

Energy Logic for Telecommunications

by Steve Roy, Global Marketing

Worldwide demand for broadband and wireless services is growing at double-digit rates as businesses and consumers rely more and more on high-speed and mobile communications platforms. The networks that service those systems require power — a lot of it.

It should come as no surprise that there are energy inefficiencies within these telecommunications networks. Industry best practices target some of the waste, but most telecom providers and their vendors have limited the discussion to the energy efficiency of individual products. As such, the total impact of deploying higher-efficiency rectifiers or cooling units remains smaller than it could be if considered in the context of the overall network. This often leads to ill-informed investments when service providers overlook real opportunities for reducing energy consumption.

Emerson Network Power analyzed those missed opportunities, along with existing network inefficiencies and available energy-saving actions and developed 12 strategies for reducing energy use in these networks. These strategies are at the heart of Energy Logic for Telecommunications, a comprehensive approach to improving energy efficiency in telecommunications networks. Energy Logic provides a complete roadmap of recommendations, presented in sequence to maximize their effectiveness, and quantifies their savings. This provides complete awareness of the energy savings opportunities and a full understanding of the real savings potential.

The key is eliminating inefficiencies along the energy paths at the radio base station and central office, triggering cascading benefits by avoiding associated losses upstream. It's the same basic approach Emerson Network Power used in developing the original Energy Logic concept, introduced last year and aimed at reducing energy consumption in data centers.

Both Energy Logic for Data Centers and Energy Logic for Telecommunications take a sequential approach to reducing energy costs, applying technologies and best practices that exhibit the most potential in the order in which they have the greatest impact. While the sequence is important in terms of prioritization, Energy Logic for Telecommunications is not intended to be a step-by-step approach in the sense that each step can only be undertaken after the previous one is complete. The energy-saving measures included in Energy Logic should be considered a guide. Many organizations already will have undertaken some measures at the end of the sequence or will have to deploy some technologies out of sequence to remove existing constraints to growth.

The Energy Logic for Telecommunications strategies include important infrastructure steps at the base station and within the central office, including cooling optimization and DC power management. All of the technologies used in Energy Logic are available today and many can be phased into the network as part of regular technology upgrades/refreshes, minimizing capital expenditures.

Table 1 – Operator Network Energy Consumption ^{[1][2][3][4][5]}

Country	Network	Energy Consumption	% of Country Total Energy Consumption
USA	Verizon 2006	8.9 TWh	0.24%
Japan	NTT 2001	6.6 TWh	0.7%
Italy	Telecom Italia 2005	2 TWh	1%
France	France Telecom-Orange 2006	2 TWh	0.4%
Spain	Telefonica 2006	1.42 TWh	0.6%

Energy Consumption in Telecommunications Networks

The potential efficiency gains through Energy Logic are significant — reducing consumption by nearly 60 percent at the base station and 40 percent at the central office. But to fully appreciate those numbers, it's important to understand just how much energy telecommunications networks are using.

In *Table 1*, we look at energy consumption for five major telecom providers around the world. They account for nearly 21 TeraWatt hours (TWh) annually. One TWh equals 1 million megaWatt hours (1 megaWatt = 1 million Watts). The Three Mile Island nuclear power plant produces 7 TWh each year, so it would take three of those nuclear plants just to power those five telecom providers.

By extrapolation, estimates indicate the telecom industry consumed 164 TWh last year, or about 1 percent of the global energy consumption of the planet. That equates to 15 million U.S. homes and matches the CO₂ emissions of 29 million cars. In fact, the U.S. EPA estimates a 10 percent reduction in energy use by telcos could save the industry more than \$200 million a year and prevent 2 million tons of CO₂ emissions^[6].

But reducing energy consumption is a challenge when consumer demand for telecommunications services is skyrocketing. Broadband subscriptions are growing at a rate of 14 percent annually and require 4 to 8 times more energy than basic telecom service. Fiber-to-the-home deployments recently topped 3 million in North America — an increase of more than 100 percent since last year (RVA Associates for the Fiber to the Home Council). Internet traffic is increasing by 60 percent annually^[7], due in large part to growing demand for Internet-based VoIP, video streaming, and movie and video downloads. On the wireless side, the industry is on its way to 3 billion connected devices, with high-speed data being the ultimate objective. All of these services drive up energy consumption within the network.

Faced with these realities and trends, it likely is only a matter of time until governments start imposing reduction targets — unless the industry takes action on its own first.

The key for the industry will be addressing the issue with a clear and defined approach that optimizes the results. In a telecom network, any system component action has a ripple effect on the other components. This applies to energy savings. When applying energy-saving actions, it's important to consider the impacts on the other system components. This is the key to the Energy Logic method, which can be applied to both wireless and wireline networks and represents a holistic approach to energy savings. In this paper, we will review the system-level impacts, introduce implementation strategies and provide recommendations.

Wireless Networks

The wireless network can be viewed in two major sections: the operators' part, which includes the Mobile Switching Center (MSC) and Radio Base Station (RBS), and the subscribers' part, normally limited to the handheld device. Estimates indicate more than 90 percent of wireless network energy consumption comes from the operators^[8]. With approximately 4 million installed Base Transceiver Station (BTS) cabinets in the world today and an estimated double-digit growth rate, the impact of any energy savings at this point is significant.

In identifying opportunities to reduce energy consumption at these sites and assessing the impact of various strategies, we used a typical RBS — a 3 sector Omni — as the model. It is the same model analyzed and presented in Ericsson's August 2007 white paper, "Sustainable energy use in mobile communications," which looked at telecom energy efficiency strategies. In fact, two of the strategies presented here come from that paper.

But before discussing the strategies, it is important to understand some characteristics of this RBS. More than 60 percent of the power used by the RBS is consumed by the radio equipment and amplifiers, 11 percent is consumed by the DC power system and 25 percent by the cooling equipment — an air conditioning unit typical of many such sites. Under these conditions, it takes 10.3 kW of electricity to produce only 120 Watts of transmitted radio signals and process the incoming signals from the subscriber cell phones. From a system efficiency perspective (output power/input power), this translates into an efficiency of 1.2 percent.

