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Reliability, Maintenance, Energy, Environment

Considerations in Electric Motor Repair vs. Replace Decisions

by Howard W. Penrose, PhD

The concept of Reliability, Maintenance, Energy, and Environment (RME&E™) was developed in the mid 1980s and evolved in the 1990s in a series of programs designed to link production, reliability, energy, waste stream, and environmental impact. The principles reside in the fact that changes in each topic impact each of the other topics to some degree. Through an understanding of these relationships, one can determine how any change can impact a significant portion of the business, either positively and negatively.

In these days of renewed interest in energy conservation and environmental consciousness, we ask ourselves what we can do to have an impact. The work behind RME&E led to the understanding that the Reliability and Maintenance (R&M) function can have the single most significant and cost effective impact on energy and environment, and that each of these efforts is directly related to each other, in addition to their individual impact on capacity and productivity. Through this article, we will introduce you to some of the concepts within RME&E and how they can be used as business decision tools even in something as mundane as motor repair versus replace decisions.

The US Department of Energy (US DOE), and independent researchers, have identified the potential energy cost reduction of at least 14% when a properly implemented condition-based maintenance program is put into place over a primarily reactive program. Note that just because equipment is greased, or data is taken for predictive maintenance, if there is no action, the program is reactive. This is in addition to the maintenance cost improvement of 33% of the comparison between condition based and reactive programs, and the potential capacity improvements of 25% on average.

The relation is interactive, so changes made to each of the elements impact all of the other elements. For instance, if it is determined that compressed air pressure can be dropped in order to reduce air leaks and generally reduce energy, what is the impact on the rest of the system? It may actually improve the system and have a positive impact on production and reliability, or it may have the opposite effect. The results provide the business information necessary to make a positive decision including the benefit of reducing the compressors' carbon footprint as energy can be directly converted to CO_2 and other emissions.

The carbon footprint reduction is converted to the equivalent energy required to produce the electricity, steam, or other forms of energy. For instance, the relationship of 0.606 tons of CO_2 per MWh of electricity is related back to the generation of power and the associated emissions. The US DOE and US Environmental Protection Agency (EPA) publish tables that relate this reduction, based upon region of the country, in order to provide a more accurate comparison.

The Case Study

For the purpose of this case study, we will use a 250 horsepower, 1800 RPM, 96.1 percent efficient motor operating 6,000 hours per year at a 75% constant load. The energy cost will be estimated at $0.08/kWh and we will use the USA national average of 0.606 tons of CO_2 per MWh (Mega-Watt hour). We will assume the motor has been operating for some time and then has a winding failure. The decision is now whether to use a low-cost repair shop that operates without a uniform quality control program or a higher-cost repair shop that includes a uniform quality control program and a motor repair specification is provided. In both cases, we will use the results of the Canadian Electrical Association 1994 independent study on motor repair, as well as the 1991 through 1993 BC Hydro and Ontario Hydro studies to demonstrate the difference between the impact of a quality repair and the low-cost repair. In the actual studies that were presented in the Uptime articles on motor repair earlier this year, the average was 1.1% reduction in efficiency per repair. For this article, we are going to round that to 1% for ease of demonstration, for a low-cost shop, and 0% reduction for the quality repair shop. The rewind cost is considered to be $1,950 for the low-cost shop and $2,825 for the quality repair shop.

Based upon experience, we will assume that the quality repair survives intact over a ten year period before bearing replacement is required and that the lower-cost repair is rewound two additional times, one after four years and one after three years, by the same facility. The first step is to calculate the impact of the changes to efficiency in which the quality repair is assumed to continue to work as normal, with the efficiency remaining at 96.1%. The annual energy cost will then be $69,864 and the annual CO2 footprint will be 529 tons per year.

$$MWh = (horsepower/efficiency) * 0.000746MW/hp * load * hours/year$$

Equation 1: MWh/year Energy Consumption

Example 1: Annual Quality Repair Energy Consumption Overall

$$(250hp/0.961eff) * 0.000746MW/hp * 0.75 load * 6{,}000 hrs/yr = 873.3 MWh/yr$$

$$\$Energy/year = MWh/yr * 1000kW/MW * \$Cost/kWh$$

Equation 2- Annual Energy Cost from MWh/year

Example 2: Annual Quality Repair Energy Cost Overall

$$873.3 MWh/yr * 1000kW/MW * \$0.08/kWh = \$69{,}864/yr$$

$$Annual\ CO2\ Emissions = MWh/yr * 0.606\ tons\ CO2/MWh$$

Equation 3 - Annual CO2 Emmissions from MWh/year

Example 3: Annual CO2 Emissions from MWh/year

$$873.3 MWh/yr * 0.606 tons CO2/yr = 529 tons CO2/yr$$

For the purpose of this article, we are not including the production impacts associated, as well as many other cause and effect issues. However, once we place the information on the quality repair and the low-cost repair into Table 1, the impact across ten years can be readily seen.

