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Green Motor Rewinds – 2021 Long-Term Monitoring and Tracking Report

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Executive Summary

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 the adoption of green motor rewind practices by Northwest motor service centers between 1999 and 2004. Since the DPI's inception, the GMPG has actively promoted green motor rewind practices, which are rigorous and include motor testing. Green practices include tight control of the burn-off process, stator core loss testing and repair, and performance criteria for the windings. When motor service centers use these green practices in commercial and industrial motor rewinds, the energy efficiency of these motors is maintained or improved. Standard rewind practices, on the other hand, can result in a decrement in efficiency relative to the original efficiency due to degradation of stator core laminations, splayed stator core teeth, increased winding resistance losses, and increased bearing friction losses.

In 2007 NEEA began tracking the market activities and trends of the drive power and motor rewinds markets via its long-term monitoring and tracking efforts for the DPI, including an update of assumptions for NEEA's cost-effectiveness analysis. In preparing this report of 2021 findings, Cadmus collected data to meet three major objectives: update the size of the Northwest motor rewind market, establish the market share[3] of green motor rewinds, and calculate regional savings for green motor rewinds. The 2021 report is the last long-term monitoring and tracking effort for NEEA's DPI.

Key Findings

This section presents Cadmus' key findings for 2021, organized by market size, market share of green motor rewinds, and regional savings.

Market Size

Cadmus determined that 62 motor service centers in the Northwest market (29 GMPG members and 33 nonmembers) conducted motor rewinds in 2021, a decrease from 64 service centers (28 GMPG members and 36 nonmembers) in 2020.

[1] The GMI offers electric utility–financed incentives for rewinds meeting the GMI standards (see https://www.greenmotors.org/).

[2] The non-profit GMPG oversees GMI's services and practices (see https://www.greenmotors.org/about_us).

[3] Market share is defined as the percentage of total motor rewinds (GMPG member and nonmember motor service center rewinds combined) that are green motor rewinds.

Performance varied by member and nonmember centers:

- **Total Number of Rewinds**. In 2021, motor service centers performed an estimated 1,603 motor rewinds (green and standard combined) in the Northwest. Of that total, GMPG members performed 1,025 (64%) and nonmembers performed 578 (36%).
- **Total Horsepower Rewound**. In 2021, motors rewound by motor service centers represented 251,873 horsepower (green and standard combined) in the Northwest. GMPG members rewound 207,900 horsepower (83%), and nonmembers rewound 43,973 horsepower (17%).

Market Share of Green Motor Rewinds

To estimate the market share of green motor rewinds, Cadmus collected data from a convenience sample of motor service centers in the Northwest, including 11 GMPG members and 14 nonmembers. Cadmus found that of 1,025 motor rewinds performed by GMPG member service centers in 2021, approximately 326 were green motor rewinds, representing 32% of GMPG member rewinds and 42% of GMPG member horsepower. Among the 14 nonmember service center surveys, only one reported conducting any green motor rewinds – it reported seven, representing 1% of 578 nonmember rewinds and 5% of nonmember horsepower.[4] For the market as a whole (representing total rewinds performed by both GMPG members and nonmembers), the market share of green motor rewinds was 21%, representing 36% of the total horsepower rewound.

Regional Savings

In 2021, green motor rewinds performed by GMPG members resulted in an estimated annual total of 1,323,318 kWh in energy savings. Table 1 provides annual kilowatt-hour energy savings from green motor rewinds (by state) for GMPG members and nonmembers.

[4] Given that only one nonmember performed any green motor rewinds, Cadmus did not extrapolate the sample green rewind to the population of nonmember service centers.

Table 1. 2021 Annual Kilowatt-Hour Savings from Green Motor Rewinds

State	Green Motor Rewind Savings (Annual kWh)		
	Member[2]	Nonmember[3]	Total
Washington	379,930	0	379,930
Oregon	570,069	0	570,069
Idaho	373,319	0	373,319
Montana	0	47,477	47,477
Total [1]	**1,323,318**	**47,477**	**1,370,796**

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

[2] Member kilowatt-hour savings reflect savings extrapolated to all member motor service centers in the population.

[3] Nonmember kilowatt-hour savings reflect savings from green motor rewinds reported from nonmembers in the sample only.

Conclusions

The Northwest market for standard motor rewinds continued to contract. The market size of motor rewinds is highly dependent on both the number of motor service centers in business and the economics of motor rewinds versus replacement.

- As in prior years, the estimated number of all motor rewinds (standard and green combined) in the Northwest continued to decrease, falling 12% from 2019 to 2020 and 13% from 2020 to 2021. The number of all rewinds has declined 65% from 2013 (4,631 rewinds) to 2021 (1,603 rewinds).
- Fewer motor service centers performed motor rewinds in 2021 than in 2020, which continues an overall trend since 2013. Cadmus determined that 62 motor service centers (29 GMPG members and 33 nonmembers) in the Northwest market performed motor rewinds in 2021, a decrease from 64 motor service centers in 2020. The number of service centers performing motor rewinds has declined 34% since 2013, when 94 service centers conducted motor rewinds.
- A variety of market factors caused some motor service centers across the Northwest to rewind fewer motors in 2021 than in 2020, while a different set of factors caused some motor service centers across the Northwest to complete more rewinds. The seven nonmember service centers that indicated they completed fewer rewinds than in 2020 gave reasons that varied from COVID-19 concerns (two survey respondents) to sales of farms (one survey respondent) and improved motor owner maintenance practices (one respondent). On the other hand, some motor service centers rewound more motors in 2021 than 2020.The eight survey respondents who indicated they completed more rewinds in 2021 gave reasons that varied from shipping delays for new motors (two nonmember and one member survey respondents) to a price increase in new motors (one member and one nonmember survey respondents).

