CALIFORNIA ENERGY COMMISSION

CALIFORNIA NATURAL RESOURCES AGENCY

Clean Transportation Program

FINAL PROJECT REPORT

Manufacturing Facility for Key Electric Truck and Bus Parts

Creation of a Production Line for Medium- and Heavy-Duty Electric Vehicle Powertrain Components

Prepared for: California Energy Commission

Prepared by: Motiv Power Systems, Inc.

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PREFACE

Assembly Bill 118 (Núñez, Chapter 750, Statutes of 2007) created the Clean Transportation Program. The statute authorizes the California Energy Commission (CEC) to develop and deploy alternative and renewable fuels and advanced transportation technologies to help attain the state's climate change policies. Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013) reauthorizes the Clean Transportation Program through January 1, 2024, and specifies that the CEC allocate up to $20 million per year (or up to 20 percent of each fiscal year's funds) in funding for hydrogen station development until at least 100 stations are operational.

The Clean Transportation Program has an annual budget of about $100 million and provides financial support for projects that:

- Reduce California's use and dependence on petroleum transportation fuels and increase the use of alternative and renewable fuels and advanced vehicle technologies.
- Produce sustainable alternative and renewable low-carbon fuels in California.
- Expand alternative fueling infrastructure and fueling stations.
- Improve the efficiency, performance, and market viability of alternative light-, medium-, and heavy-duty vehicle technologies.
- Retrofit medium- and heavy-duty on-road and nonroad vehicle fleets to alternative technologies or fuel use.
- Expand the alternative fueling infrastructure available to existing fleets, public transit, and transportation corridors.
- Establish workforce-training programs and conduct public outreach on the benefits of alternative transportation fuels and vehicle technologies.

To be eligible for funding under the Clean Transportation Program, a project must be consistent with the CEC's annual Clean Transportation Program Investment Plan Update. The CEC issued PON-11-604 to provide funding opportunities to cost-share the development of manufacturing and/or assembly facilities in California that produce alternative fuel vehicles, advanced technology vehicles, and/or eligible vehicle components. In response to PON-11-604, the recipient submitted an application which was proposed for funding in the CEC's notice of proposed awards September 27, 2010, and the agreement was executed as ARV-12-032 on May 6, 2013.

ABSTRACT

As the need for emission reductions grows, fleets have evaluated a variety of technologies at the early stages of feasibility. Zero-Emission Battery-Electric Trucks have historically been plagued with higher costs, low reliability, low range, and low technology transferability between applications. These barriers have not been adequately addressed because development of this technology is costly, risky, and vehicle volumes are too low to bring in enough capital despite opportunities for emission reductions, air quality improvements, community health benefits, and operational saving opportunities.

Incumbent players controlling the market with polluting technologies like gasoline and diesel engines are not incentivized to develop technologies that would displace their current business models. Both the right partnerships and technologies are needed to leverage capital-intense production lines already in existence for traditional trucks into producing battery-electric trucks. Technology, such as the Motiv electric Powertrain Control System, are needed for these tradition truck lines to easily integrate zero-emission battery-electric powertrains.

This project allowed Motiv Power Systems to move into a higher volume production, by building a pilot production line to manufacture and demonstrate economic viability of the Motiv electric Powertrain Control System, while creating clean manufacturing jobs in one of California's economically distressed areas in Hayward, California. Over the course of this project Motiv's technology matured and is now available in several zero-emission vehicle applications including shuttle buses, school buses, work trucks, delivery trucks, and a refuse truck. The scalability of the powertrain is seen on a Ford E450 for Class 4 applications, a Ford F59 for Class 6 applications, and a Crane Carrier COE2 for Class 8 applications. The ability for powertrains manufactured on this pilot line to be integrated into both a variety of classes and applications shows that it is possible to leverage existing truck manufacturing infrastructure to deploy emerging technologies with greater reliability, lower costs, and broader market applications.

Keywords: electric, vehicle, truck, bus, heavy-duty, zero-emissions, manufacturing, controllers, zero-emission trucks, zero-emission buses, ZEV, electric powertrain, battery-electric

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EXECUTIVE SUMMARY

Motiv Power System sought to reduce the technological and market barriers that have limited the adoption of zero-emission battery-electric vehicles. Due to the high costs of technology to develop and deploy, vehicle volumes have been too low to bring in enough new capital, Motiv worked to try a capital-efficient method of challenging polluting technologies like gasoline and diesel engine by focusing on the components needed to easily integrate zero-emission systems into existing vehicle manufacturing lines. These capital-intense production lines already in existence for traditional trucks can be configured to produce battery-electric trucks if the technology is designed to be easily integrated. Motiv's electric Powertrain Control System is a zero-emission battery-electric powertrain that was proven on predecessor projects, and this project provided an opportunity to scale it into a higher volume production, starting with a pilot production line. Motiv proposed in this project to build a line capable of supporting approximately 20 of the Motiv electric Powertrain Control System vehicle control systems per month. This project offered a unique opportunity to demonstrate economic viability of the Motiv electric Powertrain Control System, while creating clean technology manufacturing jobs in one of California's economically distressed areas.

