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Drive Power Initiative Long Term Monitoring and Tracking (LTMT) Report and ACE Model Assumption Update

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Table of Contents

Introduction

The Northwest Energy Efficiency Alliance's (NEEA) Drive Power Initiative (DPI) (via the Green Motor Initiative (GMI))[1] and the Green Motors Practices Group (GMPG)[2]) encouraged adoption of green motor rewind practices by northwest motor service centers between 1999 and 2004. The GMPG has continued to promote these practices actively. Green rewind practices are rigorous and include motor testing. When motor service centers use these practices in commercial and industrial motor rewinds, the energy efficiency of these motors is maintained or improved; this is often not the case with standard motor rewinds.

In 2013, NEEA began ongoing long-term monitoring and tracking (LTMT) of the DPI, including an update of key assumptions used by NEEA in its Alliance Cost Effectiveness (ACE) model. This report, prepared by The Cadmus Group ("Cadmus") presents the 2017 LTMT findings. Cadmus collected a range of data to meet three major objectives: (1) update the size of the motor rewind market in the Northwest; (2) establish the market share of green motor rewinds; and (3) calculate the regional savings for green motor rewinds.

The report is comprised of a short five-page description of key findings, followed by three appendices with further detail on the DPI and LTMT, Cadmus' methodology, and a sample data collection form.

Key Findings

This section presents Cadmus' key findings, organized by key takeaway, market size, market share of green motor rewinds, and regional savings.

Key Takeaway. Estimated annual total savings from green motor rewinds increased from 1,734,708 kWh in 2016 to 1,853,219 kWh in 2017. However, the size and application of motors making up these green rewind savings and horsepower in 2016 differed substantially from 2017: in 2017, GMPG member motor service centers reported more rewinds for larger horsepower, longer-operating, industrial motors than in 2016. Thus, savings increased despite a decrease in the count of motors rewound to green motor specifications.

[1] The Green Motors Initiative (GMI) offers electric utility-financed incentives for rewinds meeting the GMI standards. See http://www.greenmotors.org/gmi.htm.

[2] The non-profit Green Motors Practices Group (GMPG) oversees the services and practices of the GMI. See http://greenmotors.org/about_gmpg.htm.

More explanatory detail on the key takeaway above is provided in the remainder of the report.

Market Size. In 2017, Cadmus determined that there were 80 motor service centers in the Northwest market, a slight increase from 79 in 2016. In 2017, 32 were members of the GMPG and 48 were nonmembers. The following describes performance by member and nonmember centers:

- **Total number of rewinds (both green and standard).** In 2017, motor service centers performed an estimated 2,622 motor rewinds in the Northwest. Of that total, GMPG members performed 1,676 (64%) and nonmembers performed 946 (36%)[3].
- **Total horsepower rewound (both green and standard).** In 2017, motor service centers rewound motors representing 361,470 horsepower in the Northwest. GMPG members rewound 285,180 horsepower (79%), and nonmembers rewound 76,290 horsepower (21%).
- **Application.** Overall, in 2017, agricultural motors accounted for 52% of the total horsepower rewound at GMPG member motor service centers and 56% at nonmember motor service centers. Industrial motors accounted for the remaining 48% and 44% of total horsepower rewound for GMPG members and nonmember motor service centers, respectively.

Undocumented rewinds. Cadmus compared the number of green motor rewinds self-reported by motor service centers in the survey to the number of green motor rewinds recorded by GMPG. (GMPG tracks the green motor rewinds documented by motor service centers for receipt of utility incentives.) This comparison revealed that motors service centers did not document and receive incentives for an estimated 16% of their total self-reported green motor rewinds. These non-documented/incented green motor rewinds constituted 20% of the total horsepower rewound using green rewind practices. Table 1 lists the number of rewinds by application that motor services centers reported to GMPG

[3] Cadmus found that the estimated number of motor rewinds in the Northwest decreased substantially from 4,631 in 2013 to 2,622 in 2017, most likely, in part, from a general decline in the motor rewind industry and from changes in the sample characteristics and estimated population size.

for incentive payments, as reported to Cadmus, along with the percentage undocumented by GMPG.

