CHAPTER 5 LEADING AND CONTROLLING

5.1. LEADING

The main purpose of leading is to harmonize individual and organizational objectives. People do not work in isolation, rather they work in groups toward the achievement of personal and enterprise objectives; these objectives are not always in harmony and in fulfilling the function of leading the manager aims to align objectives of the individual with that of the enterprise.

Koontz *et al.* [14] defines the managerial function of leading as the process of influencing people so that they will strive willingly and enthusiastically toward the achievement of organizational goals. In order for people to willingly strive for such a goal they would need some form of motivation to do so. There exists various means for stimulating motivation in people (refer to Fukuda [36] and Jordaan *et al.* [37]) and one way of doing so is through awareness.

This awareness is encouraged by doing the following:

- Disclosing energy KPI's and also explaining possible abnormal deviations to employees.
- The impact certain practices of relevant departments within the plant's organization have on the plant's energy efficiency and ultimately energy cost. For example, this may include energy inefficient maintenance strategies, faulty equipment or even inefficient production schedules.

Turner [16] also lists the following relevant strategies for improved awareness:

- Providing relevant employees with energy management best practices, which are practical and relevant to their working environment within the plant's organization.
- Providing energy conservation opportunity checklists to plant operators, maintenance personnel, supervisors and engineers.

Another motivational tool is recognition. The energy manager should recognize the energy management efforts of employees and also show them the impact their efforts had during the past month.

Lastly, Turner [16] also states that competition may lead to improved performance. Fostering reasonable competition between relevant departments in the plant's organization may inspire employees to work harder in achieving their goals.

5.2. CONTROLING

Controlling is the measurement and correction of performance in order to ensure that objectives and the plans devised in attaining them are being accomplished. Koontz [14] defines three basic steps for control: 1) establishing standards, 2) measuring performance against these standards, and 3) correcting undesired deviations from standards and plans. These steps will now each be defined from an energy management perspective.

5.3. ESTABLISHING ENERGY STANDARDS/NORMS

Previously, energy management key process indicators were defined for the cryogenic air separation plant; those indicators are now utilized in the control function. The standard for each KPI is the theoretical quantity of the measured parameter, i.e. the denominator of each KPI as defined in equations (31), (32) and (33) of chapter 4, is the theoretical system performance and also the standard to which actual system performance is compared. KPI's for the compressor motors are the exception (equations (28) and (29) of chapter 4), in that the denominator in each is based on the original electromechanical efficiency specification.

5.4. PERFORMANCE MEASUREMENT

The KPI's should be trended over time and significant deviations from expected performance must be noted. This must be done on a monthly basis, except for the motor deterioration indicators, which may be assessed according that as stipulated by the maintenance strategy.

To illustrate performance measurement with a practical example, consider the month-end evaluation of one train of the seven-train oxygen plant at Sasol Secunda. This specific train boasts the characteristics listed in table 5.1.

Table 5.1: Characteristic parameters of a train used in its performance measurements.

Parameter	Value	KPI equation (Ch. 4)
1. Motors:		
1.1. Air compressor motor		28
$\eta^{i}_{AC,m}$	98.2%	
$\eta^{c}_{AC,m}$	93.0%	
1.2. Product compressor motor		29
$\eta^{i}_{PC,m}$	97.1%	
$\eta^{c}_{PC,m}$	91.0%	
2. Compressors:		
2.1. Air compressor		31
a	0.0009366	
b	-0.0574043	
c	0.0021501	
d	0.7272151	
2.2. Oxygen compressor		31
a	0.0044099	
b	0.0090275	
c	0.0030923	
d	-0.9017176	
3. ASU:		32
$\eta^{emperical}_{rec,m}$	95.41%	

What follows, will be performance measurement by means of KPI trending after which analysis of each will continue in the next section.

Results for the train's global efficiency indicator is shown in figure 5.1.