- Cadmus' and NEEA's prior market research suggests that the Northwest motor rewind market has contracted due to less expensive, imported new motors resulting in motor replacements rather than rewinds, along with a declining number of industrial manufacturing facilities based in the United States.

The increase in savings in 2021 is primarily driven by the increase in average horsepower per green motor rewind and by a small increase in the number of green rewinds.

- Total estimated savings from green motor rewinds increased 13% from 2020 to 2021. This savings increase resulted primarily from green rewinds in 2021 being, on average, performed on larger motors than in 2020. The average horsepower for green rewinds in 2020 was 249 compared to 278 in 2021. The greater number of green rewinds in 2021 (333 green rewinds) compared to 2020 (320 rewinds) also contributed to increased energy savings. However, this savings increase in 2021 is overshadowed by the long-term trend in the decline of both savings and the number of rewinds. Estimated energy savings from green motor rewinds decreased 48% from 2013 (2,632,305 kWh) to 2021 (1,370,796 kWh).
- The slight increase in the 2021 green motor rewind market share was driven by an increase in the share of green rewinds among GMPG members and a decline in the number of nonmember motor service centers. The share of green motor rewinds increased to 21% in 2021 from 17% in 2020. The GMPG member rewind activity drove this increase, with GMPG member green motor rewinds market share increasing to 32% in 2021 from 25% in 2020. Nonmember market share stayed consistent (1% in both 2020 and 2021).
- The sampled 2021 motor service centers did not identify any one reason for their own increase in green motor rewinds. Survey respondents provided a variety of reasons, including an increase in customer base, the fact that increased use of variable frequency drives reduces motor damage so that rewinds still make economic sense, an increase in large motor failures, and a perception that green rewinds will be more profitable than standard rewinds.
- Because GMPG members historically complete more green rewinds than nonmembers, the decline in the number of nonmember motor service centers also resulted in an increase in green motor rewind market share among members.

Introduction

This section provides background about the DPI and the long-term monitoring and tracking efforts of DPI, as well as a description of the report organization.

Background

NEEA funded the DPI between 1999 and 2004 to increase the efficiency of existing and new motors and to transform the electric motor market. The Electric League of the Pacific Northwest provided initial funding and NEEA continued to fund that for a number of years.

Through the DPI, NEEA sought to achieve three objectives that included, but were not limited to, green motor rewinds:

- Increase the region's overall motor fleet efficiency.
- Influence end-users' decision-making processes to rewind or replace motors and encourage them to consider lifecycle costs in investment decisions.
- Help motor service centers improve their maintenance practices and expand their motor management services.

In 2007, NEEA began tracking activities and trends of the drive power and motor rewind market through its long-term monitoring and tracking efforts.

Also in 2007, the GMPG submitted a request to the Regional Technical Forum (RTF) for approval of deemed savings for motors rewound to a particular specification by participating GMPG member service centers. The GMPG designed the green rewind specification and method so as not to lose motor efficiency. 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 green motor rewinds as an eligible energy efficiency measure.

Shortly thereafter, a group of Northwest utilities with the help of NEEA's coordination, convened to discuss an approach for supporting certified green motor rewinds at GMPG member service centers. The utilities decided to pursue a regional approach, focused on helping the GMPG, utilities, and motor service centers achieve increased numbers of certified green motor rewinds. Although the group of utilities recognized that success depended on agreeing to a simple program approach (for example, providing uniform incentives across the region for green motor rewinds), the group understood that 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 formed the GMI in 2008, which sought to educate, train, and certify service centers to follow

effective shop procedures, and also offered incentives to service centers and end users for efficient motor rewinds.

There were several specific GMI objectives:

- By 2010, grow the GMPG to sustain itself without NEEA funding through membership and utility programs
- By 2010, ensure that Northwest motor service centers train personnel and certify the process and adopt GMPG rewind practices
- Continue to promote customer motor management practices that result in all industrial customers demanding GMPG-certified rewinds

In partnership with the GMI and the GMPG, the DPI encouraged the Northwest's motor service center market to adopt green motor rewind practices intended to reduce energy use (and or maintain efficiency levels after a motor rewind) for motors used in the agricultural and industrial sectors. Though green motor rewinds require rigorous testing, they result in greater energy savings than standard motor rewinds.

Service centers offering these services must, at a minimum, meet 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, and the final core's test watts loss per pound must be no more than 20% greater than the results from the first test
- No hot spots greater than 10 degrees Celsius may occur
- Final core tests must be less than or equal to a 4-watt loss per pound
- New windings must achieve an equivalent to the manufacturer's original length, and may exceed circular mils (that is, voltage changes must be calculated to circular mil equivalents).

The Energy Trust of Oregon and other regional utilities provide incentives of $2 per horsepower for each green motor rewind conducted at a GMPG member service center. As part of the GMPG's member agreement, these centers each retain $1 per horsepower rewound and pass the other $1 per horsepower rewound directly to the customer in the form of an instant rebate. Nonmember service centers remain ineligible to receive utility incentives.

GMPG serves as the program administrator for each of the region's utilities, providing 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 for the project, 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 NEEA's crucial role as a regional collaborator and convener, it 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.

Report Organization

Cadmus organized this report into the following sections:

- Research Objectives and Methodology
- Findings
- Conclusions and Recommendations
- Appendix A (data collection form).

Research Objectives and Methodology

Cadmus designed this study to meet three key research objectives necessary to update the assumptions for NEEA's cost-effectiveness model: update the size of the Northwest motor rewind market, establish the market share of green motor rewind practices, and calculate regional savings for green motor rewinds. In coordination with the GMPG, Cadmus conducted primary and secondary research to meet the study's major objectives. Table 2 lists these objectives, their associated research activities, and respondents to the primary research data collection forms.

