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Energy Use, Energy Savings and Environmental Analysis of Industrial Boilers and Compressors

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Abstract

In this paper energy use , energy and bill savings, emission reduction and pay period using high efficient motor, variable speed drive by modulating speed of boiler and compressor has been estimated using energy audit data. It has been found that 68,923 MWh, 132,922 MWh, 78,769 MWh and 49,230 MWh of energy can be saved for 40%, 60%, 80% and 100% motor loadings, respectively for 20% speed reduction in the boiler system. Corresponding bill savings for the aforementioned energy savings have been found to be US$ 4,411,052, US$ 8,507,028, US$ 5,041,202, and US$ 43,150,751 for 40%, 60%, 80% and 100% motor loadings, respectively for 20% speed reduction in the boiler system. Energy savings and bill savings resulting from the use of high-efficiency motor in air compressor are 6703 MWh, 8251 MWh, and 10571 MWh, total energy, can be saved for 50%, 75%, and 100%, motor loadings, respectively. Similarly, bill savings for the preceding amounts of energy savings are US$ 428,984, US$ 528,042 and US$ 676,538, respectively. It is also clear that the use of high efficiency motor and VSDs leads to substantial energy savings and an enormous reduction in emissions.

Keywords: *Energy, Energy savings, Environment, Boiler, Compressor.*

1. Introduction

Energy efficiency improvement is one of the most important functions to reduce energy cost as well as production cost in the industries. Energy efficiency improvement is the main objective of many national energy policies. Monitoring of the energy consumption and developments in energy efficiency is necessary in order to check and apply desired policies. Energy is the most important sector for automation and modernization. Automation and modernization is increasing rapidly day by day in the industrial sectors. Steam and compress air systems are a part of almost every major industrial process today. All of the major industrial energy users devote significant proportions of their fossil fuel consumption to steam production: food processing (57%), pulp and paper (81%), chemicals (42%), petroleum refining (23%), and primary metals (10%). Since industrial systems are very diverse, but often have major steam systems in common, it makes a useful target for energy efficiency measures [1]. Nearly 45% of global electricity generation is derived from coal while natural gas and nuclear energy makes up about 20% and 15% respectively of the world's generated electricity [2]. Most heating systems, although not all, employ boilers to produce hot water or steam. Boiler efficiency therefore has an important influence on heating-related energy savings. The energy savings that can be achieved by improving overall boiler efficiency can be substantial. Essentially a boiler is a device in which a fossil fuel is burnt and the heat produced is transferred to water. Heat can be lost from boilers by a variety of methods, including flue gas losses, radiation losses and, in the case of steam boilers, blow-down losses [3]. To optimize the operation of a boiler plant, it is necessary to identify where energy wastage is likely to occur. A significant amount of energy is lost through flue gases as all the heat produced by the burning fuel cannot be transferred to water or steam in the boiler. The efficiency of boiler is a measure of the ability of it to generate the steam demand from a given fuel supply. Boiler efficiency is very dependent on the excess air rate. Excess air should be kept at the lowest practical level to reduce the quantity of unneeded air that is heated and exhausted at the stack temperature [4]. Most of the heat losses from the boiler appear as heat in the flue gas, the recovery of this heat can result in substantial energy savings [5, 6].This indicates that there is huge savings potentials of a boiler energy savings by minimizing its losses. By introducing variable speed to the driven load, it is possible to optimize the efficiency of the entire system, and it is in this area that the greatest efficiency gains are possible [7, 8]. Use of compressed air in industry and in service sectors is common as its production and handling are safe and easy. In most industrial facilities, compressed air is necessary to manufacturing. Compressed-air generation is energy intensive, and for most industrial operations, energy cost fraction of compressed air is significant compared with overall energy costs. There is a vacuum of reliable information

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on the energy efficiency of a typical compressed air system [9,10]. As a general rule, compressed air should be used only if safety enhancements, significant productivity gains, or labour reduction, will result as it is very expensive. Annual operating costs of air compressors, dryers, and supporting equipment, can account from 70% to 90% [11] of the total electric bill. Energy losses in a large number of industries exist, and there is evident potential for energy efficiency improvements [12]. Among the various sectors contributing to greenhouse gas emissions, the contribution of the industrial sector was significant. Thus, lowering GHG emissions from the industrial sector offers the means of reducing overall GHG emissions. Energy conservation means less reliance on energy imports and, thus, less GHG emissions. Previous studies have reported that implementing a few select options at little or no cost in the industrial sector could reduce GHG emissions by 10-30% of GHG emissions [13].