Figure 1 – RBS Block Diagram and Associated Power Losses

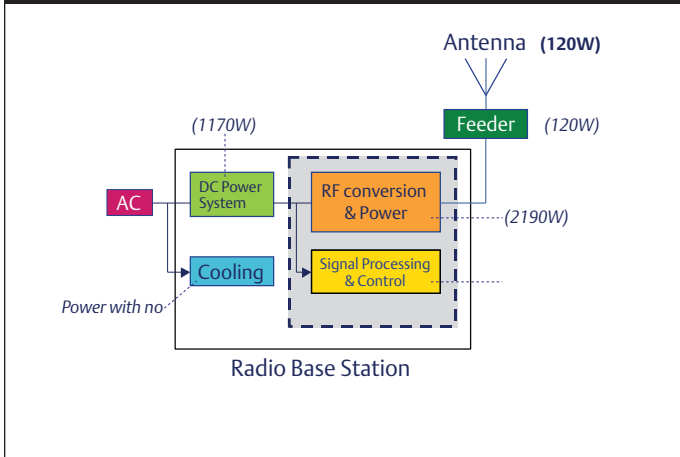
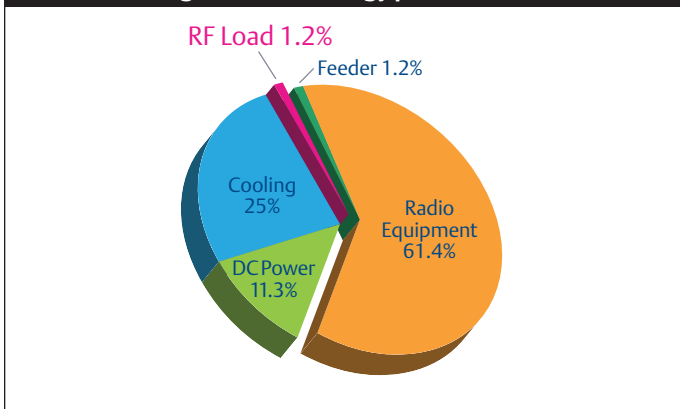


Figure 2 – RBS Energy per Function



Clearly, there are opportunities for improvement, and they become more obvious when we examine the energy flow inside the RBS (Figure 1). Specifically (Figure 2):

- Ultimately, 120 Watts of RF signals are pushed into the antenna. To deliver this, an additional 120 Watts must be fed to the feeder cable at the base of the tower. That adds up to 50 percent efficiency for the feeder.
- To produce this RF power, the radio equipment consumes 2.1 kW for signal processing and an additional 4 kW for the RF power amplification, with only 6 percent combined modulation and amplification efficiency.
- The power plant feeding this load runs at only 85 percent efficiency, well below its peak level. This is the result of the low utilization of the rectifiers and some system-level losses.
- The air conditioner, another frequently over-engineered component, draws 2.5 kW, or 0.34 W for every 1 W of heat produced by the electronics.

Figure 3 – Wireless RBS Cascade Effect

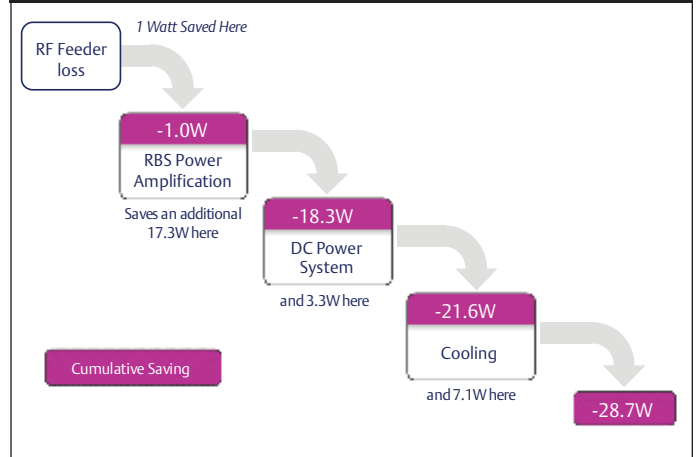


Table 2 – Cascade Effect Multiplier

1 W saved at:	Saves a total of:
RF Load	1W → 28.7W
Signal & PC	1W → 1.6W
PA Circuit	1W → 1.6W
DC Power System	1W → 1.3W
Cooling	1W → 1.0W

Because of these inefficiencies along the energy path, any Watt saved near the antenna will yield cascading benefits by avoiding the associated losses upstream. That cascade effect maximizes the ultimate energy savings at the source. The benefit of 1 Watt saved at the RF load is multiplied by the system block efficiencies, so the accumulated benefits are much higher than the original 1-Watt reduction. Table 2 shows the cascading effect of 1 Watt savings at the different RBS functional blocks.

In our model, saving 1 Watt in the feeder cables saves 17.3 Watts of modulation and amplification losses, 3.3 Watts of rectification losses and 7.1 Watts of associated cooling energy (Figure 3). In aggregate, this represents a 28X cascading benefit, with smaller benefits also occurring in signal processing and DC power. For these reasons, efforts must start closer to the antenna, where they yield greater benefits and enable reduction in cooling and power requirements.

Energy Logic for Telecommunications involves sequential steps leading to an overall reduction in energy consumption of nearly 60 percent at this typical RBS.

Table 3 – Six Energy Savings Strategies for Wireless

Strategy	Today	Tomorrow...	Savings (W)	Cascaded Savings (W)	%
1 Remote radio units	Radio equipment located away from antenna	Move radio equipment close to the antenna: avoid feeder cable losses	120	3,429	33.1%
2 Radio standby mode	Transmit and receive functions always ON	Transmit function on standby during low voice traffic periods	416	660	6.4%
3 Passive cooling	Air conditioning cooling in some applications	Environment-friendly cooling	1,179	1,179	11.4%
4 Advanced climate control	Fixed thermostat setting	Dynamic adjustment	315	315	3.0%
5 DC system ECO mode	DC system efficiency of 85%	Optimized use of rectifier efficiency curve: raise system efficiency to 90%	272	272	2.6%
6 Higher rectifier efficiency	90% DC system efficiency	94% DC system efficiency	188	188	1.8%
Telecom Equipment Power & Cooling				6,042	58.4%