All the goals and objectives of this agreement were accomplished. However, in the process of developing the manufacturing line needed to build more zero-emission vehicle powertrains, Motiv found that rather than technology limitations being the primary barrier for fleets, it was an even blend of economic limitations and technology limitations slowing the growth of zero-emission vehicles to get out of research labs and onto the streets.

The goals of this Agreement were to:

1. Position the Motiv electric Powertrain Control System as a viable and economical zero-emission powertrain product to truck builders and fleets.
2. Establish a modern, efficient production line, which included all aspects of continuous improvement philosophy through assembly, quality control, test, and reliability analysis.
3. Improve air quality and reduce pollution in critical air basins in California and other areas around the country.

To accomplish these goals, Motiv committed to meet the following objectives:

1. Create a plan for the commercial production of the Motiv electric Powertrain Control System.
2. Demonstrate this production plan by producing a pilot build of three electric Powertrain Control System systems on a line that is capable of up to 20 systems per month.
3. Make production-level systems available for sale by the conclusion of this project.
4. Collect data on all systems produced for the first six months

Motiv Power System's design of a scalable and modular electric Powertrain that can be used on existing vehicle chassis types and by existing body manufacturers has progressed greatly since Motiv was founded in 2009. Over the last six years Motiv has developed the technology necessary to allow multiple vehicle applications to use the same base technology with reconfigurations rather than more expensive system level redesigns. This modular approach to

building vehicles was previously limited by Motiv's lack of a dedicated manufacturing facility. Over the course of this grant Motiv set out to prove the system viability, build a production line, and through system deployments improve air quality. While all goals were met, the gap between supply side progress and market level growth has led Motiv to conclude that the market level barriers will continue to be as essential a barrier to progress as the technical limitations. A state of the art zero-emission powertrain plant in a disadvantaged community can create jobs, be efficient and scalable, all while facing additional barriers to solving the pressing challenge of reducing emissions.

Motiv is proud that the powertrains built on this pilot line have been used in school buses, shuttle buses, delivery trucks, a work truck, and a refuse truck to date with more vehicle types in the pipeline. The rate of growth and technology transfer of the system as well as the manufacturing process to build the components has been a great success. However, every application has a niche market with specific needs, and programs that focus on accessories needed for applications, compliance while in development, testing and validation of next generation improvement, and infrastructure funding to ensure deployments are possible are all areas of market and program development that would help take this piloted technology to the next level on the path to widespread adoption.

CHAPTER 1:
Project Intent, Goals and Objectives

Introduction

In 2012 many of the still present barriers to zero-emission technologies were identified by Motiv Power Systems, an emerging technology provider. Barriers such as cost, risk, product stability, and range concerns were all limiting the entire field of technology providers. As a three-year-old Californian company, Motiv saw a unique opportunity to leverage California's growing commitment to sustainability with fleet's desires to reduce fuel expenditures. Motiv designed a unique system that would allow for a scalable, modular, electric powertrain that could be used in a variety of applications. Existing technology providers had greater capital costs due to a focus on vehicle level designs which were less agile, required broader expertise, greater equipment costs, and increased end use knowledge requirements to scale.

As described in the grant application for PON 11-604 which was later awarded resulting in this project:

"To secure and expand market share, Motiv adopts two strategies: (one) maintaining forward compatibility with new technology, and (two) adaptation to many truck vocations over a range of sizes, use profiles, powers, and weights using the electric Powertrain Control System's (ePCS) inherent flexibility. Strategy one prevents Motiv from being tied to component suppliers and thus becoming outdated. Strategy two allows Motiv to enter a wide variety of applications within the market with the Motiv ePCS and minimal reconfiguration."

This strategy remains core to Motiv's work as a technology provider within the alternative fuel space, and has allowed Motiv in the course of three years to expand from a single repowered shuttle bus application to being able to partner within the existing vehicle manufacturer space to power California's first all new certified all-electric Type A School bus, North America's first all-electric refuse truck, new all-electric shuttle buses, all electric delivery trucks, and an all-electric work truck. Vehicle partners since 2012 have grown to include Morgan Olson, Cumberland Servicecenter, Trans Tech Bus, Ameritrans Bus, California Truck and Equipment Company, Rockport, and Roush.