The aim of the paper is to the details estimation of boiler and compressor motor energy use, energy savings and environmental analysis using VSD and high efficiency motor. It is expected that the estimation will be very useful for industry, policy makers, energy users and researchers.

2. Excess Air Control

A boiler should always be supplied with more combustion air than theoretically required in order to ensure complete combustion and safe operation. At the same time, boiler efficiency is very dependent on the excess air rate. Therefore, the excess air should be optimized to increase the system efficiency. Qureshi and Tassou [14] reviewed the VSD in refrigeration application to reduce energy uses that is shown in Figure 1.

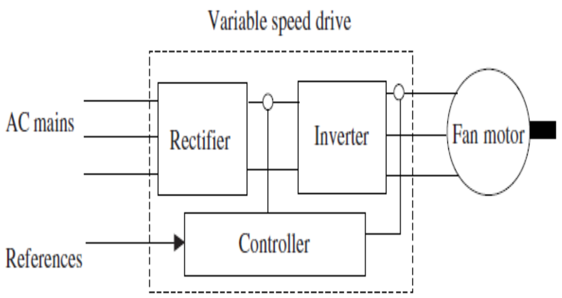

Fig. 1 Block diagram of the variable speed drive system [4]

Combustion efficiency can be improved at low fire if the fan speed is reduced. The fan motor speed control is an easy to add option on some electronic controls. The benefit of variable speed drive by using an inverter to slow down an AC electric motor causes electrical energy saving. Electric motors are over 90% efficient when running at their rated loads. Conventional electric motors typically use 60% to 80% of their rated input energy, even when running at less than 50% load [15].

3. Methodology

3.1. Data Collection for Boiler

Malaysian Energy Centre (MEC) conducted energy audit for 48 industrial facilities for about 2 years starting from 2002-2004 [16]. It was a detailed energy audit. Summary of type and number of industry visited is shown in Table 1. Number of fan motor and their corresponding power, motor loadings, and usage hours are presented in Tables 2-3. These are the data needed for boiler fan motor energy analysis.

Table 1 Types and number of audited industry

Industry	No
Food	10
Wood	7
Ceramic	6
Cement	3
Glass	3
Rubber	9
Pulp and paper	6
Iron and steel	4
Total	48

Table 2 Boiler operating time with its loading

Boiler loading	Operating hours/yr
100%	720
80%	1440
60%	3240
40%	2520

Table 3 Input data for motor energy analysis

Motor power (kW)	Quantity
11	50
15	66
19	21
22	15
30	17
37	9
45	5
56	3

3.2 Data collection for air compressor

Data were collected in a walkthrough energy audit. The reference [17] contains details of the energy audit. The most important data collected during the walkthrough audit were the power ratings, the operation times of energy-using equipment/machinery, fossil fuel and other sources used for energy, production figures, tariff usage behavior (peak and off-peak), and power factor. Table 4 shows the number of factories audited in a sector. Table 5 presents the total energy used by compressed-air systems that is about 239,450 MWh energy.

3.2. Energy Use of Compressed-Air Systems

Annual energy usage by compressed-air systems can be estimated using Equation (1) [18].

$$AEU = hp \times L \times 0.746 \times hr \qquad (1)$$

Table 4 Number of audited industrial sector [17]

Sectors	Number of audited factories
Food products	9
Wood and wood products	8
Paper and paper products	13
Chemicals	4
Petroleum refineries	5
Rubber and rubber products	13
Plastic and plastic products	7
Glass and glass products	4
Iron and steel	5
Fabricated metal products	12
Cement	6
Total	**91**