Figure 5 – Energy Consumption versus Call Traffic

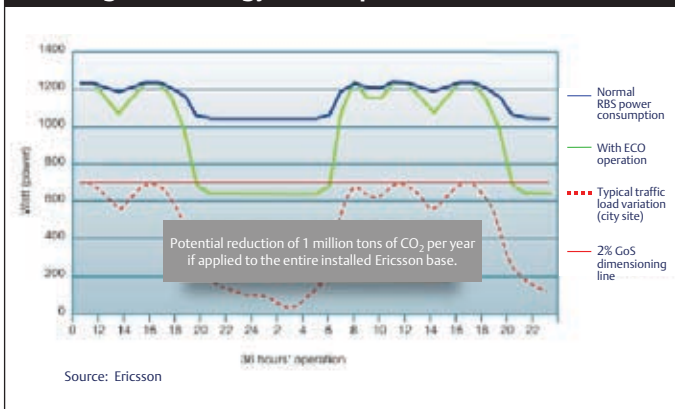
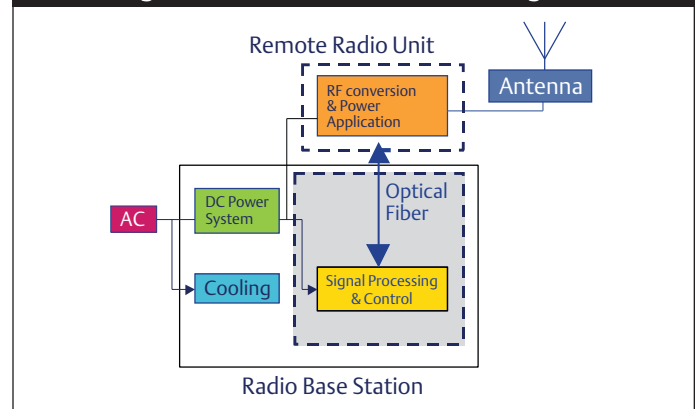


Figure 4 – RBS Remote Radio Block Diagram



Energy Logic at the RBS

We recommend six energy-saving strategies.

The first two (*gray rows in Table 3*) apply to the radio equipment and should be prioritized. These are the strategies also described in the Ericsson white paper and are available from most radio vendors. The other four strategies (*white rows in Table 3*) apply to the cooling and power equipment. When all six steps are implemented, total savings of up to 58.4 percent are possible.

1. Optimize remote radio units

A typical RBS requires 120 Watts of power to push 120 Watts of RF signals to the antenna. Moving the RF converters and power amplifiers (PA) from the base of the station to the top of the tower (close to the antenna) and connecting them via fiber cables (*Figure 4*), avoids the power drop inherent in a long feeder cable run. Power is delivered either via a separate feed from the grid or, preferably, via 48V feeds from the base station power system. In either scenario, losses are minimal and the full 120-Watt loss in the feeder cable is eliminated.

This step cuts the power requirements of the PA by half while removing 33 percent of the cooling requirements and 30 percent of the DC power load and losses.

Most radio manufacturers now offer this topology.

2. Radio standby mode

Radio transmitters and receivers can be turned to what is often called ECO mode, which turns the power off when call traffic is low — typically overnight. If a given site isn't equipped already, this capability is available through simple software and hardware upgrades.

Power consumption is fairly stable throughout the day and night and independent of traffic. In ECO mode, however, power consumption can be reduced by up to 40 percent under low traffic (*Figure 5*). Overall, this strategy will reduce power consumption between 10 and 20 percent as well as provide associated power conversion and cooling reductions.

3. Passive cooling

Historically, air conditioners have been the preferred choice for radio sites, but those AC units require power equivalent to 34 percent of the heat load produced inside the RBS. For example, if the RBS produces 1,000 Watts of heat load, the power consumed by the AC will be 0.34×1000 , or 340 Watts. They also are noisy and maintenance-intensive.

Depending on the geographic location and willingness to trade energy savings for some battery life, other cooling strategies such as free ventilation, forced fan cooling with hydrophobic filtering or heat exchangers will change the energy consumption significantly and often yield a lower total cost of ownership (TCO).

Applying a TCO analysis to a battery cabinet located in the state of New York, where the climate is moderate and the sites are generally easy to access, shows a savings of \$4,800 over a 10-year period by using free ventilation instead of air conditioning. Eliminating electricity costs provides the bulk of the savings with free cooling, but maintenance and replacement costs for the batteries also are lower than maintenance costs with the AC system.

Although it is estimated that passive cooling can provide energy savings of 10 percent or more, not all scenarios favor free cooling. Each RBS should be evaluated independently to identify opportunities to achieve those savings and the overall lower TCO.

4. Advanced climate control for air conditioners

If an air conditioner remains necessary, energy consumption can be minimized by triggering operation at a higher temperature. The higher set point not only ensures the unit will be turned on less frequently, the higher temperature delta at the air exchange enables improved operational efficiency.

A 10-site trial conducted from May to September 2007 reduced total cooling costs by 14 percent by allowing a wider fluctuation between 31°C and 26°C (Figure 6). Of course, raising the internal

cabinet temperature has to be weighed in against the potential adverse effect on component reliability, but total savings of 3-4 percent can be obtained safely without major availability impacts.

5. DC system to ECO mode

Rectifiers have a high peak efficiency, which can drop by several percentage points when the load is under 40 percent of the rectifier capacity. Because systems are configured with redundant units, and often sized based on future demand and worst-case assumptions, most remote sites operate well below 40 percent capacity. The strategies outlined above further reduce the load.

An advanced system controller scheme can ensure rectifiers operate at peak efficiency in virtually all conditions. In this energy management control scheme, the controller continuously measures the load current and allows only rectifiers operating at peak efficiency to supply the power. The controller also rotates the rectifiers so they share duty cycles equally over time. In effect, it operates as an ECO mode for the DC system.

Rapid load changes are handled without service degradation or interruption by the presence of the battery bank and the quick response of the rectifiers. The system will react to major load changes quickly by bringing idle rectifiers on line in a matter of seconds.

The energy savings are small compared to previous steps, but not insignificant, as seen when applied to a system with 11x30 ADC rectifiers, a capacity of 300A and an actual load of 110A. Without this DC ECO mode, each rectifier is loaded at 33 percent of its capacity, for an approximate efficiency of 89 percent (Figure 7).