Table 2. Key Study Objectives and Activities

Research Objectives	Study Activities	Respondents (to Primary Research)
Market Size	Review of the list of member and non-member motor service centers provided by the GMPG administrator in fall 2021; phone calls to all known motor service centers; data collection form	GMPG members and nonmembers
Market Share	Data collection form	GMPG members and nonmembers
Regional Savings	Data collection form	GMPG members and nonmembers

This report presents market estimates for number of motor rewinds, horsepower rewound, and savings at a 90% confidence level, based on data collected from a sample of motor service centers. Extrapolating from a sample to a population introduces uncertainty into the population estimate. Therefore, we built confidence intervals around each estimate to describe its uncertainty level. The confidence interval contains two parts: the confidence level and the precision level. Precision is the radius of the confidence interval, expressed as a percentage of the estimate itself, known as the "relative precision" or "relative error."[5]

Market Size

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

Secondary Research

Cadmus determined the number of Northwest motor service centers and, among these, identified the number of GMPG members and nonmembers. The market size is determined by the count of motor service centers that performed at least one motor rewind sized at 15

[5] As precision values differ for each estimate of member and nonmember rewinds, horsepower rewound, and savings rewinds, there is not an overall precision level for the study.

horsepower or greater in 2021. For 2021, Cadmus identified 62 Northwest motor service centers (29 GMPG members and 33 nonmembers), compared to 64 motor service centers for 2020. To determine the number and membership status of Northwest motor service centers in 2021, Cadmus asked the GMPG administrator to review the 2020 list of motor service centers. To determine the number of nonmember Northwest motor service centers for 2021, Cadmus asked the GMPG administrator to research the number of nonmembers through web search and phone calls. Cadmus then confirmed the number of member and nonmember motor service centers by emailing and calling each motor service center in its sample frame.

After completing data collection phone calls and emails (detailed in the next section), Cadmus adjusted the service center population as follows:

- Removed three nonmember motor service centers that did not perform motor rewinds in the Northwest in 2021
- Added one member motor service center that did not perform motor rewinds in 2020, but did so in 2021

This reduced the population from 64 to 62 service centers (29 member service centers and 33 nonmember service centers).

Primary Research

Cadmus sent the data collection form shown in Appendix A to both GMPG member and nonmember motor service centers for completion. To ensure uniform data collection across the study years, Cadmus has employed the same data collection table since 2013. This form asked service centers to provide data from their businesses:

- The number of motor rewinds conducted in the Northwest during 2021, by horsepower and by state. Cadmus uses this data to determine the total number of rewinds performed annually in the Northwest
- The number of green motor rewinds conducted in the Northwest during 2021, by horsepower and by state. This data enables Cadmus to determine the market share of green motor rewinds.

In 2021, Cadmus added five survey questions to the data collection form to assess drivers of the changes in the number of standard and green motor rewinds in 2021 and in the long term.

The GMPG provided Cadmus with the number of green motor rewinds documented by motor service centers as required for receiving utility incentives. Prior to data collection, the GMPG administrator and Cadmus contacted motor service centers twice (once in September 2021 and once in December 2021) to inform them of the 2021 study and to encourage their participation. NEEA offered nonmember service centers a $150 incentive to complete the data collection

form. To accommodate motor service centers' preferences and needs and to encourage high response rates, Cadmus provided service centers with three options for completing the data collection form: email, fax, or verbally over the telephone.

From mid-December to mid-January, Cadmus followed up with all motor service centers via telephone, requested their participation in the study, and gathered data collection forms. Cadmus contacted the motor service centers up to five times by phone. As a result, 25 motor service centers (11 members and 14 nonmembers) completed the data collection forms. Table 3 shows the number of data collection forms completed by members and nonmembers, by state.

Table 3. Completed Member and Nonmember Data Collection Forms by State

State	Member		Nonmember	
	2021 Population (N)	2021 Sample (n)	2021 Population (N)	2021 Sample (n)
Washington	8	3	5	2
Oregon	10	3	13	5
Idaho	9	4	11	5
Montana	2	1	4	2
NEEA Region Total	**29**	**11**	**33**	**14**

Market Share

Using data the motor service centers provided in the data collection forms, Cadmus estimated the market share for green motor rewind practices among Northwest motor service centers. Specifically, Cadmus determined two values:

- The number of rewinds in compliance with green motor rewind specifications
- The market share of green motor rewinds among all rewinds (standard and green rewinds combined) conducted by GMPG member and nonmember centers.

Regional Savings Analysis

To determine regional savings resulting from green motor rewinds, Cadmus calculated savings attributable to both agricultural and industrial applications for members and nonmembers. We used these same methods in prior evaluation studies.

Cadmus used two sources to estimate regional savings from green motor rewinds:

- The data collection form, which included the number and horsepower of rewinds
- The RTF industrial and agricultural workbooks (version 2.3), which record details and assumptions pertaining to green motor rewinds[6]

The RTF maintains separate workbooks for industrial and agricultural green motor rewinds. Motors in industrial applications typically operate for more hours per year than motors in agricultural settings, so the RTF adopts different assumptions per application in terms of operating hours, 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, which allowed us to determine the total annual energy savings for green motor rewinds.

To calculate savings, Cadmus used an equation:

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

Where:

i	=	Sector (agricultural or industrial)
j	=	Motor rewind horsepower
Savings rate$_i$	=	Incremental per-unit savings (kilowatt-hours 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 and within the agricultural and industrial sectors. Cadmus built a table using these quantities and descriptions.