Table 5 Compressed-air energy used in audited industries

Motor Power (HP)	Quantity	Annual energy use (MWh)
0.25	754	506
0.5	432	580
0.75	543	1,094
1	893	2,398
1.5	231	931
2	432	2,320
3	671	5,406
4	5321	57,160
5.5	112	1,654
7.5	135	2,719
15	132	5,317
20	765	41,090
25	321	21,552
30	153	12,327
40	236	25,352
50	137	18,396
60	231	37,222
75	17	3,424
Total energy use (MWh)		**239,450**

3.3. Energy Savings by Using a High-Efficiency Motor

A high-efficiency motor uses low-loss materials to reduce core, and copper, losses. Reduced losses mean that an energy-efficient motor produces a given amount of work with less energy input than that required by a standard motor. Several leading electric-motor manufacturers, mainly in USA and Europe, have developed product lines of energy-efficient electric motors that are 2-8% more efficient than the standard motors are [19].

The ratio of the mechanical power supplied by the motor to the electrical power used during operation is the motor's efficiency. High-efficiency motors cost less to operate than do their standard counterparts. Motor efficiencies range from about 70 to over 96% at full-load rated power [19]. Annual energy savings through replacement of standard efficient motors with highly energy-efficient motors can be estimated by using the methodology described in reference [17]:

$$AES = hp \times L \times 0.746 \times hr \times \left[\frac{1}{E_{std}} - \frac{1}{E_{ee}} \right] \times 100 \qquad (2)$$

Annual bill savings associated with the above energy savings can be calculated as:

$$Savings = AES \times c \qquad (3)$$

Table 6 shows the typical input data needed for electric-motor energy-saving estimation. Table 7 shows the efficiencies of various-capacity motors, against various loads.

Table 6 Input data for motor's energy savings

Parameters	Value
Average usage hours	6000
Average electricity cost (US$/kWh)	0.064

Table 7 Efficiencies of standard, and high-efficiency, motors, against various loads [17]

HP	Incremental cost (US$)	Load (50%)		Load (75%)		Load (100%)	
		E_{std}	E_{ee}	E_{std}	E_{ee}	E_{std}	E_{ee}
1	21	70.05	75.28	74.43	79.49	77.00	80.97
1.5	25	76.04	80.06	78.03	81.28	78.50	82.55
2	27	77.20	80.02	79.29	83.07	81.00	83.55
3	60	77.78	82.44	79.87	84.55	81.50	85.01
4	61	81.07	83.69	82.39	85.24	82.90	85.96
5.5	68	81.15	84.35	84.73	86.50	85.30	87.75
7.5	91	84.07	85.51	86.23	87.58	86.61	89.50
15	100	84.92	88.32	86.45	89.85	87.94	90.44
20	111	86.03	88.51	87.58	91.05	88.95	91.64
25	186	87.61	90.26	88.39	91.66	89.50	91.80
30	273	88.43	90.89	89.32	91.73	90.70	91.83
40	371	88.15	90.39	90.54	91.91	90.36	92.85
50	678	89.63	91.16	89.86	92.58	92.06	93.28
60	887	87.89	90.07	91.31	92.09	91.78	93.00
75	1172	88.77	90.86	90.19	92.72	92.44	93.02

3.4. Motor's Energy Savings through Variable Speed Drive

Most of the systems operate at their full load only for short periods. The most common method is the modulation of speed, of the motors, of pumps, compressors, and fans, to vary their capacity by using VSDs [17]. Variable-frequency drives provide continuous control, matching motor speed to the specific demands of the work being performed. Variable-frequency drives are an excellent choice for adjustable-speed-drive users because they allow operators to fine-tune processes while reducing costs of energy and of equipment maintenance. It is very important to select an electric motor of suitable power to work efficiently. In general, big-capacity motors are chosen to meet extra-load demands. Usually, motors operate more efficiently at 75% or more of rated load. Many ways can be used to estimate the energy savings from use of VSD in industrial motors for various applications [20]. A motor's energy savings through VSD can be estimated as:

$$ES_{VSD} = n \times P \times H_{avg\_usage} \times S_{SR} \tag{4}$$

Table 8 shows the potential energy savings from speed reduction, through use of VSD in industrial motors. These data can be been used to estimate a motor's energy savings through use of VSD.