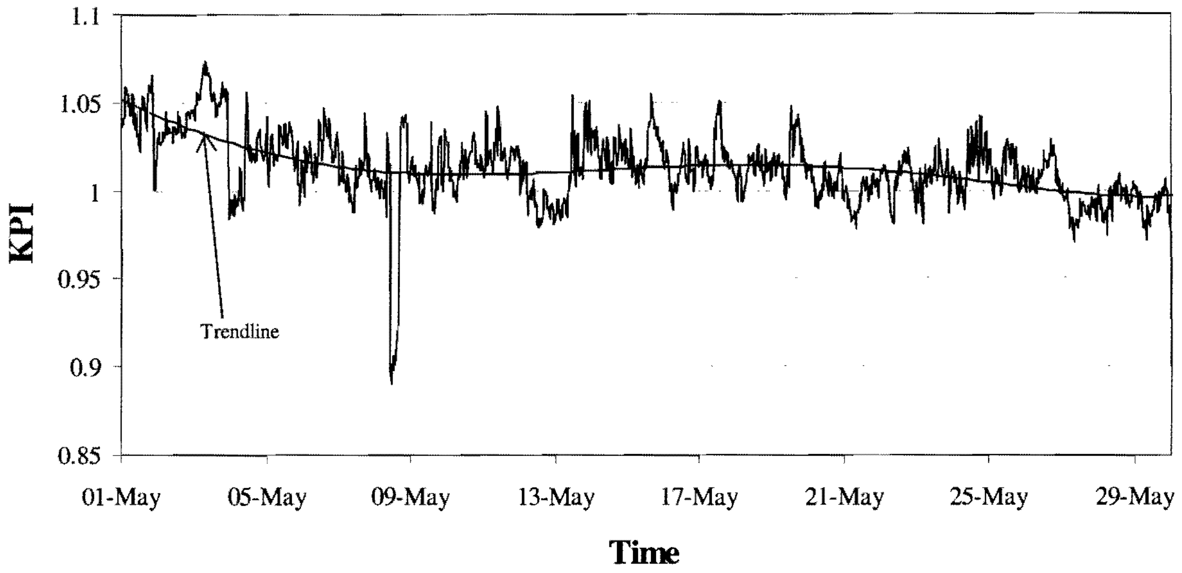

Figure 5.1: KPI trend for the global efficiency indicator.

As implied earlier, the KPI's characterizing each motor's state are not trended over time, instead its given as a single value and are listed in table 5.2.

Table 5.2: KPI values for the air and oxygen compressor motors.

Compressor motor type	**KPI value**
Air	0.949
Oxygen	0.937

Figure 5.2 shows KPI trending for the air compressor.

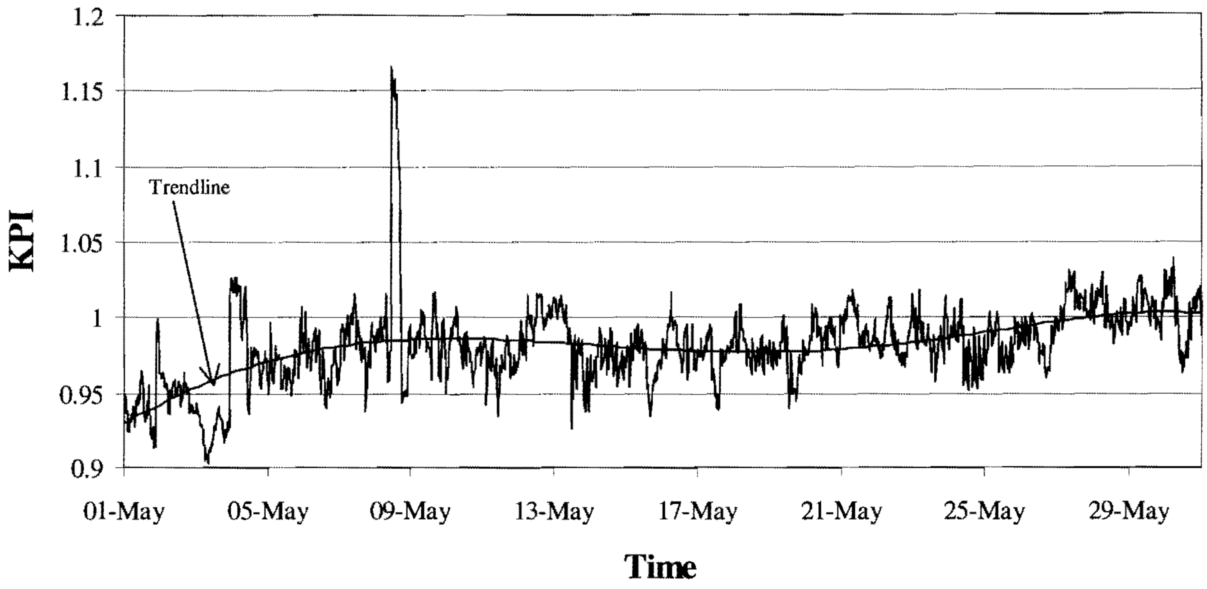

Figure 5.2: KPI trending for the air compressor

The KPI trend for the oxygen compressor is shown in figure 5.3.