The RTF's unit energy-savings Excel workbooks provided savings rates for each horsepower value indicated on the data collection forms. Cadmus calculated regional savings for green

[6] Regional Technical Forum. *UES Measure: Green Motor Rewind.* https://rtf.nwcouncil.org/measure/green-motor-rewind?id=115
Though the RTF released the green motor rewind workbooks, version 3.1, in December 2017, Cadmus used version 2.3 (published in December 2016) as these values reflect the market baseline.

motor rewinds by building a simple lookup function, which multiplied the number of rewinds by the respective annual kilowatt-hour savings for a given horsepower, applicable to 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 of members to the population. This section provides the methodology we used for the savings extrapolations.

Cadmus calculated the total savings estimate for the population 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 used the same total energy-savings calculation method for both industrial and agricultural applications. This included using a standard, stratified ratio estimate to calculate the total number of industrial and agricultural rewinds and the total horsepower rewound.

Findings

This section describes findings for market size, market share, and regional savings.

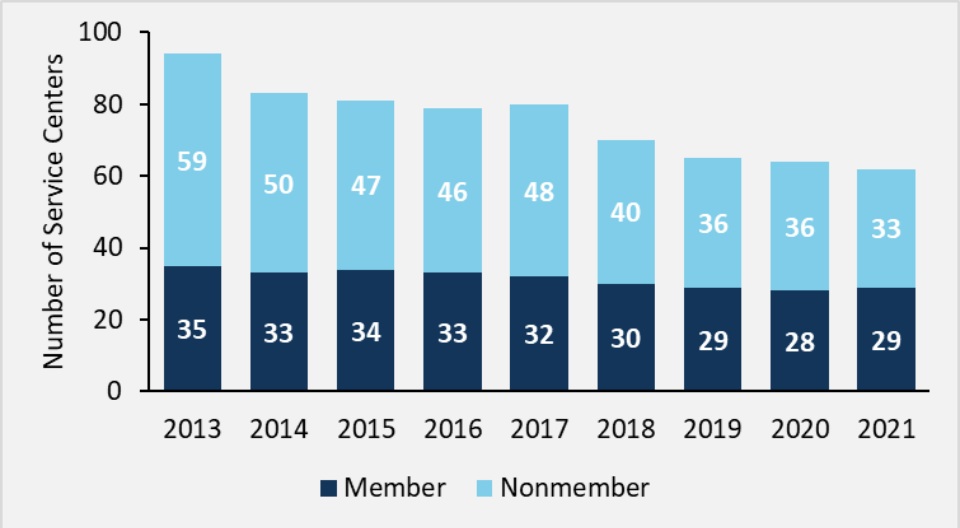
Market Size

Cadmus assessed the size of the motor rewinds market using secondary research and data collection forms.

Number of Motor Service Rewind Centers

Cadmus determined that 62 motor service centers in the Northwest market (29 GMPG members and 33 nonmembers) conducted motor rewinds in 2021, a decrease from 64 service centers (28 GMPG members and 36 nonmembers) in 2020. The decrease resulted from some motor service centers reporting that they did not perform any rewinds in 2021. Figure 1 shows that the decline in the number of motor service centers performing rewinds is part of a trend that has continued throughout the life of this study, with nonmembers representing the majority of the decline since 2013.

Figure 1. Number of Motor Service Centers Performing Rewinds in the Northwest by Study Year



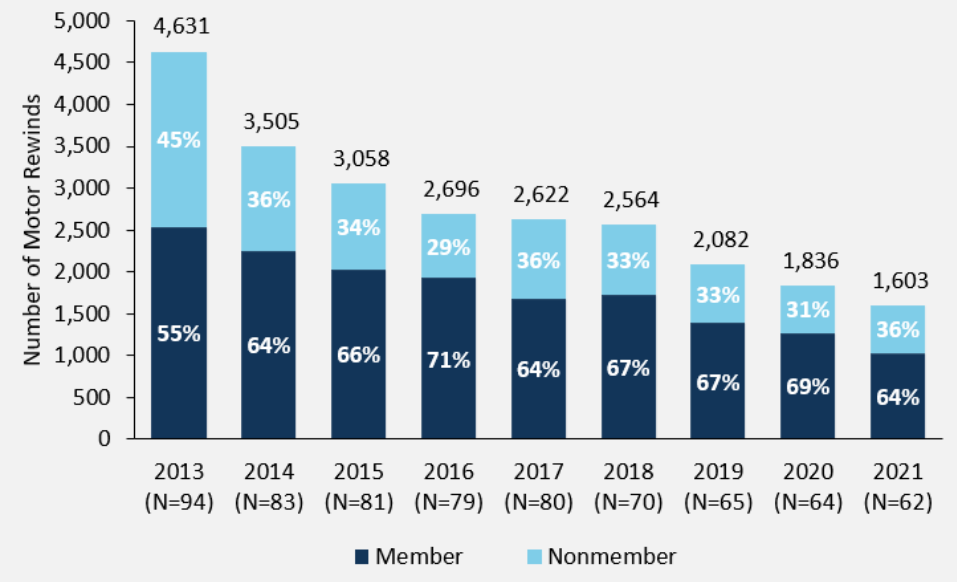
Number of Motor Rewinds Performed in 2021

In 2021, motor service centers performed an estimated 1,603 motor rewinds (green and standard combined) in the Northwest. Of that total, GMPG members performed 1,025 rewinds (64%) and nonmembers performed 578 rewinds (36%).

As shown in Figure 2, the Northwest's estimated number of motor rewinds has decreased 65% from 2013 to 2021. The largest drops in the number of rewinds occurred between 2013 and

2014 (a 24% decline) and between 2018 and 2019 (a 19% decline). The overall decrease in estimated motor rewinds since 2013 likely resulted from a decline in the number of motor service centers and a general decline in the motor rewind industry. The number of GMPG member motor service centers declined 17% between 2013 and 2021, while the number of nonmember motor service centers declined 44%. Both GMPG members and nonmembers contributed to the decline in the number of motor rewinds: GMPG members completed 60% fewer rewinds in 2021 than 2013, while nonmembers completed 72% fewer rewinds.