Table 8 Potential savings from VSD [17]

Average speed reduction (%)	Potential energy savings (%)
20	44
40	73
60	89

3.5. Mathematical Formulations of Payback Period

Payback period is the simplest method of looking at one or more investment projects or ideas. Payback period represents the amount of time that it takes for a capital budgeting project to recover its incremental price. A simple payback period for different energy savings strategies can be calculated using Equation (5).

$$\text{Payback period} = \frac{\text{Incremental cost}}{\text{Annual dollar savings}} \tag{5}$$

3.6 Emissions Mitigation

The environmental impact of the standard is the potential reduction of greenhouse gasses or other elements that cause negative impact on environment. The common emission pollutants that can be reduced are carbon dioxide, sulfur dioxide, nitrogen oxide and carbon monoxide. The impact can be considered a benefit for the society as well. Potential emissions mitigation by standard can be calculated using the following equation [21]

$$ER_i^a = ES_i^a \times (PE_i^1 \times Em_p^1 + PE_i^2 \times Em_p^2 + ... + PE_i^n \times Em_p^n) \tag{6}$$

Table 9 shows emission factors for per-unit energy that can be used to estimate reducible emission.

Table 9 Emission factors of fossil fuels for electricity generation [21]

Fuels	Emission factor (kg/kWh)			
	CO_2	SO_2	NO_x	CO
Coal	1.18	0.0139	0.0052	0.0002
Petroleum	0.85	0.0164	0.0025	0.0002
Gas	0.53	0.0005	0.0009	0.0005
Hydro	0.00	0.000	0.0000	0.0000
others	0.00	0.000	0.0000	0.0000

4. Result and Discussion

4.1. Energy Savings, Payback Periods and Emission Reductions of Boiler

Energy use by boiler fan motor for different capacities and percentage of loadings has been estimated and presented in Figure 2. Based on this figure it has been observed that more energy used by boiler fan motors for 60% loading followed by 40% as motors are engaged in operation for longer time compared to 80% and 100% loadings. It was also found that highest amount of energy used by 15 kW motor for different percentage of loadings as number of motors are higher than other capacities of motors.

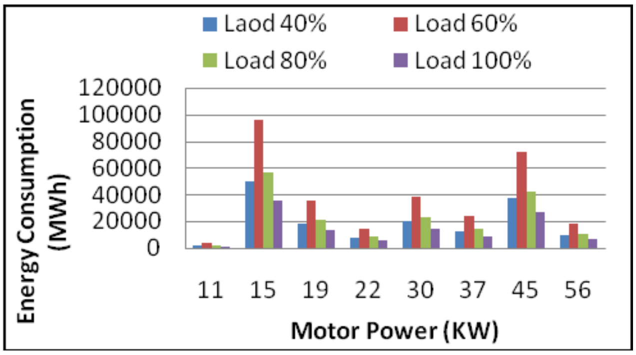

Figure 2 Energy used by different capacity and motor loadings

Table 9 summarises the cumilative amount of energy and bill that can be saved for different percentage of speed reduction and motor loadings. Payback period for energy savings associated with different percentage of speed reductions has been estimated and presented in Table 11. Emission reduction has been estimated and shown in Table 12. The energy savings and bill savings is shown that it is a protential energy and bill savings option as well as emission reduction. The payback period also economically viable and it is more economical for the high capacity motor.