With ECO mode, given that five rectifiers are in idle mode, the actual load power rectifier increases to 22A, loading the rectifiers 66 percent and providing an operational efficiency above 92 percent. This mode saves 146 Watts of dissipated heat, a 20 percent

Figure 6 – Energy Savings Field Results from Advanced Climate Control

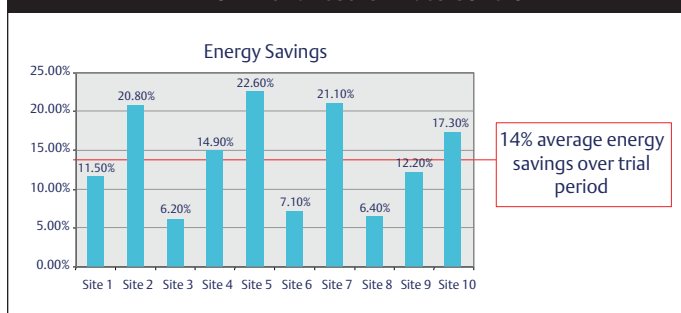


Figure 7 – Energy Efficiency Curve

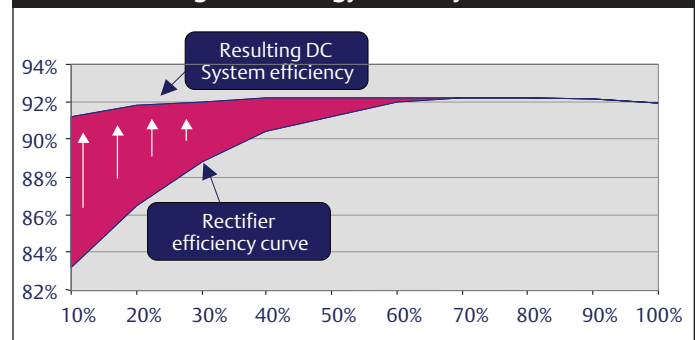
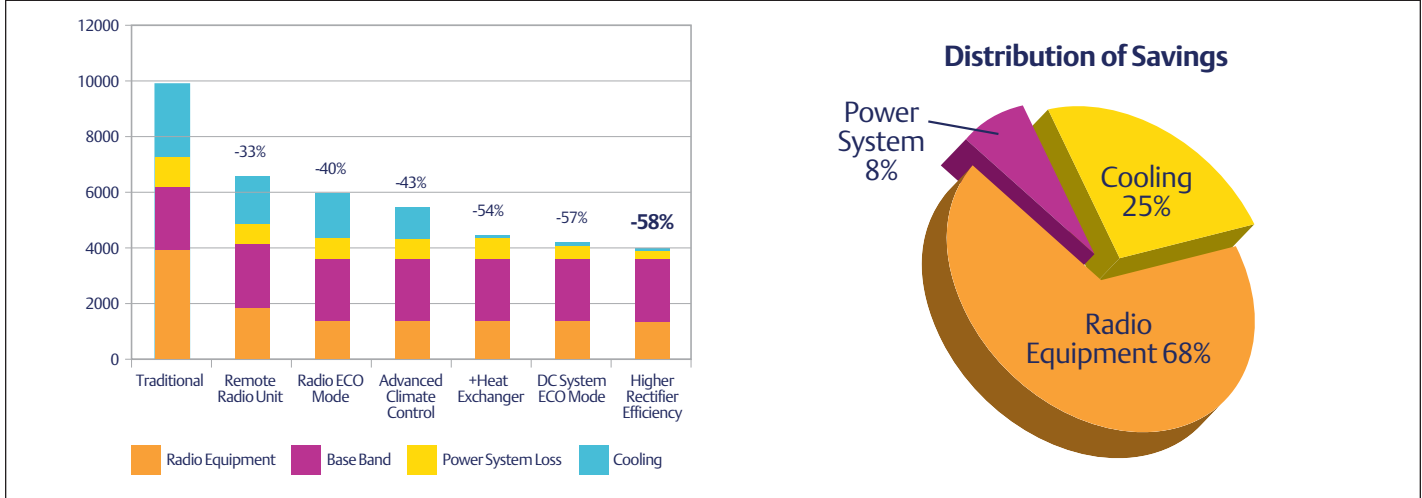


Figure 8 – Six Energy Strategies Applied to an RBS



energy savings. Although this is not negligible, the DC power system is only a small contributor to total RBS energy losses, contributing only 2-3 percent of the entire savings budget.

6. Higher-efficiency rectifiers

Until recently, rectifiers were considered an area with little benefit to overall efficiency, and customers overwhelmingly opted for lower initial cost rather than marginal efficiency gains. But this preference may be changing with the advent of higher-efficiency rectifiers.

Higher-efficiency rectifiers are appealing, but it is important to continue to take a holistic, system-wide view in evaluating their overall effectiveness. In the RBS model, the cascaded savings provided by a 4 percent rectifier efficiency gain translate to a 1.8 percent system-level energy savings. But in order to determine whether or not the full savings are realized, it is necessary to determine if the promised efficiency is delivered.

In measuring some of these products, it was determined that they meet the advertised efficiencies — but only at high line voltages. That is not where products typically operate. Beware of misleading information and demand data at a nominal line voltage, across a wide load range (typically 40 to 100 percent load).

Loads often are overstated and sites take years to reach planned capacity. As a result, rectifiers usually run at a fraction of their capacity — typically around 40 percent. With the AC consumption lower than anticipated and high-efficiency rectifiers being premium priced, an analysis must justify the financial viability of this option. Consider the return on investment (ROI) of replacing a standard 91.5 percent efficient rectifier with a high-efficiency 96.5 percent unit. In the remote site model, over five years with an

N+1 configuration, the ROI is around 30 percent. When considering ECO mode (i.e. radio standby mode), which reduces the load when traffic is low, the savings and ROI are affected negatively by 5 percent.

When the 91.5 percent rectifier is replaced with a 94 percent efficient model operating in ECO mode, savings are well beyond acceptable levels. This is one reason we believe customers can find more attractive investment options than high-efficiency rectifiers. We believe the preferred choice in today's environment is a 94 percent efficient rectifier, which comes at a minimal price impact versus today's market prices and offers the strongest ROI when operating in ECO mode.

RBS summary

Energy consumption at the RBS is a major industry issue, but opportunities for reductions of more than 50 percent are readily available (Figure 8).

- On the radio side, going to a remote radio concept and applying the radio ECO mode functionality will reduce energy consumption by 40 percent.
- On the infrastructure side, cooling costs can be reduced by optimizing air conditioner use or, preferably, by migrating to a more passive approach. These will reduce consumption by an additional 3 percent and 11 percent respectively, cumulatively down by 54 percent. But remember to look at the TCO for the cooling decision.
- Finally, a 4 percent reduction is available by implementing energy management to keep DC plant rectifiers at peak efficiency and by prudently opting for higher-efficiency rectifiers.