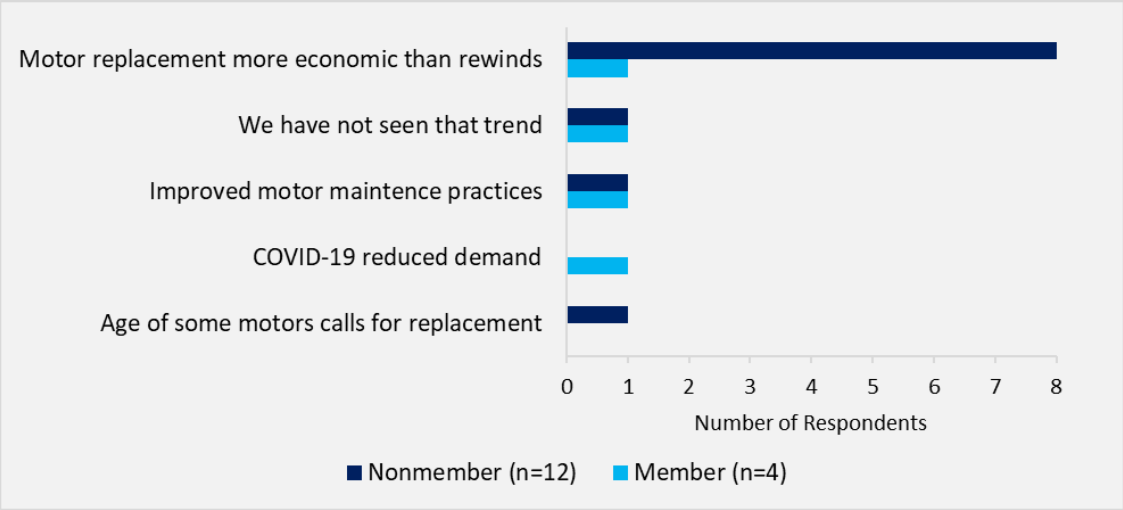
Figure 2. Historical Number of Motor Rewinds



In prior research, Cadmus found that motor replacements are more common than motor rewinds primarily due to lower new motor prices and a decline in the number of U.S.-based manufacturing facilities.[7] Similarly, survey responses from the 2021 data collection forms show that many motor service centers perceive that motor replacement is more economic than rewinds. As shown in Figure 3, a greater share of nonmembers (eight of 12) than members (one of four) thought that the decline in the number of rewinds stemmed from motor replacement being more economic than motor rewinds.

[7] Cadmus. February 14, 2014. *Evaluation of Key ACE Model Assumptions for Motor Rewinds.* Prepared for Northwest Energy Efficiency Alliance.

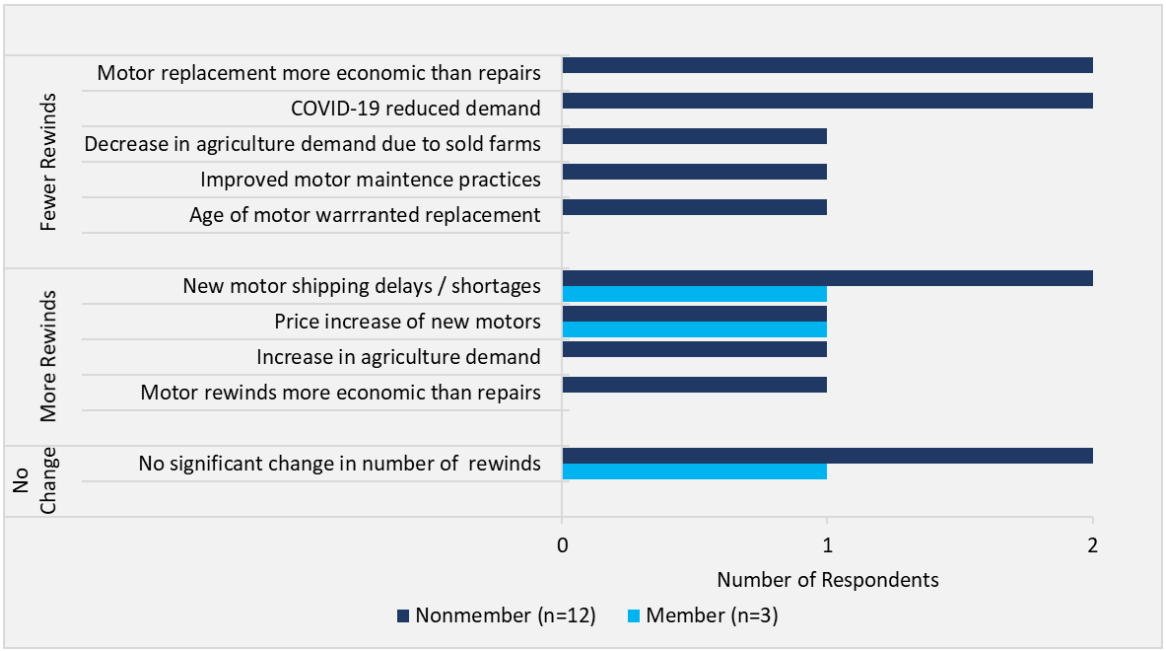
Figure 3. Motor Service Center Perceptions around Reasons for the Decline in Motor Rewinds



Source: 2021 Survey Question Q5. "Over the past few years, we have seen a reduction in the number of standard rewind and green rewinds in the Pacific Northwest. Why do you think that is?"