This strategy of flexible system architecture and scalable technology has proven itself as a viable means to introduce common components into a variety of use cases, however the rate of adoption has proven to be a slower and a much more multi-stakeholder process than originally anticipated. With many fleets choosing their suppliers based upon past relationships rather than a merit review of technologies, close partnerships must be forged for a technology to begin to establish a foothold in the market prior to being able to scale. Many of these partnerships are well underway with Motiv-powered applications beginning to enter fleet use, however the volume of commercialization in initial projections reflected optimism beyond what the market demand, level of builder commitment, depth of supply chain, and internal resources could support. Public policy has increased the use of incentives, grant funding opportunities, pilot demonstrations, and studies to provide fleets with greater support and reduce the capital expenditures necessary to move away from legacy solutions into zero-emission options, and such incentives and programs will likely be needed for the foreseeable

future to help improve air quality, reduce emissions, and support the emerging market for clean transportation solutions.

Problem Statement

Battery-electric trucks have to date been plagued with high cost, low reliability, and low electric range. These technological and market barriers have limited the adoption of these vehicles. These barriers have not been addressed because development of this technology is costly and risky, and vehicle volumes are too low to bring in enough new capital. Incumbent players already control the market with more polluting technologies like gasoline and diesel engines, and they do not have enough incentives to develop new technologies. The right partnerships and technologies are needed to leverage capital-intense production lines already in existence for traditional trucks into producing battery-electric trucks. Technology, such as the Motiv electric Powertrain Control System, is needed for these tradition truck lines to easily integrate zero-emission battery-electric powertrains. Our base technology has been proven on predecessor projects, and this project provided an opportunity to move into a higher volume production, starting with a pilot production line proposed in this project to be built with the capability of supporting approximately 20 of the Motiv ePCS vehicle control systems per month. This project offered a unique opportunity to demonstrate economic viability of the Motiv ePCS, while creating clean technology manufacturing jobs in one of California's economically distressed areas.

Goals of the Agreement

The goals of this Agreement:

1. Position the Motiv ePCS as a viable and economical zero-emission powertrain product to truck builders and fleets.
2. Establish a modern, efficient production line, which will include all aspects of continuous improvement philosophy through assembly, quality control, test, and reliability analysis.
3. Improve air quality and reduce pollution in critical air basins in California and other areas around the country.

Objectives of the Agreement

To accomplish these goals, the project team will meet the following objectives:

1. Create a plan for the commercial production of the Motiv ePCS.
2. Demonstrate this production plan by producing a pilot build of three ePCS systems on a line that is capable of up to 20 systems per month. This plan will include:
   - Assembly drawings, manufacturing work instructions, and bill of materials for the assembly areas
   - Quality control procedures for the quality control stations
   - Test plans for the test stations
   - Procedures for the Return Materials Authorization analysis center
3. Make production-level systems available for sale by the conclusion of this project.
4. Collect data on all systems produced for the first six months in order to obtain the following information:
   - Average build time

- Rejection rate on the line
- Return rate to Return Materials Authorization analysis center
- Number of installed systems
- Total fleet miles logged

CHAPTER 2:
Work Performed, Data and Results

This chapter reviews the activities performed as a part of the project, presents data collected during the project and reports the results of the activities.

Work Performed

During the agreement, Motiv staff planned and created a manufacturing facility to produce Motiv's electric truck and bus powertrain controllers. This manufacturing facility was initially sub-let inside Airtronics Metal Products at 1991 Senter Rd, San Jose, CA. During the project, the facility was relocated to a commercial property leased by Motiv for this purpose at 3510 Breakwater Ave, Hayward, CA.

Over the course of the agreement, between April 2013 and March 2016, Motiv manufactured the following components:

150 Adaptive Power Converters, 26 system controllers, 23 Auxiliary Power Units, 21 motor controllers, 50 auxiliary motor controllers, and 31 chargers.

The technical work of this project was divided into establishing the following areas of the manufacturing line:

- Assembly Area
- Test Station
- Quality Control Station
- Shipping, Receiving and Stock Room Areas
- Return Materials Authorization Area

Figures 1 through 6 show the five areas listed above.