In the first repair period, the differences are:

- Repair: $875
- Energy Cost: $735/yr
- Carbon Footprint: 6 tons/yr CO2

	QualityRepair			Low Cost Repair		
Year	MWh/yr	$ / yr	Tons CO2	MWh/yr	$ / yr	Tons CO2
1	873	69,865	529	882	70,600	535
2	873	69,865	529	882	70,600	535
3	873	69,865	529	882	70,600	535
4	873	69,865	529	882	70,600	535
5	873	69,865	529	882	71,350	540
6	873	69,865	529	882	71,350	540
7	873	69,865	529	882	71,350	540
8	873	69,865	529	901	72,116	546
9	873	69,865	529	901	72,116	546
10	873	69,865	529	901	72,116	546
Totals	**8,703**	**$698,650**	**5,290**	**8,907**	**$712,798**	**5,398**

Table 1 - Energy and Carbon Footprint Information Comparison

The result is a 14 month simple payback using the quality repair approach in the first rewind, coupled with 6 ton carbon footprint avoidance. In effect, the use of the low-cost repair facility increases your carbon footprint.

In the second repair period, the differences are:

- Repair: $1,950 (the quality repair does not require rewind)
- Energy Cost: $1,485/yr
- Carbon Footprint: 11 tons/yr CO2

At this point it is found that there is a 0 month simple payback and avoidance of 11 tons of CO2 per year.

In the final repair period, the differences are:

- Repair: $1,950 (same as the second period)
- Energy Cost: $2,251/yr
- Carbon Footprint: 17 tons/yr CO2

As is the case with the second repair period, there is a 0 month simple payback coupled with an avoidance of 17 tons CO2 per year.

Across the full ten year period of the comparison, if the company makes the choice to go after the initial cost, the total increase in repair costs would actually be $3,025 more than the quality repair. In addition, the energy costs would be $14,148 more, there would be an additional 108 tons of CO2 released and, when compared, the result is actually a 2.6 month payback associated with the quality repair across the period.

Conclusion

In these days of environmental and energy consciousness, the relationship between the elements of reliability, maintenance, energy, environment, production, and waste stream become far more apparent and important. Through the principles of RME&E, better business decisions can be made by having an understanding of the impact on the company overall. In this article, we have provided a peek at the potential power of such a decision making process that can be applied to any aspect of the business.

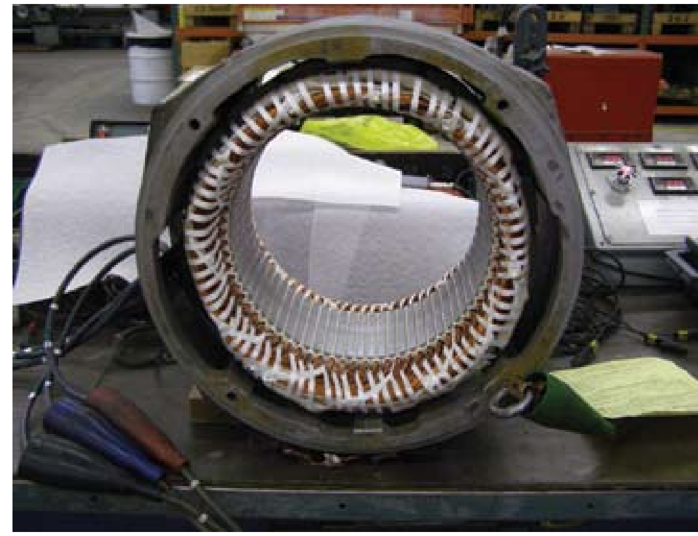

Figure 1 - A High-Quality Repair/Rewind is a better investment than a lower quality rewind/repair, which is often chosen based on price alone.

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