As shown in Figure 4, survey respondents gave varying reasons for why they completed fewer or more motor rewinds in 2021 compared to 2020. Of the seven nonmember service centers that indicated that they completed fewer rewinds than in 2020, four were located in Idaho, two were located in Oregon, and one was located in Washington. Reasons for completing fewer rewinds varied from COVID-19 (two survey respondents) to sales of farms (one survey respondent) and improved motor owner maintenance practices (one respondent). On the other hand, some motor service centers rewound more motors in 2021 than 2020. Of the eight survey respondents who indicated they completed more rewinds in 2021, three were from Oregon, two were from Washington, two were from Idaho, and one was from Montana. Reasons for completing more rewinds varied from shipping delays for new motors (two nonmembers and one member) to a price increase in new motors (one member and one nonmember).

Figure 4. Drivers for the Change in the Number of All Motor Rewinds Between 2020 and 2021



Source: 2021 Survey Question Q1. "Did your shop complete more or fewer motor rewinds in 2021 than in 2020? This includes all motor rewinds." and Q2. "What do you think caused the change in the number of all motor rewinds your shop completed in 2021?" (multiple responses allowed)

Overall, three respondents explained that it is more economic to rewind motors with low horsepower than to conduct rewinds of larger horsepower motors: two of those respondents completed motor rewinds sized under the 15 horsepower threshold of this study. The 2021 data supports the finding that some service centers find small motors more economic to rewind than large motors: rewinds of motors less than 75 horsepower made up 43% of all motor rewinds.

When asked what caused the change in the number of green motor rewinds completed by their shop in 2021 compared to 2020, six nonmembers said their shops do not offer green motor rewinds. Of the two respondents who said they completed fewer green rewinds in 2021, one member said the number of green rewinds declined because some customers refuse to provide utilities with their information, and one nonmember cited better customer maintenance of motors. The four respondents who said they completed more green rewinds in 2022 gave various reasons for the increase (one respondent each):

- Increased failure of large motors
- Motor damage has declined due to an increased use of variable frequency drives, which makes these motors paired with drives better candidates for rewinds than replacements

- Increased customer base
- Perception that green motor rewinds can increase a rewind's profit over standard rewinds.

Distribution of Motor Rewinds by Horsepower

In 2021, motors rewound by motor service centers represented 251,873 horsepower (green and standard combined) in the Northwest. GMPG members rewound 207,900 horsepower (83%), and nonmembers rewound 43,973 horsepower (17%). In 2021, industrial motors accounted for 50% of the total horsepower rewound at GMPG member motor service centers and 41% rewound at nonmember motor service centers. Agricultural motors accounted for the remaining 50% and 59% of total horsepower rewound for GMPG member and nonmember motor service centers, respectively. GMPG members rewound higher horsepower motors on average than nonmembers: while GMPG members account for 64% of all rewinds, they account for 83% of horsepower rewound. The average horsepower per GMPG member rewind was 203 horsepower, compared to 76 horsepower for the average nonmember rewind.

Motor Rewind Applications and Undocumented Rewinds

The share of green motor rewinds receiving incentives increased from 79% in 2020 to 86% in 2021. The share of agricultural motors receiving incentives increased from 53% in 2020 to 65% in 2021, and the share of industrial rewinds receiving incentives remained constant at 100%.

Cadmus compared the total number of green motor rewinds reported by GMPG member motor service centers in the study survey with the number of green motor rewinds the motor service centers documented and reported to GMPG for purposes of obtaining utility incentives. This comparison revealed that in 2021, motor service centers did not document (and therefore did not receive incentives for) an estimated 14% of the green motor rewinds they reported in the study survey. These nondocumented, nonincented green motor rewinds constituted 19% of the total horsepower rewound in 2021 using green rewind practices.

Table 4 lists the number of 2021 green motor rewinds by sector that motor service centers reported to GMPG for incentive payments (as reported to Cadmus), along with the percentage of undocumented green motor rewinds.

Table 4. Green Motor Rewinds Documented and Not Documented by Member Motor Service Centers in 2021

Sector	Number and Percentage of Green Motor Rewinds			
	Documented by Service Centers for GMPG (n=9)	Reported by Service Centers in Study Survey (n=11)	Percentage Documented by Service Centers for GMPG	Percentage Not Documented by Service Centers for GMPG
Agricultural	32	49	65%	35%
Industrial	70	70	100%	0%
Total	**102**	**119**	**86%**	**14%**

Market Share

Cadmus assessed the market share of green motor rewinds using secondary research and primary data from the collection forms.

Number of Green Motor Rewinds

The number of green rewinds increased from 320 in 2020 to 333 in 2021.The number of green rewinds increased in Oregon and decreased in Idaho, Montana, and Washington. As shown in Table 5, of 1,025 motor rewinds performed by GMPG member service centers in 2021, approximately 326 were green motor rewinds, representing 32% of GMPG member rewinds. In comparison, of the 1,268 motor rewinds performed by GMPG member service centers in 2020, 316 were green motor rewinds, representing 25% of GMPG green motor rewinds. Among the 14 nonmember service centers, only one reported conducting any green motor rewinds – it reported seven, representing 1% of 578 nonmember rewinds.[8] In comparison, one nonmember performed four green motor rewinds in 2020, representing 1% of 568 nonmember rewinds. For the market as a whole (total rewinds performed by both GMPG members and nonmembers), the market share of green motor rewinds was 21% in 2021, compared to 17% in 2020.

[8] Given that only one nonmember performed any green motor rewinds and likely does not represent the nonmember population, Cadmus did not extrapolate the sample green rewinds to the population of nonmember service centers.

Table 5. Green Motor Rewind Market Share by Number of Rewinds

	Number and Percentage of Rewinds		
	Total Rewinds	Green Motor Rewinds	Percentage Green Motor Rewinds
Member (N=29)	1,025	326	32%
Nonmember (N=33)	578	7	1%
Total (N=62)	**1,603**	**333**	**21%**

Horsepower of Green Motor Rewinds

Table 6 shows the green motor rewind market share in 2021 for GMPG members and nonmembers by horsepower rewound. The horsepower of green motor rewinds completed by GMPG members in 2021 represents 42% of their total horsepower rewound, and the horsepower of nonmember green motor rewinds represents 5% of their total horsepower rewound.

