



Project ID: TA011

FedEx Express Hydrogen Fuel Cell Extended-Range Battery Electric Vehicles

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May 1, 2019



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Project Main Objectives

| DOE Project Objectives | | Project Impact | |
|---|--|--|--|
| Demonstrate / deploy hydrogen and fuel cell technologies in real-world environments. | | 20 parcel delivery trucks will operate one shift 260 days annually for approximately 10 hours per day. | |
| Ancillary Objectives | | Project Impact | |
| Operate 5,000+ hours | | Over approx. 1.92 years, this amounts to approximately 5,000 hours per truck. Total fleet activity is 100,000 hours annually. (Numbers represent minimum.) | |
| Reduce petroleum consumption | | Each diesel truck uses 2,600 gallons per year. The program will reduce diesel consumption by 100,000 gallons over ~1.92 years. | |
| Reduce emissions | | A net of 270 metric tons of CO2 will be prevented. | |
| Potential Expansion | | | |
| Similar Assets & Duty Cycles (count) | | 7000 | |
| Annual Utilization Range (miles) | | 20k - 50k | |
| Approx Annual Fuel Displaced (gal) | | 14M | |
| Annual CO2 Avoided (Metric Tons) | | 69,500 | |

Program Overview

Hydrogen Fuel Cell Extended-Range Battery Electric Vehicles Demonstration

- \$3.0 million from Department of Energy
- Integration of fuel cells into 20 battery electric pickup and delivery vehicles, PUDs
 - **BP1 – 1 truck**
 - Design
 - Integrate & test fuel cell systems
 - Safety
 - Communication
 - Performance
 - Reliability
 - Validate in revenue service
 - **BP2 – 19 trucks**
 - Integrate hydrogen fuel cell systems
 - Operate in revenue service in Memphis, TN and locations in CA

Program Overview

Timeline

- Grant awarded – October 2015
- Kickoff meeting – May 2016
- Project end – March 2021
- Project completion - < 5%
 - Phase 1 – 99.9% complete

Budget

- DOE – \$3.0M
- Partners – \$3.367M

Barriers

- Unknown ability to meet safety, performance & reliability needs
- Variable energy requirements
 - Route differences
 - Parasitic losses (HVAC, ancillary systems, effects of temperature)
- Fuel availability

Partners

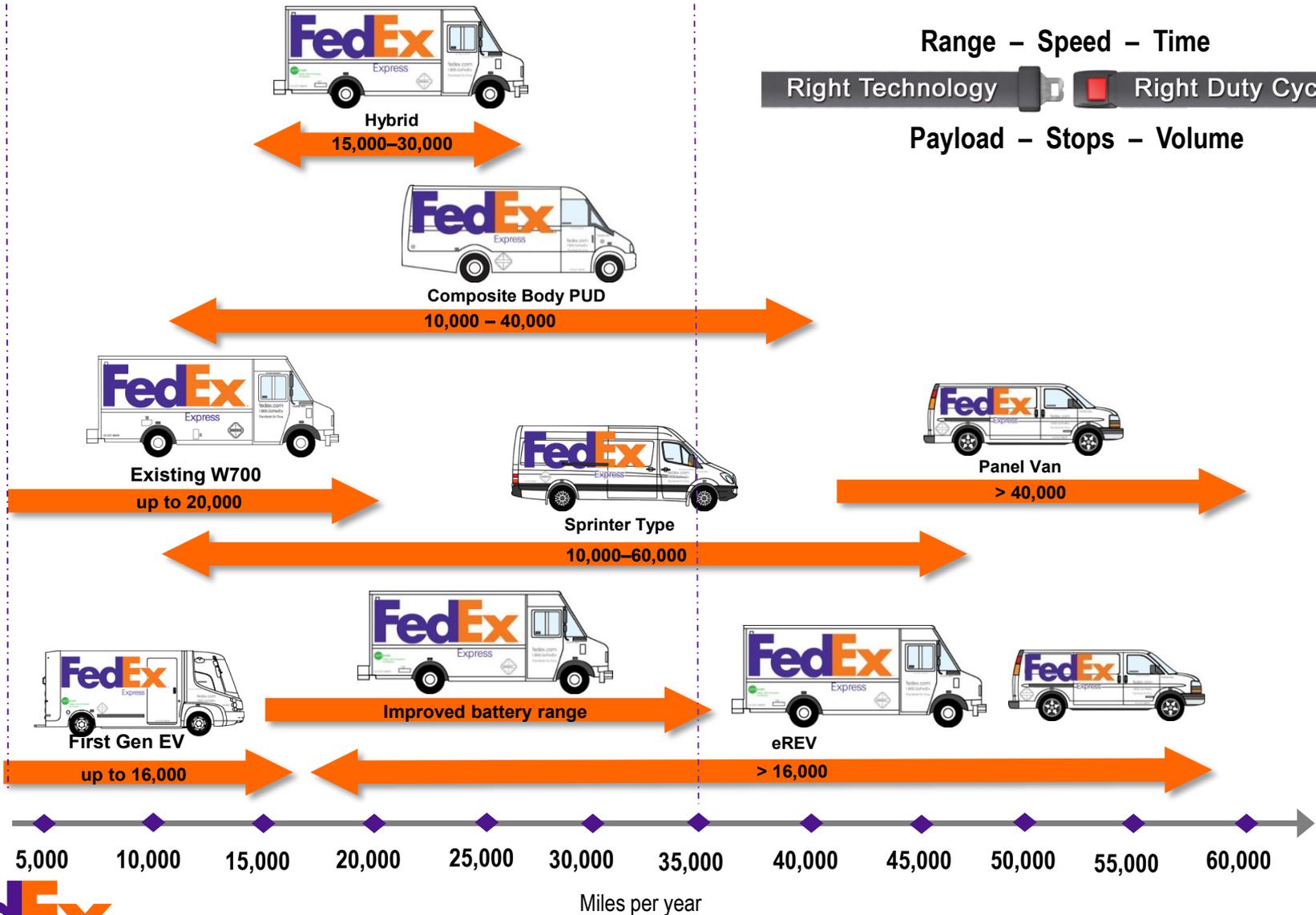
- U.S. Department of Energy
- FedEx Express – Prime recipient
- Plug Power – Fuel cell manufacturer
- Workhorse Group – Truck manufacturer