Figure 1: Assembly Area of Motiv's Manufacturing Facility

Source: Ernest Marquez, Motiv

Figure 2: Test Station

Source: Ernest Marquez, Motiv

Figure 3: Quality Control Station

Source: Ernest Marquez, Motiv

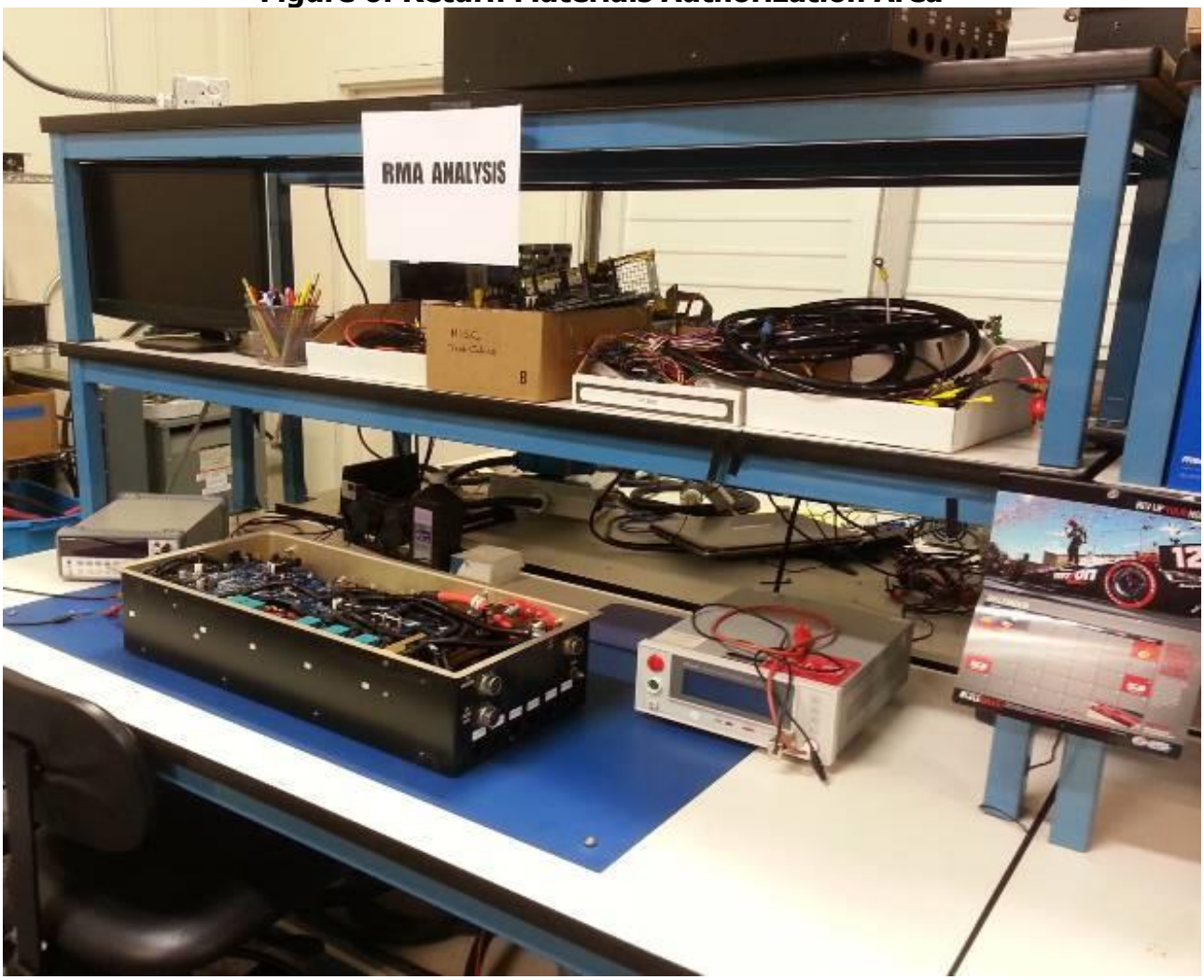
Figure 4: Stock Room

Source: Ernest Marquez, Motiv

Figure 5: Shipping and Receiving Area

Source: Henry Siller, Motiv

Figure 6: Return Materials Authorization Area



Source: Ernest Marquez, Motiv

After the manufacturing facility was set up, a pilot run was performed. A report of this pilot run, titled Manufacturing Pilot Run Report (2.6), was submitted to the CA Energy Commission on September 27, 2014.

Data Collected

After the pilot run, the manufacturing line went into operation. During the operation of the line, data was collected on the timing of the line and failure rates, returned goods, total miles logged on produced parts, and total installed unit count which can be found in Table 1.

Table 1: Number of Installed Parts

Part	# Installed	Production Notes
Adaptive Power Converter	90	
Auxiliary Power Unit	13	No longer used on latest Version of ePCS
Charger	16	
System Controller	16	
Motor Controller	14	
Auxiliary Motor Controller	30	

Source: Motiv Manufacturing Data

Motiv-powered vehicles using the above components have logged over 82,000 miles to date.

