.35	76.89	71.07	83.78
50	2	6	8	57.81	76.21	70.18	83.07	58.25	76.63	70.72	83.49	58.56	77.14	70.79	83.71
50	2	6	9	58.01	76.46	69.84	82.97	58.45	76.89	70.38	83.40	58.74	77.36	70.45	83.59
50	2	6	10	58.18	76.63	69.44	82.79	58.63	77.07	69.99	83.23	58.91	77.52	70.06	83.41
50	3	3	7	53.19	74.87	70.91	84.33	53.86	75.52	71.37	84.74	53.86	75.80	71.32	84.88
50	3	4	7	55.12	74.97	71.82	84.24	55.78	75.64	72.31	84.69	55.82	75.90	72.33	84.85
50	3	4	8	55.64	75.33	71.20	83.94	56.31	76.00	71.73	84.41	56.30	76.27	71.69	84.55
50	3	5	6	56.46	74.93	72.02	83.86	56.99	75.58	72.51	84.35	57.15	75.87	72.57	84.50
50	3	5	7	57.01	75.36	71.79	83.79	57.57	76.03	72.32	84.31	57.65	76.27	72.31	84.42
50	3	5	8	57.25	75.54	71.34	83.55	57.82	76.22	71.88	84.08	57.90	76.44	71.86	84.18
50	3	5	9	57.50	75.81	70.87	83.37	58.04	76.49	71.41	83.91	58.12	76.70	71.38	83.99
50	3	6	6	58.28	75.22	71.09	82.79	58.81	75.93	71.71	83.41	58.93	76.16	71.63	83.46
50	3	6	7	58.46	75.42	70.90	82.74	59.00	76.13	71.51	83.36	59.10	76.36	71.42	83.41
50	3	6	8	58.62	75.64	70.67	82.68	59.17	76.36	71.28	83.31	59.25	76.56	71.19	83.34
50	3	6	9	58.79	75.85	70.38	82.59	59.33	76.59	70.99	83.23	59.40	76.75	70.90	83.24
50	3	6	10	58.91	75.94	70.06	82.41	59.46	76.68	70.66	83.05	59.53	76.84	70.58	83.06
50	3	7	7	59.62	76.00	69.41	81.77	60.17	76.72	70.16	82.48	60.29	76.95	69.99	82.49
50	3	7	8	59.71	76.03	69.25	81.65	60.25	76.74	69.99	82.36	60.38	76.99	69.83	82.38
50	3	7	9	59.78	76.10	69.08	81.56	60.33	76.80	69.82	82.27	60.46	77.05	69.66	82.28
50	3	7	10	59.86	76.17	68.89	81.46	60.40	76.87	69.63	82.17	60.53	77.12	69.47	82.19
50	3	7	11	59.92	76.22	68.68	81.35	60.48	76.94	69.43	82.07	60.60	77.17	69.27	82.08
50	4	4	7	56.68	75.02	71.83	83.73	57.42	75.40	72.26	83.95	57.50	75.82	72.43	84.28
50	4	4	8	56.99	75.22	71.35	83.46	57.76	75.58	71.81	83.68	57.80	76.04	71.93	84.02
50	4	5	6	57.72	74.89	71.79	83.23	58.44	75.29	72.31	83.52	58.52	75.75	72.40	83.84
50	4	5	7	58.04	75.14	71.58	83.13	58.80	75.57	72.12	83.44	58.83	75.98	72.18	83.74
50	4	5	8	58.24	75.33	71.26	82.99	59.00	75.77	71.81	83.31	59.02	76.17	71.86	83.60
50	4	5	9	58.42	75.54	70.92	82.86	59.19	76.00	71.47	83.19	59.18	76.38	71.50	83.46
50	4	6	6	59.10	75.35	70.84	82.40	59.83	75.78	71.48	82.78	59.89	76.18	71.45	83.01
50	4	6	7	59.24	75.54	70.68	82.38	59.99	75.99	71.33	82.77	60.03	76.37	71.29	82.99
50	4	6	8	59.37	75.73	70.48	82.34	60.12	76.20	71.12	82.73	60.15	76.55	71.08	82.94
50	4	6	9	59.49	75.84	70.24	82.22	60.23	76.31	70.87	82.62	60.26	76.65	70.84	82.82