Relevance

Objective

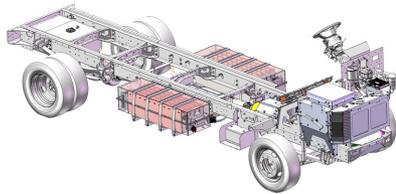
- **Budget Period 1 Go/No-Go Decision Point**
 - **Availability:** Operate the first unit under real world conditions with a down time of the truck due to the fuel cell system or fuel cell integration no more than 7%.
 - Reliability must be 93% or greater to be considered a viable alternative.
 - **Sufficient Energy:** Parcel delivery truck with a battery and fuel cell that are sized for optimal use to increase the range to 150 miles under a typical FedEx load profile.
 - **Safety:** Safety criteria able to be met.

Relevance: Mileage Management

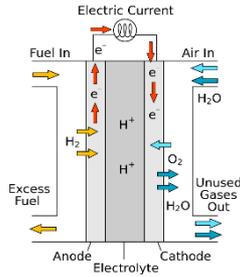


Approach

Chassis



Fuel Cell



Integration



Commissioned



Durability Test



Body Installation



Utilized on Routes



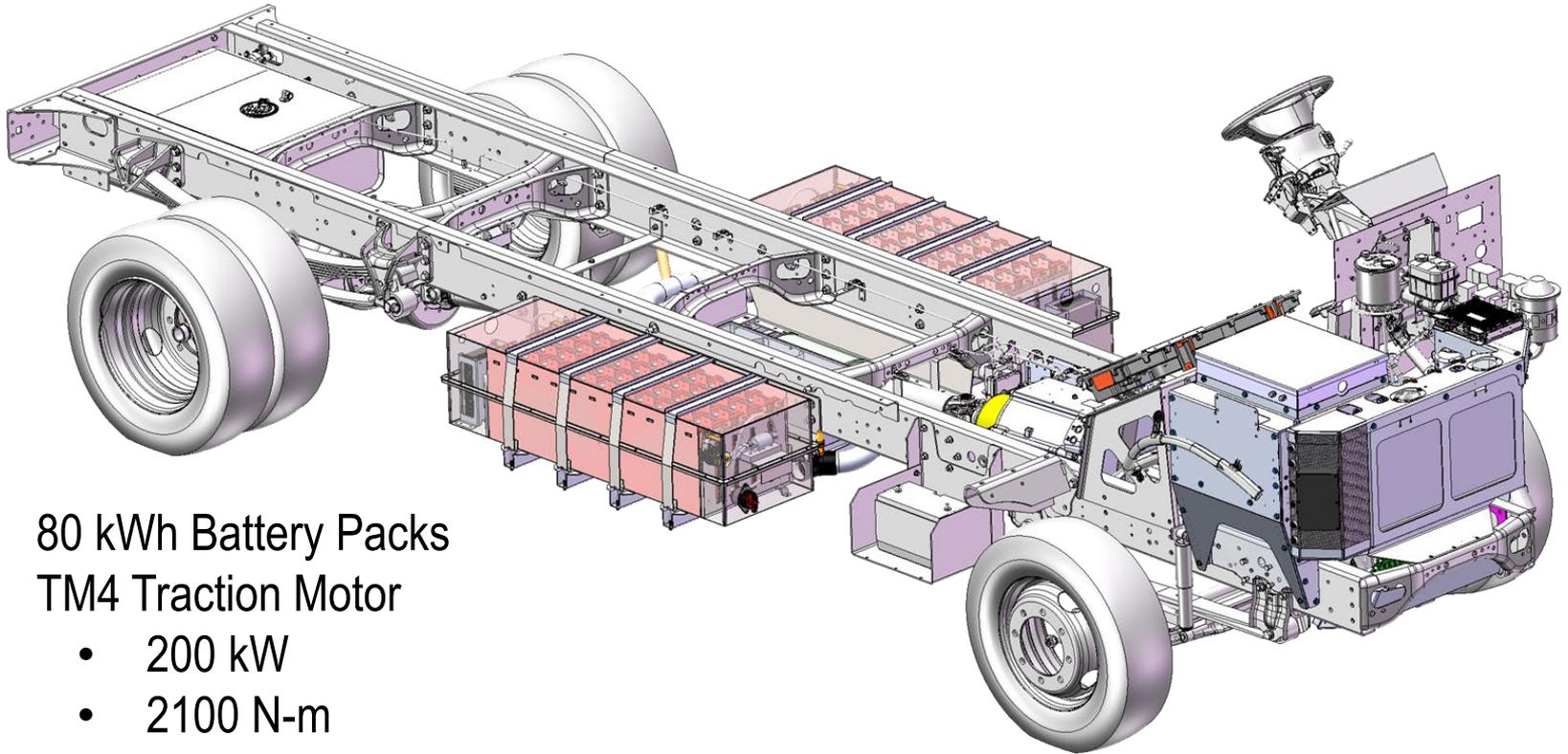