Table 1. GMPG Green Motor Rewinds Documented and Undocumented for 2016

Sector	Number of Rewinds		
	GMPG Documented (n = 16)	Reported to Cadmus (n = 16)	Percentage not Documented by GMPG
Agricultural	87	99	12%
Industrial	123	151	19%
Total	210	250	16%

Market Share of Green Motor Rewinds. Cadmus found that in 2017, out of the total 1,676 motor rewinds performed by GMPG member service centers, an estimated 372 were green motor rewinds, representing 22% of GMPG member rewinds and 38% of GMPG member horsepower rewound. Nonmembers performed no green motor rewinds in 2017.

Between 2013 and 2017, the percentage of GMPG member green motor rewinds has fluctuated between 22% and 33%. In 2017, both the number and the percentage of GMPG member green motor rewinds decreased substantially from the prior year—from 630 green motor rewinds, representing 33% of total motors rewound by GMPG members in 2016, to 372 green motor rewinds representing 22% of total motors rewound by GMPG members in 2017. The percentage of horsepower rewound to green motor rewind specifications, however, remained steady from 37% of GMPG member rewinds in 2016 to 38% of GMPG member rewinds in 2017.

Regional Savings. Green motor rewinds performed in 2017 by GMPG members resulted in an estimated annual total of 1,853,219 kilowatt hours (kWh) in energy savings.

Table 2 provides annual kWh energy savings from green motor rewinds by state for GMPG members and nonmembers.

Table 2. 2016 Annual kWh Savings from Green Motor Rewinds

State	Green Motor Rewind Savings (Annual kWh)		
	GMPG Member	GMPG Nonmember	Total
Washington	766,035	0	766,035
Oregon	471,731	0	471,731
Idaho	575,937	0	575,937
Montana	39,517	0	39,517
Total [1]	**1,853,219**	**0**	**1,853,219**

[1] Total does not equal sum of column due to rounding

Despite the decrease in number and percentage of green motor rewinds performed in 2017, estimated regional savings increased from 1,734,708 kWh in 2016 to 1,853,219 kWh in 2017. This increase in estimated energy savings was primarily due to an increase in the number of larger horsepower industrial motors reported to Cadmus in 2017—the total reported horsepower of industrial motors rewound to green motor specifications in 2017 was nearly double (42,835 horsepower) what GMPG members reported in 2016 (24,325 horsepower). Because motors in industrial applications typically operate for more hours within a year than motors in agricultural settings, energy savings assumptions are higher for industrial green motor rewinds than rewinds in agricultural applications.

Conclusions

Market Transformation. Green motor rewinds have yet to become standard practice in the Northwest. Between 2013 and 2017, the percentage of GMPG member green motor rewinds has fluctuated between 22% and 33%. Nonmembers reported performing no green motor rewinds in 2016 and 2017.

This year's study did not explore motor service center barriers and motivations, but in the 2013 study survey, reasons nonmembers reported for not performing green motor rewinds or joining the GMPG included lack of proper equipment, paperwork hassles, lack of customer interest, a perception that green motor rewinds did not last as long, and a lack of time to sign up.

According to NEEA's definition, market transformation is not complete until all opportunities have been adopted into the market or the remaining market barriers are insurmountable. Additional market intelligence research may be necessary to understand whether opportunities still exist to transform the market for motor rewinds, what barriers remain, and whether (and how) the remaining barriers can be overcome.

Future Data Collection Improvements. Given inherent issues faced when working with this hard-to-reach market segment, data collection efforts have focused on service center outreach

and solicitation. The study found such efforts successfully maintained study participation levels for GMPG member and nonmember motor service centers.

Cadmus achieved a 44% overall response rate for the data collection forms in 2017 (69% of members and 27% of nonmembers), which is comparable to the 43% response rate in 2016, but still slightly lower than the highest response rate of 47% achieved in 2015.

Because findings from the data collection forms are extrapolated to the population of 80 motor service centers, a robust sample size is necessary to produce reliable results. Maintaining high outreach and engagement levels with motor service centers is necessary to encourage continued participation in future data collection efforts. Cadmus suspects participation will likely remain low for the 26 motor service centers who are not members of the GMPG, as well as for the eight who are members but have declined to provide motor rewind data during all five study years (2013, 2014, 2015, 2016, and 2017).