50	4	6	10	59.56	75.87	69.97	82.05	60.30	76.33	70.61	82.43	60.34	76.70	70.58	82.66
50	4	7	7	60.19	75.83	69.34	81.35	60.94	76.22	70.12	81.77	60.96	76.59	69.96	81.94
50	4	7	8	60.25	75.89	69.21	81.29	61.00	76.28	69.99	81.71	61.02	76.66	69.84	81.89
50	4	7	9	60.31	75.95	69.06	81.21	61.05	76.34	69.84	81.64	61.08	76.71	69.70	81.81
50	4	7	10	60.36	76.00	68.91	81.14	61.10	76.40	69.69	81.56	61.13	76.77	69.55	81.73
50	4	7	11	60.41	76.05	68.74	81.05	61.16	76.46	69.53	81.48	61.19	76.82	69.38	81.64
50	4	8	8	60.96	76.36	67.63	80.35	61.71	76.74	68.55	80.84	61.74	77.10	68.31	80.96
50	4	8	9	61.00	76.40	67.53	80.31	61.75	76.78	68.45	80.79	61.78	77.14	68.21	80.92
50	4	8	10	61.03	76.44	67.42	80.25	61.79	76.83	68.34	80.75	61.81	77.19	68.10	80.87
50	4	8	11	61.07	76.48	67.30	80.19	61.82	76.87	68.23	80.69	61.84	77.23	67.98	80.81
50	4	8	12	61.10	76.52	67.17	80.13	61.86	76.91	68.11	80.63	61.88	77.26	67.85	80.74
50	5	5	6	59.08	74.47	70.92	81.85	59.89	75.06	71.45	82.25	59.92	75.59	71.58	82.69
50	5	5	7	59.24	74.61	70.74	81.76	60.06	75.23	71.27	82.17	60.07	75.74	71.40	82.61
50	5	5	8	59.39	74.80	70.53	81.70	60.22	75.43	71.07	82.12	60.21	75.92	71.18	82.54
50	5	5	9	59.53	74.96	70.27	81.59	60.37	75.60	70.80	82.01	60.34	76.08	70.92	82.43
50	5	6	6	60.07	74.90	70.00	81.14	60.89	75.47	70.68	81.60	60.88	75.99	70.69	82.00
50	5	6	7	60.17	75.03	69.89	81.11	61.01	75.60	70.57	81.58	60.98	76.10	70.57	81.96
50	5	6	8	60.25	75.10	69.72	81.03	61.09	75.68	70.41	81.49	61.05	76.18	70.41	81.88
50	5	6	9	60.30	75.14	69.54	80.91	61.14	75.72	70.23	81.38	61.10	76.22	70.23	81.77
50	5	6	10	60.35	75.20	69.34	80.81	61.19	75.78	70.04	81.28	61.15	76.29	70.04	81.68
50	5	7	7	60.92	75.37	68.67	80.24	61.73	75.89	69.46	80.74	61.71	76.42	69.39	81.12
50	5	7	8	60.96	75.42	68.55	80.18	61.77	75.94	69.36	80.70	61.75	76.46	69.28	81.07
50	5	7	9	60.99	75.46	68.43	80.13	61.81	75.99	69.25	80.64	61.79	76.51	69.16	81.02

				Blue				Green				Red			
				% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings	
R	k	n	p	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra
50	5	7	10	61.02	75.51	68.30	80.06	61.85	76.04	69.13	80.59	61.82	76.56	69.04	80.95
50	5	7	11	61.05	75.56	68.16	79.99	61.88	76.10	68.99	80.53	61.86	76.61	68.90	80.89
50	5	8	8	61.52	75.82	67.12	79.32	62.37	76.40	68.08	79.96	62.33	76.94	67.89	80.31
50	5	8	9	61.55	75.85	67.04	79.28	62.41	76.44	68.00	79.92	62.36	76.98	67.80	80.27
50	5	8	10	61.57	75.88	66.94	79.23	62.43	76.49	67.91	79.88	62.38	77.01	67.70	80.22
50	5	8	11	61.59	75.92	66.84	79.19	62.46	76.53	67.80	79.84	62.41	77.04	67.60	80.17