Data transmitted to NREL



Results evaluated

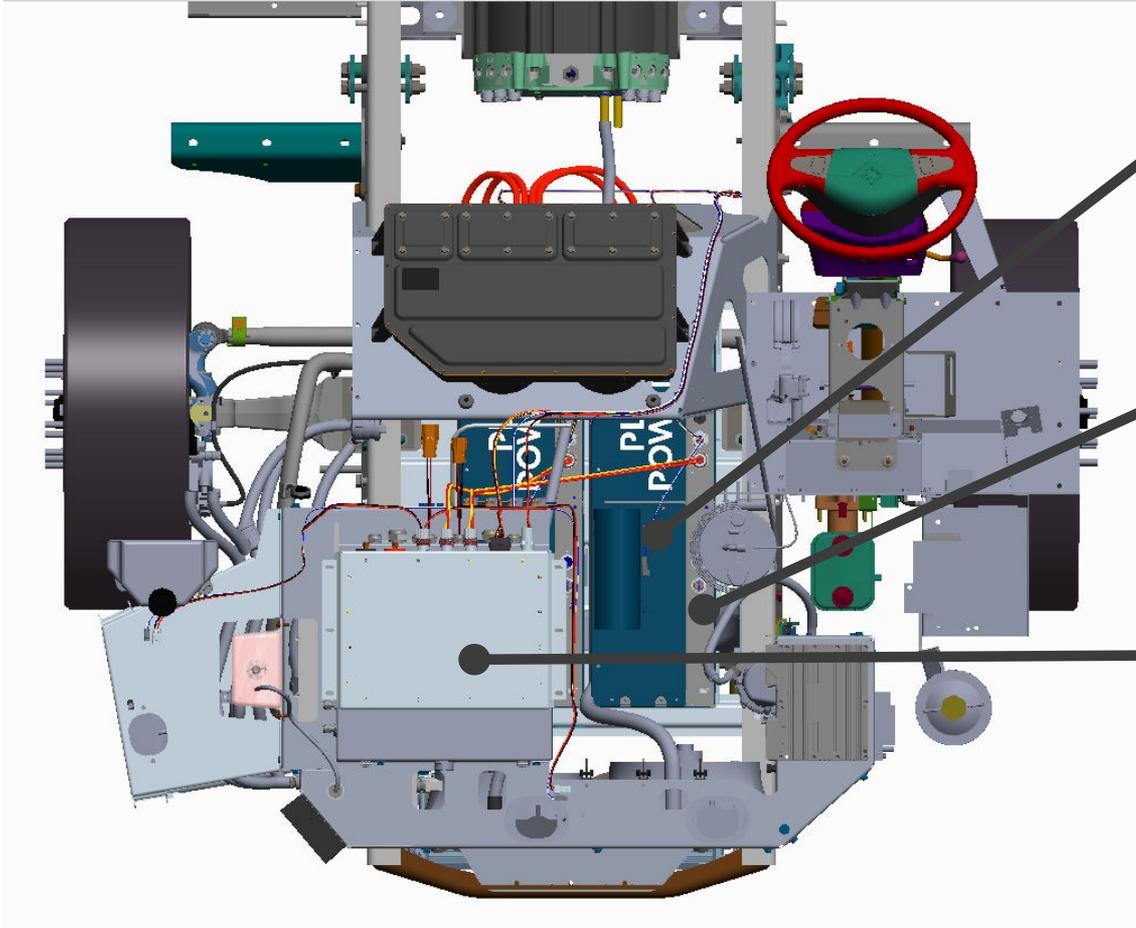


Approach: Workhorse Chassis



- 80 kWh Battery Packs
- TM4 Traction Motor
 - 200 kW
 - 2100 N-m

Technical Accomplishments and Progress: Power Generation / Vehicle Connection



10 kW Fuel Cell System x 2

- Power: 20 kW total
- Voltage Output: 48VDC

DC/DC Converter x 2

- Buck / boost dual functionality
- Voltage Output: 310-430VDC

Vehicle HV Junction Box

- Common bus for batteries and fuel cell / converter output

Milestones

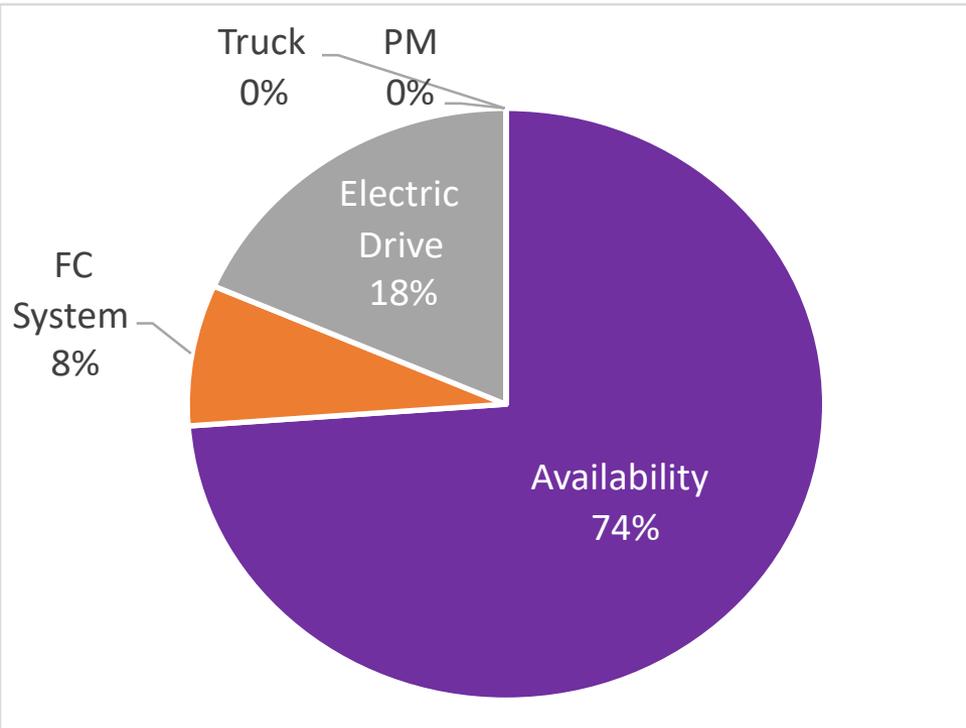
| Element Type (Task or Milestone) | Task Number (Milestone Number) | Subtask Number (if applicable) | Task Title (Milestone Description) | Task or Milestone Completion Date | | | |
|---|--------------------------------|--------------------------------|--|-----------------------------------|-----------------|------------------|----------------------------|
| | | | | Original Planned | Revised Planned | Actual Completed | Current % Complete (0-100) |
| Task 5: First Unit Validation (8 months) | | | | | | | |
| Task | 5 | 5.1 | Durability Testing | 6/1/2017 | 12/13/2017 | 1/25/2018 | 100% |
| Task | 5 | 5.2 | Delivery of Truck #1 to FedEx Menands for testing | 6/19/2017 | 12/13/2017 | 1/25/2018 | 100% |
| Task | 5 | 5.3 | Driver/Personnel Training | 6/20/2017 | 12/14/2017 | 1/23/2018 | 100% |
| Task | 5 | 5.4 | Commissioning | 6/21/2017 | 12/15/2017 | 1/30/2018 | 100% |
| Task | 5 | 5.5 | Test and Validation of Unit #1 vehicle and powertrain requirements | 6/21/2017 | 12/13/2017 | 1/25/2018 | 100% |
| Task | 5 | 5.6 | Data Analysis | 9/30/2017 | 4/30/2019 | | 95% |

