# AR ${AR}: Install Variable Frequency Drive on Electric Motor

**Recommended Action**

Install a variable frequency drive on electric motors that are running on partial load.

**Summary of Estimated Savings and Implementation Cost**

|  |  |
| --- | --- |
| Annual Cost Savings | ${TCS} |
| Implementation Cost | ${MIC} |
| Payback Period | ${PB} |
| Annual Electricity Savings | ${ES} kWh |
| Annual Demand Savings | ${DS} kW |
| ARC Number | 2.4144.1 |

**Current Practice and Observations**

In many commercial and industrial environments, the application of variable speed control is cost effective. Energy savings results from reduced power consumption by the motor. As the system power requirements are reduced, the power consumed by the equipment can be reduced by an amount significantly greater than can be achieved with the existing controls. During the visit it was identified that the motor running the ${MT} operation is a good candidate for a VFD based on partial load throughout the production cycle.

**Anticipated Savings**

The affinity laws estimate that the change in power on the motor varies as the cube of the speed of the motor, or flow, as follows:

This relationship is used to estimate the energy use of a given motor with a variable frequency drive. The table below shows the relative power consumption of a motor using VFD control, compared to a motor with standard controls[[1]](#footnote-1). Notice that the affinity laws are not exactly followed for VFD power consumption. This is a result of losses incurred by the variable frequency drive, which reduces the motor’s efficiency. Therefore, with VFD control, as the flow rate decreases the VFD/motor system efficiency decreases. Consequently, the actual power consumption is higher than the theoretical power consumption estimated by the affinity laws with more deviation at lower flow rates. More accurate power consumption estimates can be obtained for varying flows, if pump or fan curves from the manufacturers are available.

|  |  |  |
| --- | --- | --- |
| **Load**  **%** | **Power Consumption of Motor** | |
| **No Control**  **%** | **VFD**  **%** |
| 100 | 100 | 105 |
| 95 | 100 | 86 |
| 90 | 100 | 73 |
| 85 | 100 | 64 |
| 80 | 100 | 57 |
| 75 | 100 | 50 |
| 70 | 100 | 44 |
| 65 | 100 | 38 |
| 60 | 100 | 32 |
| 55 | 100 | 26 |
| 50 | 100 | 21 |
| 45 | 100 | 17 |
| 40 | 100 | 14 |
| 35 | 100 | 11 |
| 30 | 100 | 8 |
| 25 | 100 | 6 |
| 20 | 100 | 5 |

Table 1: Power Consumption of Motor with RPM.

The annual energy savings, ES, and corresponding cost savings, ECS, can be calculated as follows:

ES = CEU - PEU

where

CEU = Current time weighted energy consumption for a given motor; kWh

PEU = Projected time weighted energy consumption for a given motor; kWh.

The current energy consumption, CEU, and proposed energy consumption, PEU, can be estimated as follows:

CEU =

and

PEU =

where

HP = Horsepower of motor; ${HP} HP

OHE = Existing operating hours of motor; ${OHE} hrs/yr

OHP = Proposed operating hours of motor; ${OHP} hrs/yr

C­1 = Conversion constant; 0.746 kW/HP

LF = Load factor, fraction of power consumption of motor without VFD; ${LF}%

FR = Power consumption of motor with VFD, at average load ${FR}%;

= ${FRT}% (from table)

= Existing efficiency of motor; ${EX}%

= Proposed efficiency of motor with VFD; ${PR}%

For this calculation, it is assumed that the motor will run during 100 percent of its operating hours.

CEU = ${CEUEqn}

= ${CDU} kW× ${OHE} hrs/yr

= ${CEU} kWh/yr

PEU = ${PEUEqn}

= ${PDU} kW × ${OHP} hrs/yr

= ${PEU} kWh/yr

ES = ${CEU} kWh/yr − ${PEU} kWh/yr

= ${ES} kWh/yr.

The annual demand savings, DS, for a given piece of equipment can be estimated as follows:

DS = (${CDU} kW − ${PDU} kW) × C2 × CF

where

C2 = Conversion constant; 12 months/yr

CF = Coincidence factor – probability that the equipment contributes to the facility peak demand each month; 100%

DS= ${DUD} kW × 12 mo/yr × 100%

= ${DS} kW/yr.

The total cost savings, TCS, is:

TCS **=** ECS + DCS

= ${ES} kWh/yr × ${EC}/kWh + ${DS} kW/yr × ${DC}/kW

= ${ECS}/yr + ${DCS}/yr.

= ${TCS}/yr.

**Implementation Cost**

The cost for a ${HP} HP VFD system is estimated at ${NC}, with an additional ${EIC} in installation costs. Therefore, total cost for this recommendation is estimated at ${IC}. The plant could contact a contractor for a more accurate price for the VFD and installation.

Rebates are available for switching to VFD in a manufacturing environment (see appendix). The estimated rebate is:

RB = ${RR}/kWh × ES

= ${RR}/ kWh × ${ES} kWh/yr

= ${RB}

And the modified implementation cost, MIC, is:

MIC = IC – RB (Note: Rebate can’t exceed 50% of project cost)

= ${MIC}

**The total annual electricity savings for this AR is ${ES} kWh, and the annual demand savings is ${DS} kW/yr. The annual cost savings is likely to be ${TCS} and, with an implementation cost of ${MIC}, the payback period is about ${PB}.**

**Implementation Cost References**

The below links are for implementation cost references. We do not endorse/recommend these brands or products. Furthermore, these products may or may not be suitable for the application. The client should contact a vendor(s) to conduct a detailed study of the process, in order to determine the best product for the recommended application.

* <https://www.driveswarehouse.com/P1-00930-HFUF>
* <https://www.wolfautomation.com/products/ac-drives/40_hp/>
* <https://vfds.com/40hp-50hp-460v-weg-vfd-cfw090060tgz>

1. Electric Power Research Institute, Adjustable Speed Drives Directory, Table 3.1, p. 18, 1991. [↑](#footnote-ref-1)