Production line timing and failure rates are confidential to Motiv; however, Motiv has made the following improvements based on data collection and use:

- 23 percent reduction in the total hours required to build an Adaptive Power Converter
- 32 percent reduction in the total hours required to build a complete powertrain system[1]
- 92 percent reduction in total test time for a complete powertrain system
- 15 percent Improvement in throughput/reduction in re-test/etc.

Results

The results of this project are a capable, operational, flexible manufacturing facility located in a disadvantaged community in Hayward, CA, which is producing the electronic parts for electric trucks and buses being fielded in California and beyond.

The manufacturing facility employs state-of-the-art testing, including testing methodology patented by Motiv during the course of the project which reduces facility power requirements by as much as 90 percent.

Most of the current staff of the manufacturing facility have been trained as assembly lead technicians, which means they can work all the different stations as needed. They are also capable of training new technicians, enabling faster production capacity growth as market demand increases.

The capacity of the manufacturing facility is sufficient to produce all the necessary electronic control parts for 50 electric trucks or buses each month. This is in excess of the original project goal which was to produce the systems for 20 vehicles per month.

[1] Complete powertrain system is based on 5-battery F59 configuration

CHAPTER 3:
Assessment of Project Success

Advancements in Science

Motiv filed one patent during this project, protected a novel method for testing power electronics. Using this mothed, Motiv was able to dramatically reduce the power electronics test bench cost, size and power consumption and reported the results in a peer-reviewed publication and conference presentation with the Institute of Electrical and Electronics Engineers[2]. Power consumption to the entire facility was dramatically reduced as a result. Motiv accomplished standard power electronics "burn-in" testing using as little as 10 percent of the typical required power for such testing, on a test bench built for roughly one-tenth of the cost of a typical test bench used for the same purpose. For reference, the power device under test operated up to 30 kilowatts, and the power required for test was reduced from 30 kilowatts to 3 kilowatts which still testing the full operating range of the device under test.

Project Goal Accomplishment

The goals of the agreement can be found in Chapter 1. All three goals have been completed accomplished during this project.

Goal 1

The Motiv ePCS is now a viable and economical zero-emission powertrain product purchased and used by truck builders and fleets.

At the beginning of this project Motiv marketed this ePCS in a standalone manner and discussed the technical merits of the system. However, over the course of this project as production scaled up, Motiv has recognized additional barriers to market based upon knowledge gaps existing builders had regarding the optimal configuration of the Motiv ePCS on a chassis. To ensure the ePCS works as designed, Motiv has transitioned to marketing the Motiv ePCS as a part of a Motiv Powertrain Upfit Kit, which includes the Motiv ePCS, batteries, motor, cables, brackets, and auxiliary system power. These commercial kits are available in three configurations shown in Figure 7 below: A Ford E450 Upfit Kit for Class 4 applications, a Ford F59 Upfit Kit for Class 6 applications, and a Crane Carrier COE2 Upfit Kit for Class 8 applications. These kits help builders by allowing a body builder to purchase an electrified chassis that is able to have a body built on top of it in the same assembly lines as its diesel counterparts. Present applications built using Motiv Powertrains include a Type A school bus, a shuttle bus, a walk-in style delivery van, a cargo port style delivery van, a flatbed work truck with a dump bed, and a rear loader style refuse truck. The variety of applications with differing auxiliary power needs, operational power needs, and configurations has shown potential vehicle partners the inherent flexibility of the Motiv technology.

Motiv has strategically partnered with vehicle builders who bring critical knowledge of end use applications to ensure the final vehicle applications meet fleet needs. Furthermore, by selling

[2] Publication and conference presentation with the Institute of Electrical and Electronics Engineers
http://ieeexplore.ieee.org/xpl/articleDetails.jsp?reload=true&arnumber=7165829

the Motiv ePCS within an upfit package as seen in Figure 8, Motiv has ensured there is no knowledge gap between the technology provider and the builder that could adversely impact the end use application. Figure 9 below shows various types of All-electric Zero-Emission using Motiv powertrains.

Each of the vehicle types in the figure above is made by a different vehicle manufacturer. All have been able to successfully integrate the Motiv Powertrain into a vehicle with the body designed for legacy technologies. This is key to Motiv's success in reducing overall capital costs associated with bringing new all-electric vehicles to market. Unlike companies who build complete vehicles, this allows Motiv to maintain expertise in a limited segment of the market while addressing the broader emission concerns of the transportation sector, and more easily accessing markets of scale through partners.