Recommendations

Consider continuing (or adopting) the following methods for maintaining and increasing participation by motor service centers in future years' data collection efforts:

- Notify motor service centers as far in advance of data collection efforts as possible. Motor service centers would prefer to receive the notification at the beginning of the data collection year; this may not be feasible, given NEEA's decision-making timeline.
- For 2018 data collection, continue to employ the outreach and solicitation tactics used in 2017.
- To solicit participation from less-engaged GMPG nonmembers, explore opportunities to partner with the Electrical Apparatus Service Association (EASA) in reaching out to EASA-member motor service centers to encourage participation in 2018 data collection.

Appendix A. Drive Power Initiative and LTMT Background

NEEA funded the Drive Power Initiative (DPI) between 1999 and 2004 to increase motor efficiency and to transform the electric motor market. The Electric League of the Pacific Northwest provided the effort's initial funding.

Through the DPI, NEEA sought to achieve the following objectives:

- Increase the region's overall motor fleet efficiency.
- Influence end users' decision-making processes to repair or replace motors and to encourage consideration of life-cycle costing in investment decisions.
- Help motor service centers improve their repair practices and expand their motor management services.

In 2007, NEEA began tracking activities and trends in the drive power and motor rewinds markets through its long-term monitoring and tracking (LTMT) efforts. Subsequent LTMT reports in 2009 and 2011 updated the ACE model assumptions for motor rewinds, as did NEEA's 2013, 2014, 2015, and 2016 Evaluation Reviews of Key ACE Model Assumptions for Motor Rewinds.

Also in 2007, the Green Motors Practices Group (GMPG) submitted a request to the Regional Technical Forum (RTF) for approval of deemed savings for motors rewound by participating member centers. GMPG further requested that the RTF recognize and include green motor rewinds on its list of eligible energy efficiency measures. Later that year, the RTF approved the green motor rewinds as an eligible energy efficiency measure.

Shortly thereafter, a group of northwest utilities convened to discuss an approach for supporting certified green motor rewinds at GMPG member service centers. The utilities decided to pursue a regional approach, focusing on helping the GMPG, motor service centers, and utilities achieve increased numbers of certified green motor rewinds. Though the group recognized that success depended on agreeing to a simple, market-based approach (e.g., providing incentives for green motor rewinds), it understood complete uniformity in executing the approach might not be possible due to utility-specific preferences.

With assistance from NEEA and the region's utilities, the Bonneville Power Administration (BPA) formed the Green Motor Initiative (GMI) in 2008. GMI sought to educate, train, and certify service centers to follow effective shop procedures and to offer incentives to service centers and end users for efficient motor rewinds.

Specific GMI objectives included the following:

- By 2010, grow the GMPG to self-sustain through membership and utility programs.
- By 2010, ensure Northwest motor service centers train personnel and adopt GMPG rewinding practices.
- Continue to promote customer motor management practices that result in all industrial customers demanding GMPG-certified rewinds.

Via the GMI and the GMPG, the DPI encourages the Northwest's motor service center market to adopt green motor rewind practices. These practices reduce energy use for motors utilized in the agricultural and industrial sectors. Green motor rewinds require rigorous testing and offer greater energy savings compared to standard motor rewinds.

Service centers offering these services must, at a minimum, meet the following GMPG specifications for green motor rewinds:

- There must be no visible damage to the motor's core.
- The burn-off temperature must not exceed 385 degrees Celsius (720 degrees Fahrenheit) using verified water mist controls.
- The motor must undergo two (or more) core loss tests before and after stripping. The final core's test watts loss per pound must be no more than 20% greater than results during the first test.
- No hot spots may occur that are greater than 10 degrees Celsius.
- Final core tests must be less than or equal to 4 watts loss per pound.
- The new winding must achieve an equivalent to the manufacturer's original length and (may exceed) circular mils (voltage changes must be calculated to circular mil equivalents).

BPA, Energy Trust, and other regional investor-owned utilities provide incentives of $2 per horsepower, per GMPG member service center, for green motor rewinds. Each member service center retains $1 per horsepower rewound and passes the other $1 per horsepower rewound directly to the customer as part of its GMPG member agreement. Nonmember service centers remain ineligible to receive utility incentives.