50	5	8	12	61.62	75.95	66.73	79.13	62.48	76.56	67.69	79.78	62.43	77.07	67.49	80.11
50	5	9	9	62.04	76.25	65.49	78.38	62.92	76.87	66.60	79.12	62.87	77.39	66.30	79.43
50	5	9	10	62.06	76.27	65.41	78.34	62.94	76.89	66.52	79.08	62.88	77.41	66.22	79.38
50	5	9	11	62.08	76.28	65.33	78.29	62.96	76.91	66.43	79.03	62.90	77.42	66.13	79.33
50	5	9	12	62.10	76.30	65.24	78.24	62.98	76.93	66.34	78.98	62.91	77.44	66.04	79.28
50	5	9	13	62.11	76.32	65.15	78.18	63.00	76.95	66.25	78.93	62.93	77.45	65.94	79.22
50	6	6	6	61.03	74.71	68.72	79.70	61.87	75.17	69.37	80.06	61.86	75.64	69.43	80.47
50	6	6	7	61.06	74.77	68.60	79.65	61.91	75.24	69.27	80.02	61.89	75.69	69.32	80.43
50	6	6	8	61.10	74.83	68.48	79.60	61.94	75.29	69.15	79.96	61.93	75.76	69.20	80.38
50	6	6	9	61.12	74.87	68.35	79.53	61.98	75.34	69.02	79.90	61.96	75.81	69.07	80.32
50	6	6	10	61.15	74.93	68.20	79.46	62.01	75.39	68.89	79.83	61.99	75.86	68.94	80.26
50	6	7	7	61.61	75.14	67.50	78.95	62.49	75.66	68.31	79.43	62.47	76.16	68.28	79.85
50	6	7	8	61.64	75.19	67.42	78.92	62.51	75.71	68.22	79.40	62.49	76.21	68.19	79.82
50	6	7	9	61.66	75.23	67.33	78.89	62.54	75.75	68.13	79.36	62.52	76.25	68.10	79.77
50	6	7	10	61.69	75.28	67.22	78.84	62.56	75.80	68.03	79.32	62.54	76.29	67.99	79.73
50	6	7	11	61.71	75.32	67.11	78.79	62.59	75.85	67.92	79.27	62.56	76.33	67.88	79.67
50	6	8	8	62.13	75.63	66.16	78.22	63.02	76.18	67.10	78.79	62.99	76.66	66.99	79.17
50	6	8	9	62.15	75.65	66.08	78.18	63.04	76.21	67.02	78.75	63.01	76.69	66.91	79.12
50	6	8	10	62.16	75.68	66.00	78.13	63.06	76.23	66.93	78.71	63.03	76.71	66.82	79.07
50	6	8	11	62.18	75.70	65.90	78.08	63.08	76.26	66.84	78.66	63.04	76.73	66.72	79.02
50	6	8	12	62.20	75.73	65.81	78.03	63.09	76.28	66.74	78.60	63.06	76.75	66.62	78.97
50	6	9	9	62.58	75.94	64.73	77.31	63.47	76.44	65.80	77.91	63.41	76.90	65.58	78.24
50	6	9	10	62.59	75.95	64.66	77.27	63.48	76.45	65.73	77.88	63.42	76.92	65.51	78.21
50	6	9	11	62.60	75.97	64.58	77.23	63.50	76.48	65.66	77.84	63.43	76.93	65.45	78.17
50	6	9	12	62.61	75.98	64.51	77.19	63.51	76.50	65.58	77.80	63.45	76.95	65.38	78.13
50	6	9	13	62.62	76.00	64.42	77.14	63.53	76.52	65.50	77.76	63.46	76.96	65.30	78.09
50	6	10	10	62.97	76.28	63.16	76.38	63.85	76.75	64.35	77.04	63.77	77.24	64.05	77.37
50	6	10	11	62.98	76.29	63.09	76.34	63.87	76.77	64.29	77.00	63.78	77.25	63.98	77.33
50	6	10	12	62.99	76.30	63.02	76.30	63.88	76.78	64.22	76.96	63.79	77.26	63.92	77.29
50	6	10	13	62.99	76.32	62.95	76.27	63.89	76.80	64.15	76.93	63.80	77.28	63.85	77.26