Table 6. 2021 Green Motor Rewind Market Share by Horsepower Rewound

	Horsepower of Rewinds		
	Total Horsepower	Green Motor Rewind Horsepower	Percentage Green Motor Rewind Horsepower
Member (N=29)	207,900	87,425	42%
Nonmember (N=33)	43,973	2,400	5%
Total (N=62)	**251,873**	**89,825**	**36%**

Table 7 shows the share of 2021 motor rewinds by horsepower and industry, with rewinds under 101 horsepower making up more than half the share of motors rewound.

Table 7. 2021 Distribution of Motor Rewinds by Horsepower and Industry

Horsepower	Horsepower of Rewinds		
	Agricultural	Industrial	Total
Less than 75	39%	47%	43%
75 to 100	19%	13%	16%
125 to 200	19%	13%	16%
250 to 500	19%	24%	21%
600 to 1,000	3%	2%	3%
1,250 to 5,000	1%	1%	1%
Total	**100%**	**100%**	**100%**

Penetration of Green Motor Rewinds

Table 8 shows the share of all GMPG member rewinds that were green motor rewinds each year since tracking started in 2013, and Table 9 shows the share of all horsepower rewound

attributable to those green motor rewinds. Between 2013 and 2021, the share of rewinds fluctuated between 21% and 36%. Additionally, the share of all horsepower rewound by GMPG members to green motor rewind specifications stayed within the range of 32% to 43% between 2013 and 2021.

Table 8. 2013 through 2021 Green Motor Rewind Market Share by Number of Rewinds

	Share of Green Motor Rewinds								
	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
GMPG Members	29%	22%	23%	33%	22%	21%	36% [1]	25% [1]	32% [1]
GMPG Nonmembers	36%	5%	12%	0%	0%	0%	1%	1%	1%

[1] The increase in the share of green motor rewinds from 2018 and 2019 is statistically significant at the 90% level (p<0.1), as are the changes in the share of motor rewinds from 2019 to 2020 and from 2020 to 2021.

Table 9. 2013 through 2021 Green Motor Rewind Market Share by Horsepower Rewound

	Share of Green Motor Rewinds								
	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
GMPG Members	34%	34%	32%	37%	38%	34%	43%	32%	42%
GMPG Nonmembers	33%	13%	22%	0%	0%	2%	2%	5%	5%

Regional Savings

Using results from the data collection efforts and RTF per-unit energy savings, Cadmus estimated regional savings for GMPG member and nonmember motor service centers resulting from green motor rewinds conducted in 2021.

In 2021, green motor rewinds performed by GMPG members resulted in an estimated annual total of 1,370,796 kWh (0.16 aMW) in energy savings. Table 10 provides annual kilowatt-hour energy savings from green motor rewinds (by state) for GMPG members and nonmembers.

Table 10. 2021 Annual Kilowatt-Hour Savings from Green Motor Rewinds

State	**Green Motor Rewind Savings (Annual kWh)**		
	Member[2]	**Nonmember**[3]	**Total**
Washington	379,930	0	379,930
Oregon	570,069	0	570,069
Idaho	373,319	0	373,319
Montana	0	47,477	47,477
Total [1]	**1,323,318**	**47,477**	**1,370,796**

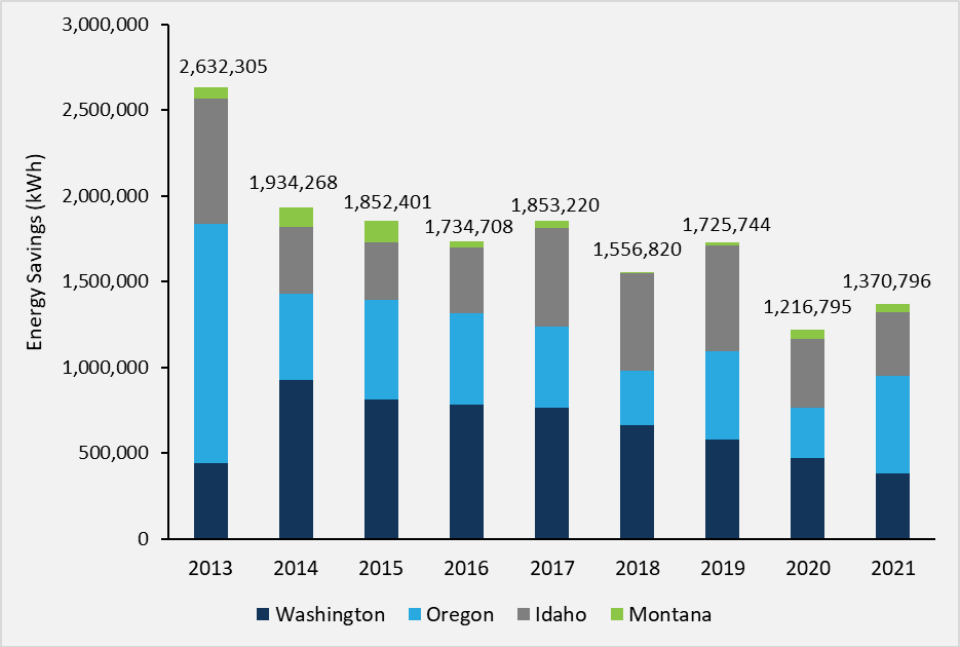
[1] Total does not equal sum of column due to rounding.

[2] Member kilowatt-hour savings reflect savings extrapolated to all member motor service centers in the population.