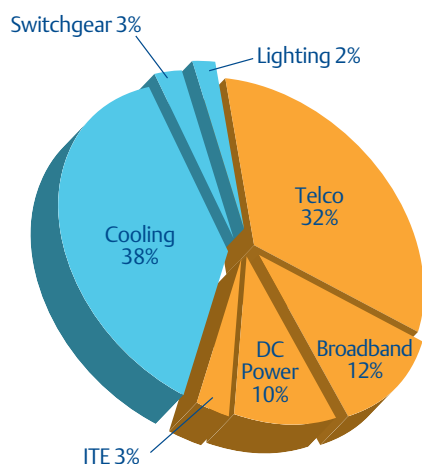
Table 4 – Broadband Power per Subscriber^{[9][10]}

Technology	Watts/subs.	Bandwidth (Mbit/sec)
Dial-up	1.2	0.064
ADSL2	1.54	25
VDSL2	2.75-3	50
GPON	0.17	75
E-FTTH	3.3	100

Table 5 – Central Office Power Consumption Model

Equipment Category	Energy Consumption	
Telecom Equipment	53	kW
IT Equipment 1	5	kW
Broadband Equipment	20	kW
Lighting	3	kW
DC Power & Distribution Losses	17	kW
Cooling Power Draw	64	kW
Building Switchgear/MV Transformer	5	kW
Total Power Draw	167	kW

Figure 9 – Central Office Energy Repartition per Function



Wireline Networks

Wireline networks are in the middle of dramatic structural changes that affect how and when various strategies for reducing energy consumption can be applied. Transitioning circuit switching to packet switching implies new equipment overlays to enable service continuity are forthcoming. Broadband access technology choices also affect how the network will be shaped. *Table 4* shows the power draw per subscriber using different broadband technologies.

With the exception of GPON, a passive optical technology in the early stages of adoption, the trend is clear: the higher the bandwidth, the more power is required. In fact, the short- and medium-term energy consumption of the wireline network will increase for at least three reasons:

- Additional consumption from access technology
- Increased penetration rate: 46 percent of the US population is still on dial-up or has no Internet access
- Higher bandwidth = new services = new equipment to be powered

At the same time, power is being slowly de-centralized and pushed more and more toward the user. According to Nokia Siemens Network^[11], less than 30 percent of broadband power consumption is under the operator's OPEX responsibility, meaning more than 70 percent is the responsibility of the user. Obviously, the user part is the dominant aspect, but the amount per user is so small that energy-saving actions are limited. Operator-focused actions, on the other hand, have immediate and direct returns. With that in mind, we propose six Energy Logic strategies targeted at the central office.

The strategies were applied to a typical central office power consumption model. This model was based on a traditional architecture with a voice-switch, Digital Subscriber Line Access Multiplexer (DSLAM), some IT and inverter equipment, and a -48VDC ferro-resonant power plant, cooled by a standard central air conditioner system installed more than 20 years ago. *Table 5* shows the power consumption of each main functional block. The energy consumption is limited to the equipment room and does not include other building infrastructure equipment.

Figure 9 shows the relative power losses of each of these functional blocks within the facility. Close to 60 percent of the power dissipation is associated with the network elements. The most significant point, however, is that nearly 40 percent of the power dissipation is tied to one element: cooling.

Figure 10 – Wireline Cascade Effect

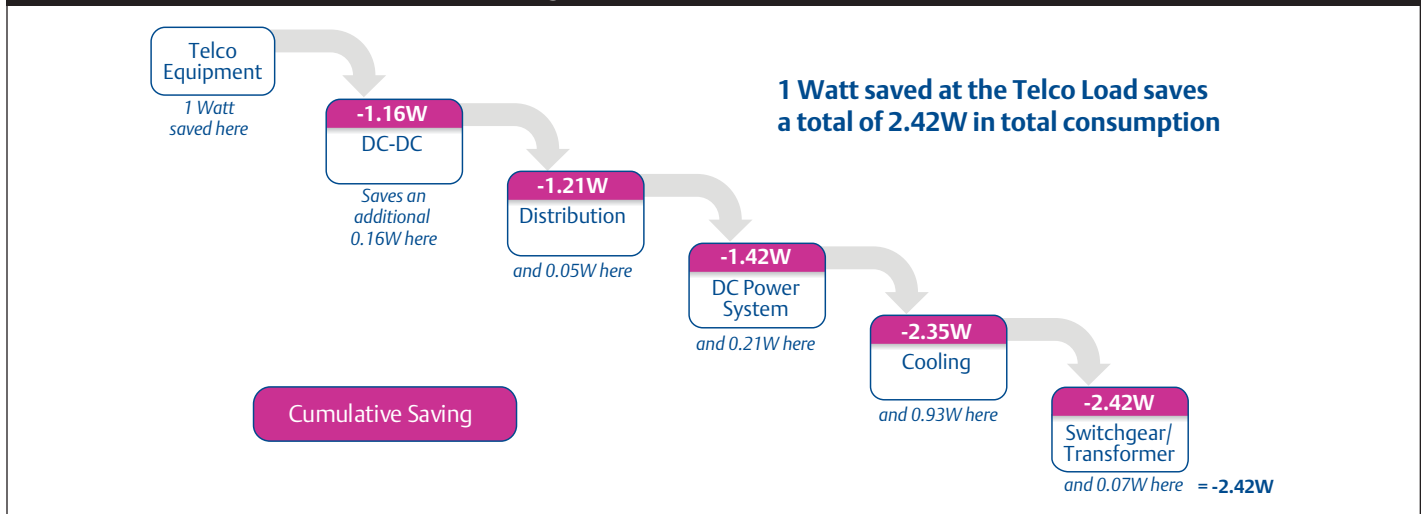


Table 6 – Central Office Energy Savings Strategies

Strategy	Description	Savings (kW)	Cascaded Savings (kW)	%
1 Energy savings mode in Telco and IT equipment	Energy savings mode implemented	9.9	24.3	14.6%
2 DC Powered IT Equipment	Eliminate inverters	1.4	2.8	1.7%
3 Implement cooling best practices	>3kW/rack: optimized Cold Aisle, No Mixing of Hot and Cold Air	16.4	16.9	10.2%
4 Supplemental High Density Cooling	Cooling at the load	10.7	11.0	6.0%
5 Replace legacy rectifiers	New generation rectifiers: 93% efficiency	5.2	7.1	4.3%
6 DC System ECO Mode	New generation rectifiers: 93% efficiency	1.6	2.2	1.3%
		64.3	38.6%	

Table 7 – Proposed Broadband Power per Subscriber Objectives

		Full Power Mode	Low Power Mode	Standby Mode
ADSL2+	Today	1.5	–	–
	2009	1.2	0.8	0.4
VDSL2	Today	2.75	–	–
	2009	1.6	1.2	0.8

As is the case with the wireless model, the cascade effect exponentially increases energy savings in the central office. As shown in Figure 10, 1 Watt saved in the telco equipment generates an additional 0.16 Watts saved from the internal DC-DC converter (86 percent efficiency), 0.05 Watts from the distribution (96 percent efficiency), 0.21 Watts from the DC power system (85 percent efficiency), 0.9 Watts from the cooling, and 0.07 Watts from the input AC switchgear, resulting in 2.42 Watts saved in total.