50	6	10	14	63.00	76.34	62.87	76.23	63.90	76.83	64.08	76.90	63.81	77.29	63.78	77.22
255	2	5	9	56.82	76.47	70.51	83.80	57.36	76.82	71.05	84.13	57.48	77.26	71.05	84.33
255	2	6	9	58.42	76.67	70.11	83.10	58.88	77.08	70.66	83.51	59.01	77.50	70.63	83.68
255	2	6	10	58.62	76.86	69.72	82.93	59.09	77.29	70.27	83.35	59.19	77.68	70.25	83.52
255	3	5	9	57.85	76.04	71.07	83.50	58.42	76.71	71.61	84.03	58.37	76.88	71.53	84.10
255	3	6	9	59.19	76.06	70.66	82.73	59.75	76.78	71.27	83.36	59.67	76.89	71.08	83.34
255	3	6	10	59.35	76.23	70.33	82.59	59.93	76.97	70.94	83.22	59.81	77.04	70.77	83.20
255	3	7	9	60.26	76.43	69.44	81.82	60.84	77.15	70.19	82.53	60.76	77.30	69.89	82.48
255	3	7	10	60.35	76.55	69.22	81.73	60.94	77.28	69.98	82.45	60.86	77.41	69.69	82.39
255	3	7	11	60.43	76.65	68.98	81.63	61.04	77.40	69.75	82.36	60.94	77.49	69.46	82.29
255	4	5	9	58.77	75.78	71.12	83.00	59.56	76.23	71.67	83.31	59.42	76.55	71.64	83.57
255	4	6	9	59.88	76.09	70.52	82.40	60.65	76.55	71.18	82.78	60.52	76.83	71.04	82.95
255	4	6	10	60.00	76.22	70.25	82.28	60.79	76.69	70.90	82.66	60.63	76.96	70.77	82.84
255	4	7	9	60.78	76.32	69.42	81.50	61.57	76.72	70.24	81.93	61.39	76.99	69.93	82.02
255	4	7	10	60.86	76.42	69.25	81.43	61.66	76.84	70.06	81.87	61.47	77.08	69.77	81.95
255	4	7	11	60.93	76.51	69.05	81.34	61.75	76.95	69.87	81.80	61.53	77.15	69.59	81.86
255	4	8	8	61.49	76.69	68.07	80.63	62.30	77.08	69.04	81.12	62.09	77.34	68.60	81.16
255	4	8	9	61.54	76.76	67.97	80.60	62.36	77.16	68.94	81.10	62.13	77.39	68.50	81.12
255	4	8	10	61.59	76.83	67.84	80.55	62.42	77.24	68.81	81.06	62.18	77.44	68.38	81.07
255	4	8	11	61.64	76.89	67.70	80.50	62.47	77.31	68.68	81.00	62.22	77.49	68.25	81.00
255	4	8	12	61.68	76.95	67.55	80.42	62.52	77.36	68.53	80.93	62.25	77.53	68.11	80.93
255	5	5	9	59.87	75.20	70.50	81.75	60.73	75.83	71.05	82.16	60.57	76.24	71.08	82.55
255	5	6	9	60.72	75.49	69.86	81.17	61.61	76.07	70.58	81.64	61.39	76.47	70.45	81.97
255	5	6	10	60.82	75.59	69.65	81.08	61.71	76.20	70.38	81.56	61.47	76.57	70.25	81.88
255	5	7	9	61.50	75.88	68.83	80.45	62.38	76.43	69.70	80.99	62.13	76.82	69.43	81.26
255	5	7	10	61.55	75.95	68.68	80.39	62.45	76.53	69.55	80.94	62.18	76.88	69.29	81.19
255	5	7	11	61.61	76.04	68.51	80.32	62.51	76.62	69.38	80.88	62.23	76.94	69.14	81.12
255	5	8	8	62.08	76.13	67.60	79.59	63.01	76.73	68.63	80.24	62.71	77.16	68.21	80.50
255	5	8	9	62.12	76.20	67.51	79.57	63.06	76.80	68.54	80.22	62.75	77.21	68.13	80.46
255	5	8	10	62.16	76.25	67.41	79.52	63.10	76.87	68.44	80.18	62.77	77.24	68.02	80.40