[3] Nonmember kilowatt-hour savings reflect savings from green motor rewinds reported from nonmembers in the sample only.

Figure 5 shows regional savings over time. Since 2013, total savings have decreased year-over-year except from 2016 to 2017, 2018 to 2019, and 2020 to 2021. Green motor rewinds performed in 2021 resulted in an estimated annual total savings of 1,370,796 kWh, up 13% from 2020 savings (1,216,795 kWh) and down 48% from 2013 (2,632,305 kWh).

Figure 5. Historical Green Motor Rewind Regional Savings



Despite the overall reduction from 2020 to 2021 in total rewinds performed (both standard and green), savings increased in 2021. This savings increase resulted primarily from an increase in the market share of green rewinds and by green rewinds in 2021 being, on average, performed on larger motors than in 2020. The average horsepower for green rewinds in 2020 was 249 compared to 278 in 2021. However, this savings increase in 2021 is overshadowed by the long-term trend in the decline of both savings and the number of rewinds.

Conclusions

The Northwest market for standard motor rewinds continued to contract. The market size of motor rewinds is highly dependent on both the number of motor service centers in business and the economics of motor rewinds versus replacement.

- As in prior years, the estimated number of all motor rewinds (standard and green combined) in the Northwest continued to decrease, falling 12% from 2019 to 2020 and 13% from 2020 to 2021. The number of all rewinds has declined 65% from 2013 (4,631 rewinds) to 2021 (1,603 rewinds).

- Fewer motor service centers performed motor rewinds in 2021 than in 2020, which continues an overall trend since 2013. Cadmus determined that 62 motor service centers (29 GMPG members and 33 nonmembers) in the Northwest market performed motor rewinds in 2021, a decrease from 64 motor service centers in 2020. The number of service centers performing motor rewinds has declined 34% since 2013, when 94 service centers performed motor rewinds.
- A variety of market factors caused some motor service centers across the Northwest to rewind fewer motors in 2021 than in 2020, while a different set of factors caused some motor service centers across the Northwest to complete more rewinds. The seven nonmember service centers that indicated they completed fewer rewinds than in 2020 gave reasons that varied from COVID-19 concerns (two survey respondents) to sales of farms (one survey respondent) and improved motor owner maintenance practices (one respondent). On the other hand, some motor service centers rewound more motors in 2021 than 2020.The eight survey respondents who indicated they completed more rewinds in 2021 gave reasons that varied from shipping delays for new motors (two nonmember and one member survey respondents) to a price increase in new motors (one member and one nonmember survey respondents).
- Cadmus' and NEEA's prior market research suggests that the Northwest motor rewind market has contracted due to less expensive, imported new motors resulting in motor replacements rather than rewinds, along with a declining number of industrial manufacturing facilities based in the United States.

The increase in savings in 2021 is primarily driven by the increase in average horsepower per green motor rewind and by a small increase in the number of green rewinds.

- Total estimated savings from green motor rewinds increased 13% from 2020 to 2021. This savings increase resulted primarily from green rewinds in 2021 being, on average, performed on larger motors than in 2020. The average horsepower for green rewinds in 2020 was 249 compared to 278 in 2021. The greater number of green rewinds in 2021 (333 green rewinds) compared to 2020 (320 rewinds) also contributed to increased energy savings. However, this savings increase in 2021 is overshadowed by the long-term trend in the decline of both savings and the number of rewinds. Estimated energy savings from green motor rewinds decreased 48% from 2013 (2,632,305 kWh) to 2021 (1,370,796 kWh).
- The slight increase in the 2021 green motor rewind market share was driven by an increase in the share of green rewinds among GMPG members and a decline in the number of nonmember motor service centers. The share of green motor rewinds increased to 21% in 2021 from 17% in 2020. The GMPG member rewind activity drove this increase, with GMPG member green motor rewinds market share increasing to 32%

in 2021 from 25% in 2020. Nonmember market share stayed consistent (1% in both 2020 and 2021).

- The sampled 2021 motor service centers did not identify any one reason for their own increase in green motor rewinds. Survey respondents provided a variety of reasons including an increase in customer base, the fact that increased use of variable frequency drives reduces motor damage so that rewinds still make economic sense, an increase in large motor failures, and a perception that green rewinds will be more profitable than standard rewinds.
- Because GMPG members historically complete more green rewinds than nonmembers, the decline in the number of nonmember motor service centers also resulted in an increase in green motor rewind market share.

Appendix A. 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 2021.
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 2021.
(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.)
Section C
Answer 5 short survey questions

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 Gerardo Aguilera-Navarrette at the Cadmus Group, at greenmotors@cadmusgroup.com or (303) 389-2520. Please also email completed forms to Gerardo Aguilera-Navarrette at the email address above, or fax to: (503) 821-7845 by December 11, 2021.
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																
200 HP																
250 HP																
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500 HP																
600 HP																
700 HP																
800 HP																
900 HP																
1000 HP																
1250 HP																
1500 HP																
2000 HP																
2250 HP																
2500 HP																
3000 HP																
3500 HP																
4000 HP																
4500 HP																
5000 HP																

Survey Questions:

1. Did your shop complete more or fewer motor rewinds in 2021 than 2020? This includes **all** motor rewinds.

   ☐**More** ☐ **Fewer** ☐ **Don't know**

2. What do you think caused the change in the number of **all** motor rewinds your shop completed in 2021?

3. Did you shop complete more of fewer **green** motor rewinds in 2021 than 2020?

   ☐**More** ☐ **Fewer** ☐ **Don't know**

4. What would you say caused the change in the number of **green** motor rewinds your shop completed in 2021?

5. Over the past few years, we have seen a reduction in the number of standard rewind and green rewinds in the Pacific Northwest. Why do you think that is?