Energy savings farther from the AC grid yield the highest returns. In our model, the greatest results are achieved with energy-saving actions on the load. Cooling is the other major element that can be optimized.

Energy Logic in the Central Office

We recommend six energy-saving strategies in the central office (Table 6). When all strategies are considered, total savings of nearly 40 percent are possible.

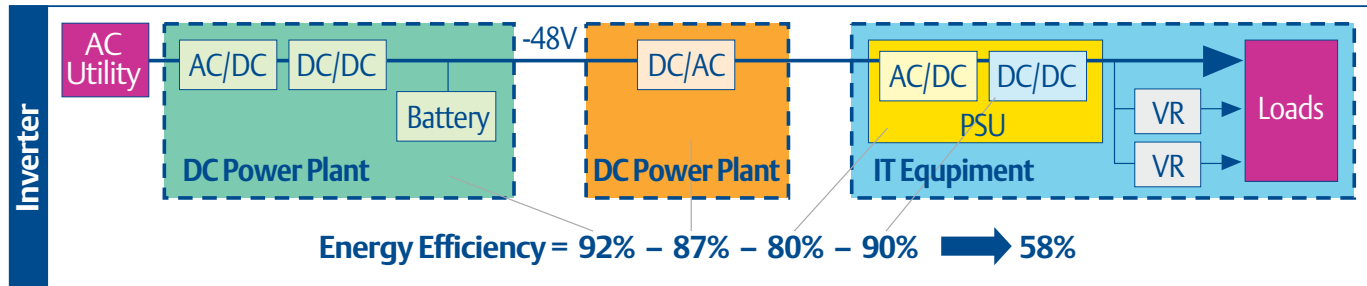
1. Energy Savings Mode in Telco and IT Equipment

Equipment suppliers are being challenged to reduce energy consumption. Procurement specifications increasingly require an Energy Savings Mode in telecom and IT equipment. Like ECO mode, Energy Savings Mode reduces equipment energy consumption during low activity periods.

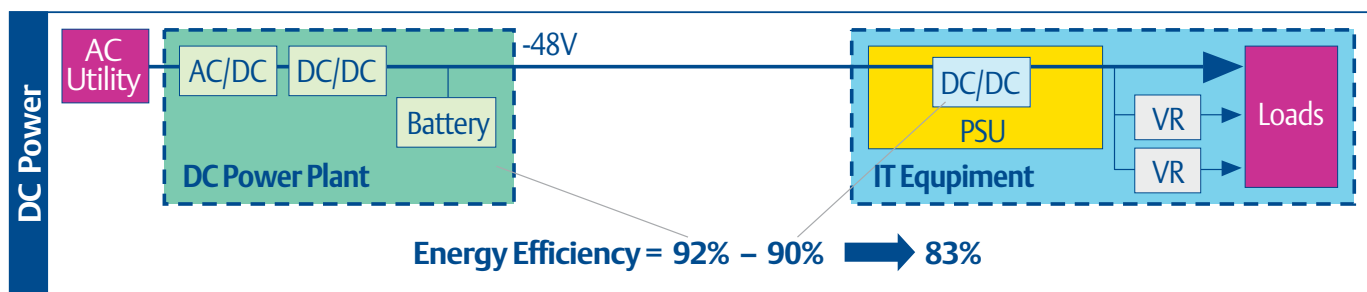
The European Commission has established the Code of Conduct on Energy Consumption of Broadband Equipment^[12] to bring some operational standards to these technologies. A proposal under consideration would introduce new, mandatory operational modes (Full Power Mode, Low Power State and Standby State). Even when considering only the full power mode, this will provide a minimum 20 percent energy savings for ADSL2 and 40 percent savings for VDSL2, as shown in Table 7.

In the Energy Logic central office model, a 15 percent energy savings on the telco equipment amounts to 9.9 kW and increases to 24.3 kW due to the cascading effect. This clearly is where the greatest benefits can be achieved.

Figure 11 – Power Efficiency Block Diagram



a) IT equipment powered with an inverter



b) IT equipment powered from the -48Vdc power plant

2. DC-Powered IT Equipment

Any power converter has an operational inefficiency related to heat losses that must be addressed by the cooling mechanism. Minimizing the number of power converter stages in an equipment room should be a top priority when trying to limit energy consumption in a central office.

Telco providers are introducing new equipment to the network environment, some of which traditionally has been used in data centers. Inverters have been the simple powering option, converting DC power from the power plant to AC power that then is pushed to the IT equipment. Typically, inverter power accounts for 10 percent of the power budget in a central office and more than

20 percent in a wireless MSC. By eliminating the power conversion at the inverter and using the traditional -48VDC architecture (Figure 11), the end-to-end efficiency is 25 percent higher. This improvement is related to not only the inverter efficiency itself, but also to the elimination of the additional power supply inside the IT equipment. For a 5 kVA load, this would translate to a reduction of 2,600 Watts in heat dissipation.

In our model, the inverter load is not a high contributor, and therefore the impacts are limited to 1.9 percent of the total reduction in energy consumption. However, in applications where the inverter or UPS component is more predominant, this strategy should strongly be considered.