255	5	8	11	62.19	76.30	67.30	79.48	63.15	76.92	68.33	80.13	62.80	77.28	67.91	80.35
255	5	8	12	62.23	76.33	67.18	79.41	63.18	76.97	68.20	80.07	62.83	77.30	67.80	80.29
255	5	9	9	62.66	76.59	66.01	78.67	63.63	77.22	67.19	79.41	63.27	77.62	66.64	79.62
255	5	9	10	62.68	76.63	65.93	78.63	63.66	77.25	67.11	79.37	63.29	77.65	66.56	79.58
255	5	9	11	62.71	76.65	65.84	78.58	63.69	77.29	67.02	79.33	63.31	77.67	66.47	79.53
255	5	9	12	62.73	76.67	65.75	78.53	63.71	77.32	66.93	79.28	63.33	77.69	66.38	79.48
255	5	9	13	62.75	76.70	65.65	78.48	63.74	77.35	66.83	79.23	63.34	77.71	66.28	79.43
255	6	6	9	61.62	75.27	68.74	79.85	62.53	75.75	69.47	80.23	62.30	76.10	69.35	80.55
255	6	6	10	61.68	75.36	68.58	79.78	62.62	75.86	69.32	80.17	62.36	76.18	69.20	80.49
255	6	7	9	62.23	75.60	67.82	79.20	63.19	76.14	68.69	79.70	62.90	76.51	68.43	79.99
255	6	7	10	62.27	75.67	67.70	79.16	63.24	76.22	68.58	79.66	62.94	76.55	68.32	79.94
255	6	7	11	62.32	75.73	67.58	79.11	63.29	76.29	68.45	79.61	62.97	76.60	68.20	79.88
255	6	8	8	62.74	75.98	66.71	78.54	63.72	76.54	67.73	79.12	63.40	76.90	67.36	79.38

				Blue				Green				Red			
				% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings		% Energy Savings		% EDP Savings	
R	k	n	p	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra	Total	Intra
255	6	8	9	62.77	76.03	66.63	78.51	63.76	76.60	67.65	79.10	63.42	76.94	67.28	79.35
255	6	8	10	62.80	76.08	66.54	78.48	63.79	76.65	67.56	79.06	63.44	76.97	67.18	79.30
255	6	8	11	62.82	76.11	66.44	78.42	63.82	76.69	67.46	79.02	63.46	76.99	67.09	79.25
255	6	8	12	62.85	76.15	66.34	78.37	63.85	76.72	67.36	78.96	63.48	77.02	66.99	79.20
255	6	9	9	63.23	76.34	65.30	77.66	64.24	76.87	66.46	78.28	63.83	77.19	65.95	78.49
255	6	9	10	63.25	76.37	65.23	77.63	64.26	76.90	66.40	78.25	63.85	77.20	65.89	78.46
255	6	9	11	63.27	76.39	65.16	77.59	64.28	76.93	66.33	78.22	63.86	77.23	65.82	78.43
255	6	9	12	63.28	76.41	65.08	77.55	64.30	76.95	66.25	78.19	63.88	77.24	65.75	78.39
255	6	9	13	63.30	76.43	65.00	77.50	64.32	76.98	66.17	78.15	63.89	77.26	65.68	78.35
255	6	10	10	63.64	76.73	63.77	76.79	64.65	77.25	65.06	77.48	64.21	77.56	64.45	77.67
255	6	10	11	63.65	76.75	63.70	76.76	64.66	77.27	65.00	77.45	64.22	77.58	64.39	77.64
255	6	10	12	63.66	76.76	63.64	76.73	64.68	77.28	64.94	77.42	64.23	77.59	64.33	77.60
255	6	10	13	63.67	76.78	63.57	76.69	64.69	77.31	64.87	77.39	64.24	77.60	64.26	77.56
255	6	10	14	63.68	76.79	63.50	76.65	64.70	77.33	64.81	77.35	64.25	77.61	64.20	77.53

VITA

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