In addition to the manufacturing capacity needed to build these vehicles, there was additional support of other public programs needed to allow the components to go from being parts, to being part of finished vehicles. This is an emerging industry, and each application requires some specification with the new partners. California has supported the work necessary to achieve this growth as demonstrated in multiple grant projects that allowed Motiv powered vehicles to be demonstrated. California Energy Commission grants that specifically helped in this process include ARV-11-014 for the build and demonstration of four new medium-duty all-electric trucks and buses and ARV-13-010 for repowering five Walk-In Vans for AmeriPride in Vernon, California. ARV-11-014 allowed Motiv to apply the powertrain in both new shuttle buses and a work truck application, and ARV-13-010 expanded the electric vehicle offering to include delivery vans. The joint support for scaling manufacturing and increasing applications have allowed this technology to progress from a single application to multiple over the course of three years.

While both the public support and development of new vehicle partners was key to the success of achieving the desired applications and laying the groundwork for a more robust zero-emission vehicle portfolio, the increased time investment to develop such partnerships also meant the initial growth was slower than projected. The need for funding to support such development has also meant that while moving forward it is key engage in policy efforts that shape the industry and can either accelerate or impede growth beyond the technical scope of work within projects. For example, two recently awarded grants ARV-14-004 to build five school buses and ARV-14-050 to build three refuse trucks, are in the pipeline and will use components manufactured on this line. However, due to the time needed to engage with the relevant agencies, that timeline will not fall within the scope of this project. Nevertheless, those projects will continue to benefit from this project and the ongoing work done on the line.

Goal 2

Motiv has established an efficient production line using Lean Manufacturing techniques where each assembly station performs a set function and only has the materials and tools to perform that function. All personnel are cross trained in each of the functions. The units are moved from station to station in a flow, instead of being built in lots. This helps to reduce rework and waste.

Motiv has also incorporated a Continuous Improvement and Quality Control Program where periodic reviews are done of the work being performed and any discrepancies. All Manufacturing personnel are encouraged to make suggestions for improvements in cost or

efficiency using a Change Order process and by using data collection for Root-Cause Analysis of discrepancies, Motiv is made to make corrections in designs and provide Supplier feedback for Quality improvement.

Goal 3

Motiv successfully improved air quality and reduced pollution in critical air basins in California and other areas around the country. Specifically, Motiv-powered electric trucks and buses have offset over 82,000 miles of diesel or gasoline vehicle operations with zero-emission vehicle operations in the California cities and areas surrounding Mountain View, Reedley, Santa Ana, Hayward, and Vernon. Additionally, Motiv-powered trucks and buses have offset gasoline and diesel vehicles in Chicago, IL and on Long Island, NY.

Project Objective Accomplishment

The objectives of this project can be found in Chapter 1. All objectives were fully accomplished, as explained below.

Objective A

A plan for the commercial production of the Motiv ePCS was created and then implemented, resulting in the operational manufacturing facility that Motiv continues to run.

Objective B

Motiv demonstrated its production plan by producing a pilot build of three ePCS systems on a line that is capable of more than 20 systems per month. The actual number of systems per month this manufacturing line is capable of is 50 systems. The manufacturing production process included assembly drawings, work instructions, and bills of materials for the assembly areas. Plans also included quality control procedures and after the test plans for the test stations were included, they were completely automated, so that testing consisted of connecting the part to the test bench, scanning the barcode of the part, initiating the test with single button press, receiving pass/fail result, with the test results automatically saved and indexed by serial number. Procedures for the Return Materials Authorization analysis center were implemented.