4.2 Energy Savings, Payback Periods and Emission Reductions of Air Compressor

Table 13 presents, for various motor sizes and loads, the energy savings, bill savings, and payback periods resulting from the use of high-efficiency motor. Based on this table and data analysis, 6703 MWh, 8251 MWh, and 10571 MWh, total energy, can be saved by using energy-efficient motors, for 50%, 75%, and 100%, motor loadings, respectively. Similarly, bill savings for the preceding amounts of energy savings are US$428,984, US$528,042 and US$676,538, respectively.
The payback periods when energy-efficient motors were used range from 0.82 to 11.11 years, for various percentages of motor loadings. The periods indicate the cost-effectiveness of energy-efficient motors, as in most cases their payback periods are less than one third of the motor's life (if an average life of 20 years is considered). Installing high efficiency motors in compressor systems reduce annual energy consumption by 2%, with a payback period of less than 3 years [22]. Tables 14 show energy savings, bill savings, and payback periods for various percentages of motor-speed reductions through VSD. Table 14 shows how huge amounts of energy could be saved for various

percentages of speed reductions. More energy could be saved for higher speed reductions. Along with energy savings, huge amounts could be saved off electricity bill, and associated emission reductions could be achieved through use of VSD in industrial motors in Malaysia. Implementing adjustable speed drives in rotary compressor systems can save 15% of the annual energy consumption [22]. From Table 14, payback periods for larger motors at higher speed reductions (i.e. speed reduction above 30%) are found to be economically viable as the payback periods are short. However, VSD is not cost effective for smaller motors as their payback period is significantly high. Abbott [23] reported that payback periods for VSDs of various motor sizes and categories range from 0.4 years to 1.5 years. From Table 15, it is found that huge amount of emission cab be saved by using variable speed drive. It is also found that more the speed reduction more emission reduction.

5. Conclusion

It has been found that maximum amount of energy can be saved for 60% of motor fan speed reduction for 60% motor loading using VSD in boiler. However, it was also found that sizeable amount of energy and bill can be saved for 20% and 40% speed reduction for different loadings. It was found that payback period for using VSD to save fan motor energy to be 0.23 to 5.58 years. It may be stated that use of VSD in fan motor energy saving is economically very viable for motor capacities 15kW and above. Study also found that 69,770,744 kg, 134,558,329 kg, 79,738,065 kg, 49,836,603 kg of CO_2 emission can be avoided for the associated energy savings as a result of energy savings using VSD for 40%, 60%, 80% and 100% motor loadings. In the compress air sytem, based on data analysis, 6703 MWh, 8251 MWh, and 10571 MWh energy can be saved by using energy-efficient motors, for 50%, 75%, and 100%, motor loadings where the bill savings US$ 428,984, US$ 528,042 and US$ 676,538, respectively. It has been found that 52,679 MWh of energy can be saved for 10% speed reduction using VSDs whereas 213,111 MWh energy can be saved for 60% speed reduction. So, it can be concluded that more energy could be saved for higher speed reductions. Along with energy savings, huge amounts could be saved off electricity bill, and associated emission reductions could be achieved through use of VSD in industrial motors in Malaysia.

Nomenclature

AEU = Annual energy consumption (MWh)

AES = Annual energy savings (MWh)

c = Average energy cost (RM/kWh)

C^a = Capacity of equipment (kW)

E_{ee} = Energy efficient motor (%)

EM_i = Total amount of emission (ton)

EM_p^n = Fossil fuel emission for a unit of electricity generation of fuel type *n* (ton)

EP_i = Electricity production in the year *i* (GWh)

E_{srd} = Standard efficiency motor (%)

ES_{VSD} =Energy saving with the application of VSD

H_{avg_uage} = average usage hour (hr)

hp = Motor rated horsepower (hp)

hr = Annual operating hour (hr)

L = Load factor (either 50%, 75% or full load)

n = Number of motor

P = Power factor

PE_i^n = Percentage of electricity generation in a year *i* of fuel type *n* recommended

S_{SR} = Percentage energy savings associated with speed reduction

Table 10 Cumilative energy and bill savings for different percentage of speed reductions and motor loadings

Speed reduction (%)	Energy savings (MWh)				Bill savings (US$)			
	Load 40%	Load 60%	Load 80%	Load 100%	Load 40%	Load 60%	Load 80%	Load 100%
20	68,923	132,922	78,769	49,230	4,411,052	8,507,028	5,041,202	3,150,751
40	114,349	220,530	130,685	2,123,624	7,318,335	14,113,933	8,363,812	135,911,944
60	139,412	268,866	159,328	99,580	8,922,354	17,207,397	10,196,976	6,373,110