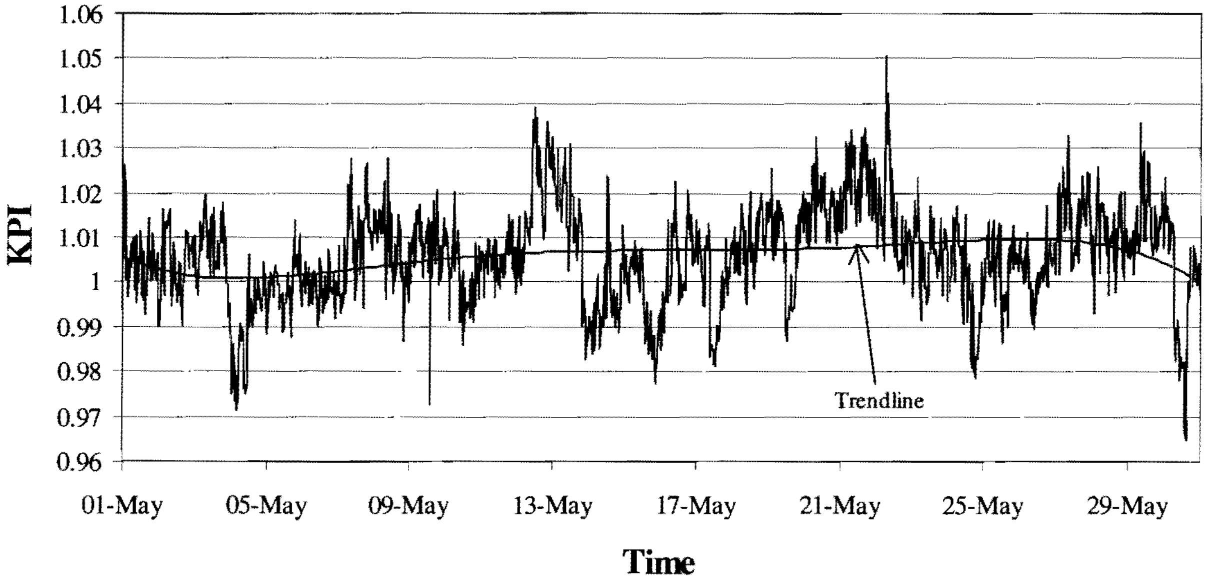

Figure 5.3: KPI trend for the oxygen compressor.

The KPI trend for the air separation unit (ASU) is shown in figure 5.4.