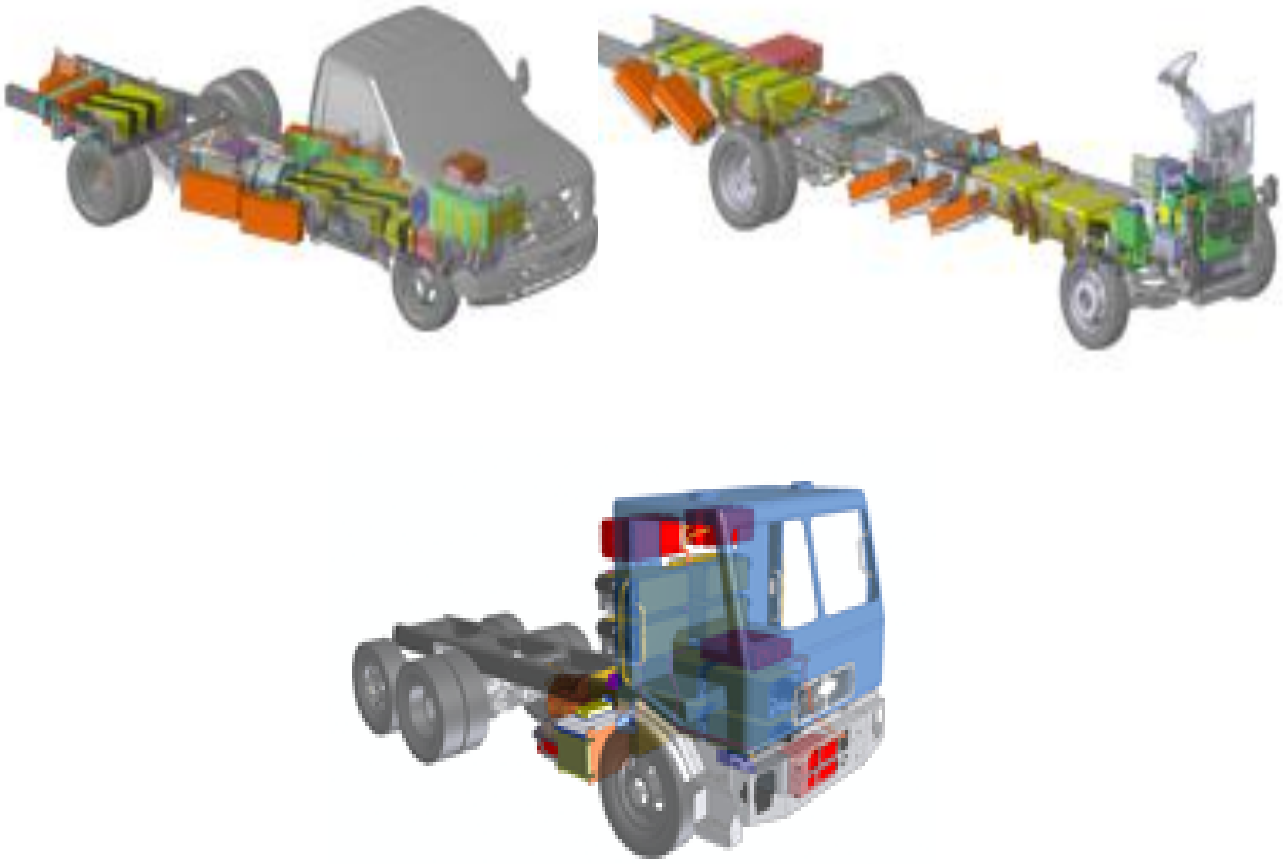
Objective C

Production-level systems are available for sale and have been sold to vehicle builders and fleets which have used these systems in vehicles in operation in California and beyond.

Objective D

Data was collected on all systems produced for the first six months which revealed average build time, rejection rate on the line, return rate to Return Materials Authorization analysis center, number of installed systems and total fleet miles logged. The non-confidential parts of this data set are presented in Chapter 2 which also presents examples of how the confidential data was used to improve manufacturing processes.

Figure 7: Motiv Chassis Upfit Packages: Ford E450, Ford F59, and Crane Carrier COE2



Source: Motiv Mechanical CAD renderings, formatted by Urvashi Nagrani, Motiv.

Figure 8: A Work Truck Built on the Ford E450 Chassis Using the Motiv ePCS

The Utility Box behind the cab is for tool storage and not powertrain components.

Source: California Truck Equipment Company, CTEC. Notation from Urvashi Nagrani, Motiv.

Figure 9: Applications of Motiv Powertrains on All-Electric Zero-Emission Vehicles.

From Left to Right: Shuttle Bus, Cargoport, Walk-in-Van, Refuse Truck, School Bus, and Motiv ePCS component on a chassis

Source: Urvashi Nagrani (All left images and bottom right) and Nash Witkin (Top two right images), Motiv

Table 2 shows where vehicles have been fielded.

Table 2: Motiv-powered Vehicles Fielded

Location	# Motiv-powered Zero-emission Vehicles
Mountain View, CA	6
Reedley, CA	4

Location	# Motiv-powered Zero-emission Vehicles
Vernon, CA	2–3
Hayward, CA	1
Chicago, IL	1
Long Island, NY	1

Source: Motiv Vehicle Delivery Data

CHAPTER 4:
Conclusion

Summary of Results

This project has been very successful at achieving Motiv's goals. The project was begun with three goals, all of which have been achieved:

Goal One: The Motiv ePCS is now a viable and economical zero-emission powertrain product purchased and used by truck builders and fleets.

Goal Two: Motiv has established an efficient production line using Lean Manufacturing techniques.

Goal Three: Motiv successfully improved air quality and reduced pollution in critical air basins in California and other areas around the country through offsetting over 82,000 miles of diesel or gasoline vehicle operations with zero-emission vehicle operations.

All defined objectives have been accomplished.

Objective A: A plan for the commercial production of the Motiv ePCS was created and then implemented.