Table 11 Payback period for different percentage of speed reductions using VSDs

Motor power (kW)	For 20% speed reduction				For 40% speed reduction				For 60% speed reduction			
	Load 40%	Load 60%	Load 80%	Load 100%	Load 40%	Load 60%	Load 80%	Load 100%	Load 40%	Load 60%	Load 80%	Load 100%
11	3.98	2.07	3.49	5.58	2.40	1.25	2.10	0.13	1.97	1.02	1.72	2.76
15	0.25	0.13	0.22	0.35	0.15	0.08	0.13	0.01	0.12	0.06	0.11	0.17
19	0.24	0.13	0.21	0.34	0.15	0.08	0.13	0.01	0.12	0.06	0.11	0.17
22	0.49	0.25	0.43	0.68	0.29	0.15	0.26	0.02	0.24	0.13	0.21	0.34
30	0.26	0.14	0.23	0.37	0.16	0.08	0.14	0.01	0.13	0.07	0.11	0.18
37	0.27	0.14	0.23	0.37	0.16	0.08	0.14	0.01	0.13	0.07	0.12	0.18
45	0.06	0.03	0.05	0.08	0.03	0.02	0.03	0.00	0.03	0.01	0.02	0.04
52	0.16	0.09	0.14	0.23	0.10	0.05	0.09	0.01	0.08	0.04	0.07	0.11

Table 12 Emission reduction (tons) for 40% speed reduction

HP	Incre-mental Price (US$)	Energy savings (MWh)			Bill savings (US$/year)			Payback period (year)		
		Load 50 %	Load 75 %	Load 100 %	Load 50 %	Load 75 %	Load 100 %	Load 50 %	Load 75 %	Load 100 %
1	21	198	256	255	12,686	16,408	16,290	1.51	1.17	1.18
1.5	25	51	60	97	3,277	3,815	6,204	1.74	1.49	0.92
2	27	88	166	146	5,649	10,653	9,326	2.04	1.08	1.24
3	60	327	468	456	20,953	29,971	29,213	1.92	1.34	1.37
4	61	1,840	2,899	4,091	117,735	185,565	261,809	2.77	1.76	1.25
5.5	68	59	45	76	3,750	2,906	4,854	2.03	2.62	1.57
7.5	91	45	61	123	2,905	3,890	7,854	4.24	3.16	1.57
15	100	149	141	145	9,554	9,041	9,260	1.38	1.45	1.42
20	111	1,164	1,111	1,614	74,504	71,126	103,316	1.14	1.19	0.82
25	186	468	712	948	29,950	45,587	60,690	1.99	1.31	0.98
30	273	59	221	279	3,761	14,132	17,843	11.11	2.96	2.34
40	371	594	787	1,254	38,008	50,339	80,261	2.30	1.74	1.09
50	678	596	566	310	38,132	36,226	19,868	2.44	2.56	4.68
60	887	928	626	676	59,424	40,051	43,277	3.45	5.12	4.73
75	1172	136	130	101	8,699	8,332	6,471	2.29	2.39	3.08

Table 13 Energy savings and payback periods for high-efficiency motor

HP	For 40% Load				For 60% Load				For 80% Load				For 100% Load			
	CO_2	SO_2	NO_x	CO	CO_2	SO_2	NO_x	CO	CO_2	SO_2	NO_x	CO	CO_2	SO_2	NO_x	CO
11	680	4	2	0	1311	8	4	1	777	5	2	0	12627	76	36	8
15	18,165	109	51	11	35,032	210	99	21	20,760	124	59	13	33,7347	2019	951	205
19	6813	41	19	4	13,140	79	37	8	7786	47	22	5	12,6531	757	357	77
22	2728	16	8	2	5261	31	15	3	3118	19	9	2	50,663	303	143	31
30	7264	43	20	4	14,009	84	40	9	8301	50	23	5	134,898	808	380	82
37	4547	27	13	3	8769	52	25	5	5196	31	15	3	84,439	505	238	51
45	13,632	82	38	8	26,290	157	74	16	15,579	93	44	9	253,163	1515	714	154
52	3400	20	10	2	6557	39	18	4	3886	23	11	2	63,138	378	178	38