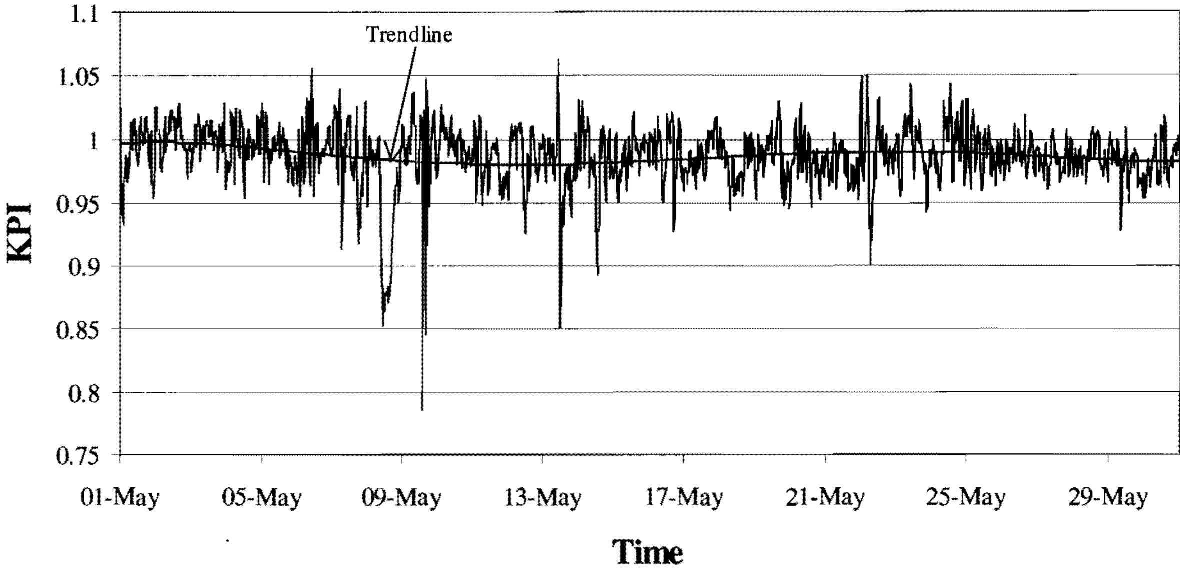

Figure 5.4: KPI trend for the ASU.

Table 5.3 shows the average power loss contribution from each of the major systems. These results were obtained by calculating the average power loss, defined as the difference between actual performance and expected performance (i.e. at KPI equal to unity), during that particular month.

Table 5.3: System inefficiencies quantified in terms of average power loss.

System	**Average power loss**
Air compressor motor	660 *kW*
Oxygen compressor motor	400 *kW*
Total	***1060 kW***
Air compressor	630 *kW*
Oxygen compressor	-70 *kW*
Air separation unit (ASU)	430 *kW*
Total	***990 kW***
Grand total	**2050 kW**

5.5. CORRECTIVE ACTION

Now that system performance have assessed, the energy manager is now in a position to manage equipment inefficiencies and determine whether there has been improvement in those that have been addressed on previous occasions.

5.5.1. Global efficiency indicator

This KPI should be below one, in case of energy efficient train operation, but as can be seen from figure 5.1, it is mostly above unity, implying some form of efficiency loss within the oxygen train.

On 8th May, there was a sudden improvement in the global efficiency indicator and the reason for this will become apparent in the discussion regarding the KPI trend for the air compressor.

It is worth noting from the graph that there seem to be a slight trend downwards up to around 27th May were it stayed on or below unity for the rest of the remaining time; the reason for this is that average ambient temperature decreased as the year approached June, ultimately leading to increased train efficiency. This trend can also be seen in the air compressor graph of figure 5.2 and the fact that the ambient temperature has such a favorable effect on train energy efficiency, its actual performance is disguised somewhat and one can expect that the losses listed in table 5.3 may even be slightly higher during the summer months.

5.4.2. Compressor motors

The fact that these two values are below one (refer to table 5.2), implies that there has been some degradation in motor efficiencies; the air compressor motor is currently about 95% of its original efficiency and that of the oxygen compressor motor is around 94%. Based on this assessment the energy manager may quantify the cost associated with the respective 5% and 6% degradation in motor efficiencies and is now in a position to manage this energy loss.

5.4.2.1. Air compressor motor

All air compressor motors on this plant are rated 37MW and are 2-pole synchronous motors. This air compressor motor's KPI is at 0.949 (table 5.2), which equates to an average power loss of 660 kW. The energy cost associated with this loss combined with current maintenance costs cannot, at this stage, justify buying a new high-efficiency synchronous motor; therefore other corrective actions should be employed in improving the motor's energy efficiency and in this particular case, the following steps will be taken:

- Assessment of partial discharge condition monitoring results, and scheduling an opportunity maintenance action if these results show a degree of partial discharge.
- Schedule an in-situ motor inspection, carried out by the OEM in which the state of the stator and rotor may be determined, minor servicing of the motor may be enabled and recommendations can be made by the OEM.

5.4.2.2. Oxygen compressor motor

All oxygen compressor motors on the plant are 13.7 MW, 4-pole induction machines and for this particular motor its KPI has been evaluated at 0.937, leading to an average power loss of 400 kW (this result takes into account the principles discussed in section 4.4.3.3 and is based on the power saving that would result in upgrading it to its original specifications).