GMPG serves as the program administrator for each of the region's utilities and provides the documentation necessary for each utility to claim savings and pay incentives. Monthly, GMPG collects this documentation from each member service center.

Although NEEA no longer provides funding, GMI's formation would not have been possible without NEEA's initial funding of the DPI and its subsequent funding to support development of

the GMPG and GMI. Due to its crucial role as regional collaborator, NEEA seeks to understand the current northwest motor rewind marketplace and to identify underlying data and assumptions that will allow NEEA to claim savings from this market transformation initiative.

Overview of LTMT Research Objectives and Methodology

Cadmus designed this study to meet three key research objectives necessary to update NEEA's ACE model assumptions for motor rewinds: (1) determine the size of the motor rewind market in the Northwest; (2) establish the market share of green motor rewind practices; and (3) calculate regional savings for green motor rewinds.

Market Size

To determine the motor rewind market size, Cadmus conducted the following secondary and primary research:

- **Secondary Research:** This research determined the number of Northwest motor service centers, and, among these, identified the number of GMPG members and nonmembers.
- **Data Collection Forms:** This research collected the number of motor rewinds conducted at service centers to determine the total number performed annually in the Northwest and the distribution among GMPG members and nonmember groups by horsepower. This research also collected the number of green motor rewinds documented by GMPG motor service centers that received utility incentives, and the number of undocumented green motor rewinds that did not receive utility incentives.

Market Share

Using feedback from the data collection forms described in the Market Size section above, Cadmus measured the market share of green motor rewind practices among Northwest motor service centers. Specifically, Cadmus determined the following:

- The number of rewinds in compliance with green motor rewind specifications; and
- The penetration of green motors practices among GMPG member and nonmember centers.

Savings Rate

For 2017, Cadmus used several sources to estimate regional savings from green motor rewinds:

- The data collection form described in in the Market Size section above.
- The RTF industrial and agricultural workbooks (version 2.3), which recorded details and assumptions pertaining to green motor rewinds[4,5].

The RTF maintains one workbook each for industrial and agricultural green motor rewinds. Motors in industrial applications typically operate for more hours within a year than motors in agricultural settings, meaning they adopt different assumptions per application in terms of hours of operation, savings values, and measure lifetimes.

The RTF workbooks also contain annual energy-savings estimates for agricultural and industrial motors for a range of discrete horsepower values, from 15 horsepower to 5,000 horsepower. Cadmus multiplied these savings estimates by the number of green rewinds for each horsepower level within each market sector; this determined total annual energy savings for green motor rewinds.

[4] Regional Technical Forum. *UES Measure: Green Motor Rewind.* Retrieved from https://rtf.nwcouncil.org/measure/green-motor-rewind?id=115.

[5] The RTF released version 3.1 of the green motor rewind workbooks in December 2017, however Cadmus used version 2.3 (published in December 2016), as these values reflected NEEA's practice of using the start year of the initiative for current practice baseline measures.

Appendix B. Detailed Methodology

Cadmus conducted secondary and primary research to meet the study's major objectives. Table 3 lists these objectives, their associated research activities, and respondents to the primary research (data collection forms).

Table 3. Key Study Objectives and Activities

Study Objectives	Study Activities	Respondents (to primary research)
Market Size	Review GMPG membership list; data collection form	GMPG members and nonmembers
Market Share	Data collection form	GMPG members and nonmembers
Savings Rate	Data collection form	GMPG members and nonmembers

Secondary Research

For 2017, Cadmus identified 80 motor service centers in the Northwest—32 member service centers and 48 nonmember service centers—compared to 79 motor service centers identified in 2016. To determine the number and membership status of the Northwest motor service centers in 2017, Cadmus asked the GMPG administrator to review the 2017 list of motor service centers (33 GMPG members, 46 nonmembers). Following the review, the GMPG administrator added one additional nonmember service center to the list, and informed Cadmus that one former member was no longer a member of the organization.