Table 14 Motor's energy savings through VSD, for various speed-reduction percentages

HP	Energy savings (MWh/year)			Bill savings (USD/year)			Payback period (year)		
	20%	40%	60%	20%	40%	60%	20%	40%	60%
1	1,055	1,751	2,134	67,534	112,046	136,604	56.0	33.7	27.7
1.5	409	679	828	26,205	43,476	53,005	39.0	23.5	19.3
2	1,021	1,694	2,065	65,341	108,407	132,168	30.6	18.4	15.1
3	2,379	3,946	4,811	152,236	252,574	307,932	22.0	13.3	10.9
4	25,151	41,727	50,873	1,609,634	2,670,530	3,255,851	17.8	10.7	8.8
5.5	728	1,208	1,472	46,586	77,290	94,231	14.3	8.6	7.1
7.5	1,196	1,985	2,420	76,572	127,040	154,884	11.8	7.1	5.8
15	2,340	3,882	4,733	149,740	248,433	302,884	8.4	5.1	4.2
20	18,079	29,995	36,570	1,157,085	1,919,710	2,340,468	7.6	4.6	3.7
25	9,483	15,733	19,181	606,903	1,006,907	1,227,599	7.1	4.2	3.5
30	5,424	8,999	10,971	347,126	575,913	702,140	6.7	4.1	3.3
40	11,155	18,507	22,563	713,914	1,184,448	1,444,054	6.3	3.8	3.1
50	8,094	13,429	16,373	518,041	859,478	1,047,857	6.1	3.6	3.0
60	16,378	27,172	33,128	1,048,183	1,739,031	2,120,189	5.9	3.5	2.9
75	1,507	2,500	3,047	96,424	159,976	195,039	5.7	3.5	2.8

Table 15 Emission reductions associated with energy savings through VSD

HP	Emission reductions (kg) for 20% speed reduction				Emission reductions (kg) for 40% speed reduction				Emission reductions (kg) for 60% speed reduction			
	CO_2	SO_2	NO_x	CO	CO_2	SO_2	NO_x	CO	CO_2	SO_2	NO_x	CO
1	391,366	2,343	1,104	238	649,107	3,886	1,830	395	649,107	3,886	1,830	395
1.5	48,545	291	137	30	81,076	485	229	49	81,076	485	229	49
2	325,304	1,947	917	198	539,505	3,229	1,521	328	539,505	3,229	1,521	328
3	881,324	5,276	2,485	536	1,461,867	8,751	4,122	889	1,461,867	8,751	4,122	889
4	5,345,999	32,001	15,076	3,252	8,869,794	53,095	25,013	5,395	8,869,794	53,095	25,013	5,395
5.5	178,667	1,070	504	109	296,778	1,777	837	181	296,778	1,777	837	181
7.5	487,956	2,921	1,376	297	809,257	4,844	2,282	492	809,257	4,844	2,282	492
15	251,235	1,504	708	153	416,890	2,496	1,176	254	416,890	2,496	1,176	254
20	6,525,102	39,059	18,401	3,969	10,825,623	64,802	30,528	6,584	10,825,623	64,802	30,528	6,584
25	2,439,281	14,602	6,879	1,484	4,047,285	24,227	11,413	2,462	4,047,285	24,227	11,413	2,462
30	975,913	5,842	2,752	594	1,619,014	9,691	4,566	985	1,619,014	9,691	4,566	985
40	2,601,933	15,575	7,337	1,583	4,317,037	25,842	12,174	2,626	4,317,037	25,842	12,174	2,626
50	1,626,521	9,736	4,587	989	27,063,705	162,003	76,320	16,461	32,995,476	197,511	93,047	20,069
60	4,908,590	29,383	13,842	2,986	81,142,057	485,716	228,821	49,353	98,926,617	592,174	278,973	60,170
75	1,256,675	7,522	3,544	764	20,236,456	121,135	57,067	12,308	24,671,844	147,686	69,575	15,006

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