For the oxygen compressor motor, there is much more potential for a replacement action, because of the relatively high energy loss and the fact that maintenance costs for this motor has risen quite dramatically over the past two years. Considering all the related variables, a payback period of 17 years has been calculated when replacing this motor with a new one. Management rules state that business-case approval will only be given to projects with a payback period of 15 years or less, however, KPI monitoring on the other trains revealed that the majority of oxygen compressor motors are in a worse state than the motor from this particular train and by consolidating the project (i.e. recommending replacement of all motors at once instead of just the one), the payback period was calculated at just below 15 years.

5.4.3. Air compressor

On 8th May the actual compressor performance was significantly above that expected (refer to figure 5.2.), the reason for this being that demand at that time required high product flow at high purity, and auxiliary air compressors were put online to supplement this demand; the auxiliary air compressors are unaccounted for in the model, which ultimately manifests in exceptional compressor performance.

Although air compressor performance did improve as the month progressed (gradual decrease in ambient temperature), for the majority of operational time it remained below expected performance. This under-performance resulted in an average power loss of 630 kW (table 5.3) and upon further investigation it was found that routine maintenance was done quite a long way back, and given the poor air quality at Sasol Secunda, a significant amount of compressor fouling was inevitable. Production requirements from production department and low priority assignment from maintenance department resulted in these irregular and, mostly, delayed maintenance intervals. A proper corrective action from the energy manager in this case would be to facilitate a compromise between these two departments by ensuring that consensus have been reached on the scheduling of this maintenance action, and also that this scheduling leads to increased energy efficiency.

5.4.4. Oxygen compressor

Figure 5.3 shows the KPI trend for the oxygen compressor and, as can been seen from this figure, the KPI stayed above unity for the majority of time which implies good compressor operation. This is also manifested in the average power loss for this compressor, which has been calculated at $-70kW$, as listed in table 5.3, implying that the oxygen compressor, overall, operated slightly above expectation.

In general, one can expect that the product compressor's performance, in terms of energy efficiency, should normally be above that of the air compressor because, as opposed to the air compressor, it handles a clean and pure gas and is therefore not as susceptible to compressor fouling, also, in some cases it is less prone to physical damage resulting from large solid particles.

5.4.5. Air separation unit

From figure 5.4 it can be seen that the ASU under-performed for the majority of time, resulting in an average power loss of 430 *kW* (table 5.3). Calculations showed that the average recovery efficiency for this time was 94.17%, which is slightly less than its empirical value (95.41%), meaning the air compressor has to make an added effort for compensating this drop in efficiency.

Production department acknowledged the decrease in recovery efficiency and the problem was identified as damaged distillation trays inside the distillation column. Initiating a maintenance action to repair defective trays in the near future will not be feasible because this would lead to significant production losses. Again, the energy manager has to manage this loss to the minimum. The following actions would do just this:

- Keep monitoring the recovery efficiency and initiate a maintenance action as soon as energy loss could justify this and/or determine the production loss when the air compressor has reached its full capacity and cannot compensate for the recovery efficiency loss anymore, which ever comes first or, should it be it the case, when both conditions have been reached.
- Minimize the loss by sharing a portion of this train's load equally between the more efficient trains at times of low oxygen demand or whenever there is more efficient spare capacity available.

5.5. CONCLUSION

In this chapter the managerial functions of leading and energy management controlling have been discussed.

The managerial function of leading involves, leadership, motivation and communication. Leadership refers to the ability to lead, which involves the process of influencing people so that they will strive willingly and enthusiastically toward the achievement of energy management goals. Motivation is vital in aligning objectives of the individual with that of the energy management program and it is important that the energy manager practice effective motivational techniques. Communication is the process by which information can be received or send. It is a vital skill and an essential activity in the energy management program.

Controlling is one of the functions the energy manager has to perform in order to ensure continuity of an effective energy management program.

Control is necessary in the energy management program, as it brings actual performance in line with desired performance, and based on the discrepancy between these two, the energy manager is in a position to strategize corrective measures. It is important for the energy manager to establish good communication links with the relevant departments within the plant's organization, as they are in a position to provide information relevant in the control phase and are also the stakeholders that need convincing before buying into corrective action strategies.