Objective B: Motiv demonstrated its production plan by producing a pilot build of three ePCS systems on a line that is capable of 50 systems per month

Objective C: Production-level systems are available for sale and have been sold to vehicle builders and fleets which have used these systems in vehicles.

Objective D: Data was collected on all systems produced for the first six months which revealed average build time, rejection rate on the line, return rate to Return Materials Authorization analysis center, number of installed systems and total fleet miles logged.

Barriers and Opportunities

Based upon the project success Motiv believes continued funding for projects like this is essential to ensure the next generation of technology providers have the resources needed to demonstrate the feasibility of manufacturing their clean technologies in California.

It is full integration into the vehicle market that will lead to the actualization of emission reduction targets, air quality improvement, and economic development within the State of California, and this market and its needs are still in its infancy.

Barriers and opportunities for improvement are outlined below.

Accessory System Integration Funding

The number of systems actually manufactured on this line was lower than Motiv's initial target due to optimistic forecasts that did not fully recognize the complexity of growing the zero-emission vehicle market. While our system could easily power the vehicles, the heating and cooling needs of passenger vehicles, and some of the auxiliary systems for work trucks require components that are not yet ruggedized and/or have few suppliers. The lack of options on high powered components has been a barrier to providing the same quality level fleets expect and is a barrier to growing the portfolio of zero-emissions vehicle offerings. The powertrain

performance only accounts for the driving needs of fleets, and with the diversity of truck and bus applications, funding to provide incentive to develop more robust accessories would reduce that barrier. This is a key ingredient to market viability of the technology beyond the base vehicle technology.

Streamlining Compliance Mechanisms

Certification of Zero-Emissions vehicles is an evolving process. While the lack of emissions means no such certification is needed to sell a vehicle in California, to be eligible for programs such as The California Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project, vehicles must receive a letter from the California Air Resources Board indicating the vehicle itself is zero-emission. Streamlining this process would allow grant recipients to spend more resources on the technology development, design, manufacturing, and deployment and fewer resources on trying to summarize new research in evolving forms that may become outdated.

Increase Funding for Testing

While there is a substantial pool of funds invested in clean technologies, there is a gap between the steps of the pipeline which include initial level research, initial deployments, and large pilots. There is little funding for design iterations. In the process of building this facility, design reviews of the manufacturing process showed there were opportunities to revisit initial component design to make better components. Design improvements can lead to greater efficiencies, cost reductions in the end-product, and better serve both customer fleets and the communities in which they operate; however, the cost of design improvements can be high. Small companies often cannot afford immediate design improvements, and so they delay such improvements. The result is that more early-design-stage products get on the road, which ultimately become a liability. Past electric truck companies which are no longer actively operating were significantly damaged by this problem. Projects which would support California's emission reduction goals are sometimes abandoned for lack of funding for design improvements rather than technical feasibility.

Infrastructure Must Be Considered

While working with potential fleets, a key barrier to selecting a zero-emission electric vehicle we encountered, was the cost of upgrading facilities to account for the charging needs. Beyond the cost of the charge station, fleets in disadvantaged communities also had to account for older facilities with less power in the building than modern industrial spaces. While incentives such as The California Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project help with the vehicle side, there is little assistance with industrial charging infrastructure, and many programs for charge stations specifically focus on residential light duty needs. This demand-side concern can range from an additional $5,000 for a charger only in an area with adequate power access to hundreds of thousands of dollars for new substations, trenching, wiring, and construction costs.

GLOSSARY

CALIFORNIA ENERGY COMMISSION (CEC)—The state agency established by the Warren-Alquist State Energy Resources Conservation and Development Act in 1974 (Public Resources Code, Sections 25000 et seq.) responsible for energy policy. The CEC's five major areas of responsibilities are:

1. Forecasting future statewide energy needs.
2. Licensing power plants sufficient to meet those needs.
3. Promoting energy conservation and efficiency measures.
4. Developing renewable and alternative energy resources, including providing assistance to develop clean transportation fuels.
5. Planning for and directing state response to energy emergencies.

Funding for the CEC's activities comes from the Energy Resources Program Account, Federal Petroleum Violation Escrow Account, and other sources.

ELECTRIC POWERTRAIN CONTROL SYSTEM (ePCS)—a single platform that can electrify any truck or bus chassis with a variety of commercially-available battery packs and motors that are upgradable over time. The ePCS is installed instead of an engine and transmission on new incomplete chassis such as the Ford E450, as a ship-through modification.[3]

[3] Motiv Article (https://www.motivps.com/news/motiv-power-systems-wins-popular-sciences-2014-best-of-whats-new-award-in-green-category/)