Figure 12 – Heat Load Trend

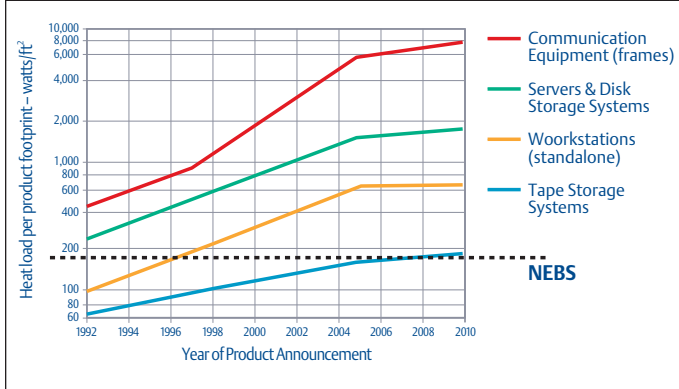


Table 8 – NEBS and ASHRAE Operating Environment Conditions

NEBS/ETSI

- 5 to 40°C operating temperature
- 5 to 85% relative humidity

ASHRAE

- 5 to 32°C operating temperature
- 21-23°C for optimal reliability
- 40 to 60% relative humidity

3. Implement Cooling Best Practices

Evolving technologies are raising power densities to levels never before seen in the central office, raising concerns about providing the right environmental conditions to optimize equipment reliability.

Figure 12 shows results of an equipment power density survey conducted by the Uptime Institute. The levels shown are several times higher than the Telcordia GR-63 recommendation of 181.2 Watts per square foot.

Additionally, if the equipment meets the ASHRAE standard, environmental operating parameters are much more stringent than with NEBS (Table 8). This will impose new challenges on the cooling techniques used to avoid hot spots or overcooling.

These simple best practices can help improve cooling efficiency by close to 30 percent:

- Ensure the hottest air is returned to the cooling unit (through hot-aisle/cold-aisle configuration, blanking plates)
- Pressurize the cold aisle or use return air ducting for hot air containment
- Raise the chilled water temperature above 45°F (up to 50°F)
- Isolate equipment room with vapor seal to avoid unnecessary humidification/dehumidification
- Maintain the proper cold aisle temperature — adjust room set point (68°F to 70°F)

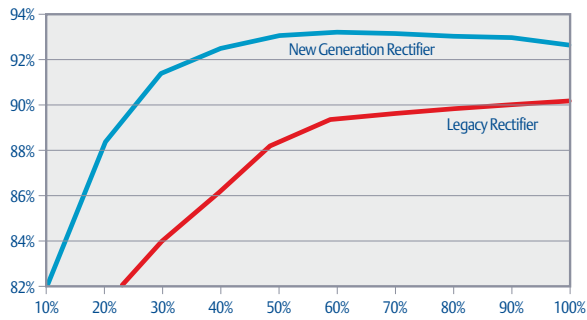
- Use Variable Frequency Drives (VFD) for air handling unit fans (reducing fan speed by 20 percent reduces power consumption by 50 percent)
- Choose cooling equipment featuring Digital Scroll Compressors to allow the air conditioner capacity to match the room condition without switching the compressors on and off. This can lower energy consumption by as much as 47 percent in some applications.

4. Supplemental High-Density Cooling

Sometimes simply following best practices is not enough. In the central office, more significant heat-related issues have been treated on a case-by-case basis either by spreading the equipment across numerous racks, or having additional cool air supplied in front of the system. Data center cooling has moved beyond these approaches to more aggressively and effectively counter high-density heat issues.

High-density supplemental cooling has been deployed in data centers for years with tremendous success. These assemblies are fitted over the rack or cabinet from the ceiling or in the row and provide the necessary cooling at the source — and they do it 30 percent more effectively than chilled water cooling systems. Refrigerant-cooled cabinets can deliver similar results. These also are being deployed in the data center environment and could prove just as effective in the telco world.

Figure 13 – 100A Rectifier Efficiency



5. Replace Legacy Rectifiers

The longevity of some telecommunications equipment buildings has led to the continued use of older generation -48VDC rectifiers in the network (ferroresonant, controlled ferro, SCR, etc.). Most of this installed equipment is at the end of its useful life. There are serious reliability concerns, and replacement parts are more and more difficult to find. In addition, energy efficiency improvements of 3 to 7 percent are possible (Figure 13), specifically in the 20 to 50 percent load range utilization.

Table 9 shows the annual energy savings related to such an equipment change. The same 100A rectifier model is used, and different load factors are considered. At US\$0.10/kWh, the savings add up quickly. In our model, this strategy provides the highest savings potential related to DC power actions, with 4.2 percent of the total savings.

Table 9 – Annual Energy Costs Saving of Replacing Legacy Rectifiers

Number of rectifiers:	System Load (Amperes)					
	600	1200	1800	2400	3000	4200
8	1,019 \$					
14	2,071 \$	1,968 \$				
20	2,630 \$	2,615 \$	2,952 \$			
26	2,916 \$	3,101 \$	3,502 \$	3,936 \$		
32	2,916 \$	4,142 \$	3,922 \$	4,699 \$	4,920 \$	
38	2,916 \$	5,259 \$	3,922 \$	4,211 \$	5,638 \$	5,905 \$
44	2,916 \$	5,259 \$	4,652 \$	4,211 \$	6,537 \$	7,003 \$
						6,869 \$

6. DC System ECO Mode

The effective equipment room load is likely to become more and more unpredictable. Wider load excursions are expected, and DC System ECO mode ensures optimal energy utilization of the DC power plant.

Although this strategy provides lower returns than others, the return on investment is immediate and ongoing. ECO mode is a software feature resident in most modern controllers and is likely to become mandatory.

Central office summary

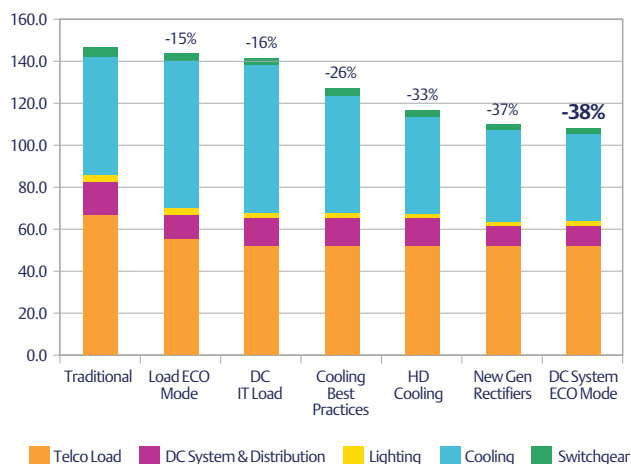
Applying these six Energy Logic strategies to the central office can reduce energy consumption by nearly 40 percent (*Figure 14*).