Primary Research

Preliminary Solicitation Outreach

Given the issues inherent in working with this hard-to-reach market segment, the 2017 data collection efforts focused on service center outreach and solicitation. Based on lessons learned from previously collecting motor rewind sales data from motor service centers in the Northwest, Cadmus employed several tactics to increase response rates. Prior to data collection, the GMPG administrator and Cadmus contacted motor service centers two times to inform them about the 2017 study and to encourage their participation.

Contact 1: In October 2017, Cadmus and the GMPG administrator provided advance notification to motor service centers. The GMPG administrator e-mailed all member service centers and Cadmus e-mailed all nonmember service centers. These e-mails provided notification of the study and a copy of the data collection form.

Contact 2: During the last week of November 2017, the GMPG administrator and Cadmus again e-mailed the data collection form to member and nonmember motor service centers, reminded them about the study, and asked them to the complete the form.

During the first week of December, Cadmus then began following up with all motor service centers via telephone to request their participation in the study and begin collecting data collection forms.

Data Collection Forms

NEEA annually updates the key ACE model assumptions for estimating energy savings from motor rewinds. Cadmus used a data collection form to acquire the data necessary for these calculations (e.g., the number of motor rewinds performed annually in the Northwest; the distribution of rewinds between GMPG members and nonmembers, by horsepower).

To ensure uniform data collection across the study years, Cadmus used the same data collection form implemented in NEEA's 2013, 2014, 2015, and 2016 update of ACE model assumptions for motor rewinds. This form asked service centers to provide the following sales data for their businesses:

- The number of motor rewinds conducted in the Northwest during 2017, by horsepower and by state.
- The number of green motor rewinds conducted in the Northwest during 2017, by horsepower and by state.

To accommodate motor service centers' preferences and needs, and to encourage high response rates, Cadmus provided service centers with three options for completing the forms:

- **Electronic:** The GMPG administrator and/or Cadmus e-mailed the data collection form (in Excel format) to the motor service centers, which they completed and returned by email.
- **Manual:** Cadmus faxed the data collection form to motor service centers. Motor service center staff completed the form by hand and returned it to Cadmus by fax or email.
- **Verbal:** For motor service center staff finding it more convenient to complete the data collection form verbally, Cadmus also provided the option for service centers to complete the form by phone. However, in 2017, no motor service centers completed the data collection form through this method.

To increase response rates, Cadmus and NEEA offered nonmember service centers a $150 incentive to complete the form. Cadmus also conducted all service center outreach and solicitation in-house using staff familiar with the technical aspects of green motor rewinds.

Cadmus contacted the 80 motor service centers five times by phone. For those indicating willingness to provide data collection forms, Cadmus conducted up to five follow-up phone calls to encourage them to provide sales data.

Thirty-five motor service centers (22 members and 13 nonmembers) completed the data collection forms—an increase from the 34 motor service centers completing the form in 2016. Table 4 and Table 5 show the number of completed member and nonmember data collection forms, by state and study year.

Table 4. Completed Member Data Collection Forms by State and Study Year

State	Member					
	2017 Population (N)	2013 Sample (n)	2014 Sample (n)	2015 Sample (n)	2016 Sample (n)	2017 Sample (n)
Washington	9	7	3	4	5	5
Oregon	10	4	4	6	6	6
Idaho	9	5	7	8	7	8
Montana	4	2	2	3	3	3
NEEA Region Total	**32**	**18**	**16**	**21**	**21**	**22**

Table 5. Completed Nonmember Data Collection Forms by State and Study Year

State	Nonmember					
	2017 Population (N)	2013 Sample (n)	2014 Sample (n)	2015 Sample (n)	2016 Sample (n)	2017 Sample (n)
Washington	9	1	5	4	3	2
Oregon	17	6	5	4	4	4
Idaho	14	2	6	7	4	5
Montana	8	0	3	2	2	2
NEEA Region Total	**48**	**9**	**19**	**17**	**13**	**13**

Savings Rate Analysis

To calculate savings, Cadmus used the following methodology:

$$Energy\ Savings = \sum_{ij} Savings\ Rate_{ij} \times Reported\ Units_{ij}$$

Where:

i	=	sector (agricultural or industrial)
j	=	motor rewind horsepower
Savings rate$_i$	=	incremental per-unit savings (kWh per year) over baseline unit energy consumption
Reported units$_i$	=	green motor compliant rewinds

On the data collection forms, the motor service centers recorded the number of rewinds (green or standard) by horsepower within the agricultural or industrial sectors. Cadmus built a table using these quantities and descriptions.