On the telecom equipment side, a minimum 15 percent energy savings was achieved by applying the ECO mode to the broadband and IT load only. This number will climb with continued pressure from operators to make energy savings a priority and part of requirement specifications.

On the infrastructure side, a 17 percent reduction in energy use is available through the application of cooling best practices, many of which are standard fare in today's data centers.

Finally, a 6 percent reduction is available through energy management at the DC plant, including maintaining rectifier efficiency and using higher-efficiency rectifiers.

Figure 14 – Six Energy Strategies Applied to a Telecom Central Office



Integrated energy management software

All of these RBS and central office strategies are applied to a specific functionality of the network, but system-level energy management software is an essential element to maximizing energy conservation.

System-level energy management software is flexible and can be adapted to target specific energy management issues. For example, by using alternative energy sources to supply the load during peak hours, it's possible to recuperate the energy during off-peak hours.

Figure 15 shows the actual results of applying this type of software control in a central office. In this example, when the input power level exceeded a pre-set threshold, the individual equipment room thermostat was raised by 1 – 2°C. This fairly simple action enabled a 4 percent reduction in energy consumption.

The lack of integration between building and site equipment management systems leads to further missed opportunities for energy conservation.

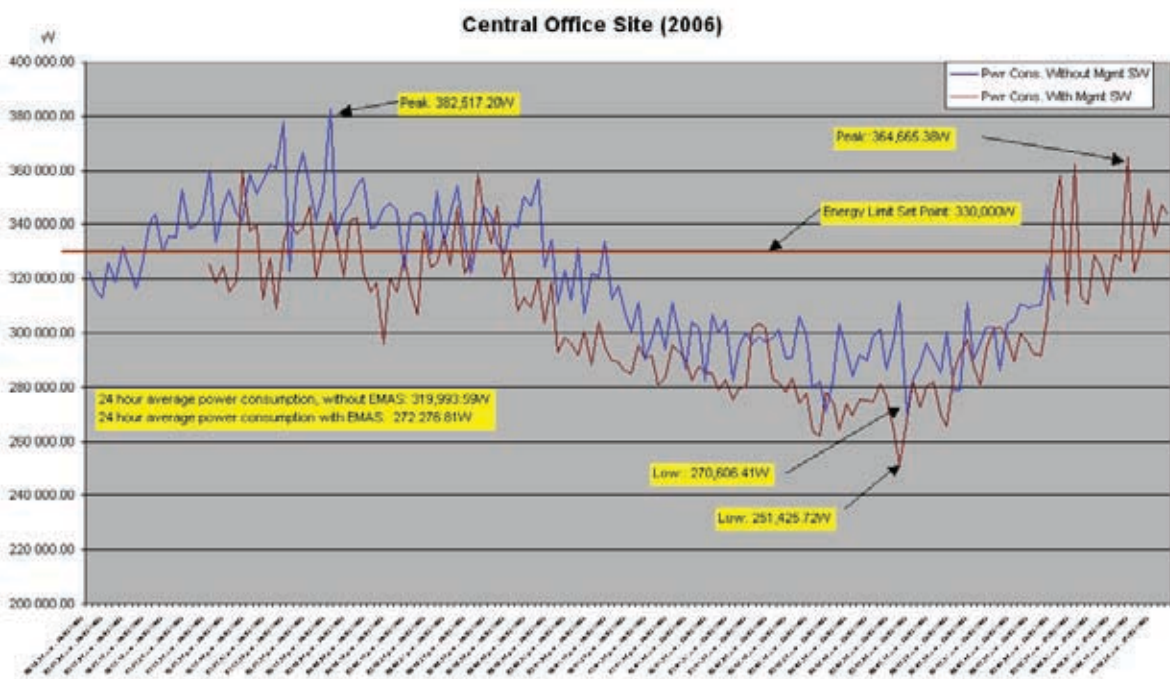
We have demonstrated that cooling is where most savings can be achieved in the future. In the access world, cabinet cooling is under

the supplier's control, as are the design and technology decisions. In the indoor world, it's a different story. In many organizations, cooling may be specified by network equipment considerations, but it is managed by the real estate group based on different considerations and objectives. This same departmentalized approach applies to the management software, where each use different protocols and different interfaces. A real potential for harmonization and energy savings optimization can be achieved through software management.

A September 2005 paper from Deutsche Telekom, "Energy Savings at Deutsche Telekom — Two Case Studies^[13]," showed that simple software integration has enabled 10-20 percent energy savings across 2,900 facilities, with a return on investment of 1.5 to 2.5 years.

Whether it's re-use of equipment-generated heat for building heating purposes, incorporation of outside air cooling, or automatic modification of environmental conditions triggered by the presence of someone in the room, tremendous energy-savings potential exists by combining the different operating modes of the building and equipment and making them work as one homogeneous system.

Figure 15 – Energy Management Software Results on Input Power



Conclusion

Several organizations have gone public with energy efficiency, power reduction, and carbon footprint reduction objectives.

- Verizon has established an objective for its vendors to achieve 20 percent greater efficiency by January 2009, as compared to today's equipment
- France Telecom is planning to reduce the greenhouse emissions per customer by 20 percent between 2006 and 2020
- British Telecom claims to have reduced its carbon footprint by 60 percent since 1996, and has an objective to reach 80 percent by 2016

Using Energy Logic for Telecommunications strategies can generate savings of close to 60 percent in the wireless network and 40 percent in wireline. In the case of the RBS alone, this translates to potential global savings of 11.8 TW of demand — or US\$10.3 trillion per year.

All of this is possible through these 12 basic Energy Logic strategies, which can be summarized in a few simple guidelines:

- Savings further away from the AC grid yield the most returns
- Be cool with your cooling; cooling can no longer be taken for granted and needs to be adapted to its operating environment
- Savings from higher rectifier efficiency yield less overall impact and shall be considered only with mature technology
- Implement energy management to optimize the operation of your equipment

Again, the key is addressing the issue with a clear and defined approach that optimizes results. Looking at energy consumption at the network level and considering energy-saving actions holistically is the key to Energy Logic for Telecommunications and to successful energy conservation.

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Emerson Network Power

Energy Systems, North America

4350 Weaver Parkway, Warrenton, IL 60555

Toll Free: 800-800-1280 (USA and Canada)

Telephone: 440-246-6999 **Fax:** 440-246-4876

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