The Regional Technical Forum (RTF) unit energy-savings Excel workbooks provided the savings rate for each horsepower value indicated on the data collection forms. Cadmus calculated total regional savings for green motor rewinds by building a simple lookup function that multiplied the number of rewinds times the respective annual kWh savings for a given horsepower for agricultural and industrial sector motors.

Savings Extrapolations

To estimate total energy savings attributable to green motor-compliant rewinds, Cadmus extrapolated savings from the reported sample to the population. This section provides the statistical basis for the savings extrapolations.

For each motor service center, Cadmus calculated the energy savings resulting from the green motor rewinds shown in the Savings Rate Analysis section above. The primary objective for determining regional savings included calculating the savings attributable to agricultural and industrial applications for members and nonmembers. The 2013, 2014, 2015, and 2016 evaluation studies used the same methods for determining regional savings.

Cadmus calculated the total savings estimate and its precision level using a standard, stratified mean estimation.

$$Total\ Savings_{\mathrm{i,h}} = Savings_{i,h} \times N_h / n_h$$

Where:

i	=	motor service center
h	=	stratum
N	=	population
n	=	sample

Cadmus also used the same method for calculating total energy savings for industrial and agricultural applications.

Cadmus calculated the total number of rewinds, the total horsepower rewound, and the precision estimates using a standard, stratified ratio estimation.

Savings Confidence Interval

Extrapolating from a sample to a population introduces uncertainty into the population estimate. Therefore, it is necessary to build a confidence interval around an estimate to describe its uncertainty level. The confidence interval contains two parts: the confidence level and precision level.

This report presents the extrapolation results of motor rewinds, horsepower rewound, and savings at a confidence level of 90%. Precision is the radius of the confidence interval, as a percentage of the estimate itself, and can be called the relative precision or relative error.

Appendix C. Data Collection Form

Motor Rewind Data Sheet Directions
On the next tab, labeled "Motor Rewind Data Sheet", you will find the motor rewind form. Please use the directions below to complete the form.
Section A
Record a count of all 15 to 5,000 HP motor rewinds (green motor rewinds **and** standard motor rewinds) in 2017.
In the data sheet, record the number of motor rewinds for each sector (agriculture or industrial), state, and HP.
Section B
Record a count of Green Motor rewinds for 15 to 5,000 HP motors in 2017.
(NOTE: If your company is a member of the Green Motors Practices Group, this includes both green motor rewinds you have reported and received an incentive for, as well as those you have not reported or received an incentive for.)

Important Definitions
Green Motor Rewinds, in contrast to standard motor rewinds, refer to motors that are rewound to their original nominal efficiency. The Green Motors Initiative rewind specifications require several criteria for a motor rewind to be considered a green rewind. The minimum criteria are as follows:
a. There must be no visible damage to the core
b. The burn-off temperature should not exceed 725 degrees F using verified water mist control
c. Service center must conduct two (or more) core-loss tests before and after stripping with the final core test watts loss per pound no more than 20% greater than the first test
d. There must be no hot spots greater than 10 degree C
e. The final core test must be less than or equal to 4 watts loss per pound
f. The new winding must be equivalent to the manufacturer's original length and (may exceed) circular mils (voltage changes must be calculated circular mil equivalent)

Contact Information and Form Submittal
For questions about this form or project, please contact Hanna Lee at the Cadmus Group, at hanna.lee@cadmusgroup.com or (503) 467-7110.
Please also email completed forms to Hanna Lee at the email address above, or fax to: (503) 575-4710 by **December 15, 2017.**
Name:
Company:
Address:

Rewind Type	Section A: Count of all Motor Rewinds								Section B: Count of Green Motor Rewinds							
End Use	Agriculture				Industrial				Agriculture				Industrial			
State	ID	MT	OR	WA	ID	MT	OR	WA	ID	MT	OR	WA	ID	MT	OR	WA
15 HP																
20 HP																
25 HP																
30 HP																
40 HP																
50 HP																
60 HP																
75 HP																
100 HP																
125 HP																
150 HP																
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