Milestones

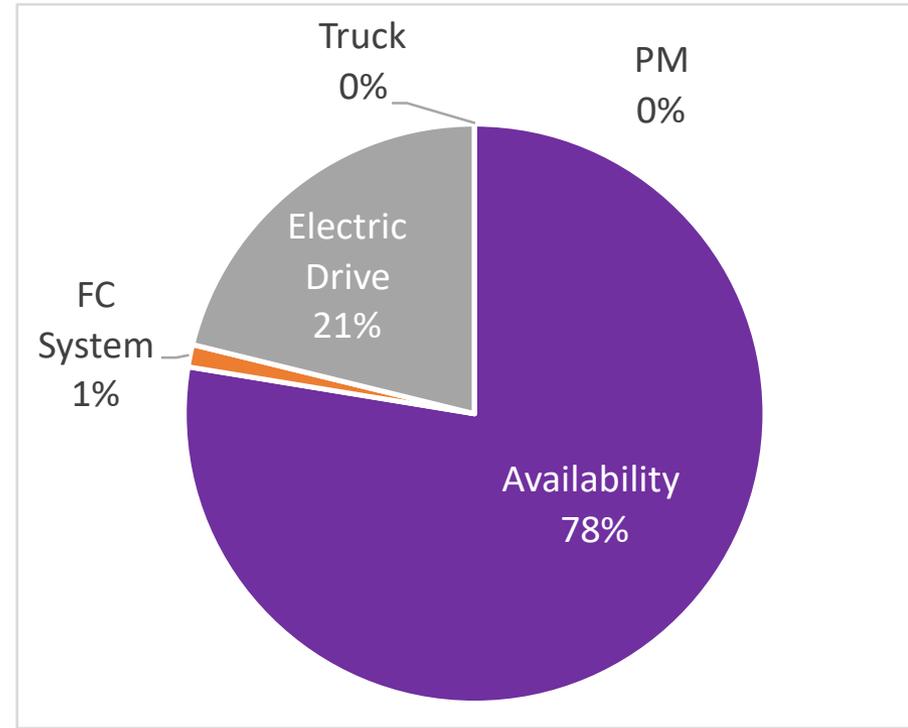
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| Task 5: First Unit Validation (8 months) | | | | | | | |
| Task | 5 | 5.6 | Data Analysis | 9/30/2017 | 4/30/2019 | | 95% |
| Task | 5 | 5.6.1 | Data Transmission to DOE/NREL-1 st Feb-Mar | 9/30/2017 | 4/15/2018 | 4/27/2018 | 100% |
| Task | 5 | 5.6.2 | Data Transmission to DOE/NREL-2 nd Apr-Jun | | 7/15/2018 | 7/27/2018 | 100% |
| Task | 5 | 5.6.3 | Data Transmission to DOE/NREL-3 rd Jul-Sep | | 10/31/2018 | 11/10/2019 | 100% |
| Task | 5 | 5.6.4 | Data Transmission to DOE/NREL-4 th Oct | | 11/30/2018 | 11/30/2018 | 100% |
| Task | 5 | 5.6.5 | Data Transmission to DOE/NREL-5 th Nov | | 12/31/2018 | 1/4/2019 | 100% |
| Task | 5 | 5.6.6 | Data Transmission to DOE/NREL-6 th Dec | | 1/31/2019 | 1/31/2019 | 100% |
| Task | 5 | 5.6.7 | Data Transmission to DOE/NREL-7 th Jan | | 2/28/2019 | 2/28/2019 | 100% |
| Task | 5 | 5.6.8 | Data Transmission to DOE/NREL-8 th Feb | | 3/31/2019 | 3/22/019 | 100% |
| Task | 5 | 5.6.9 | Data Transmission to DOE/NREL-9 th Mar | | 4/30/2019 | | |
| Milestone | 5 | 5.0 | Evaluation Document of First Unit Performance | 9/30/2017 | 4/30/2019 | | 70% |

Technical Accomplishments and Progress: Overall Availability

Data from Mar 2018 – Feb 2019

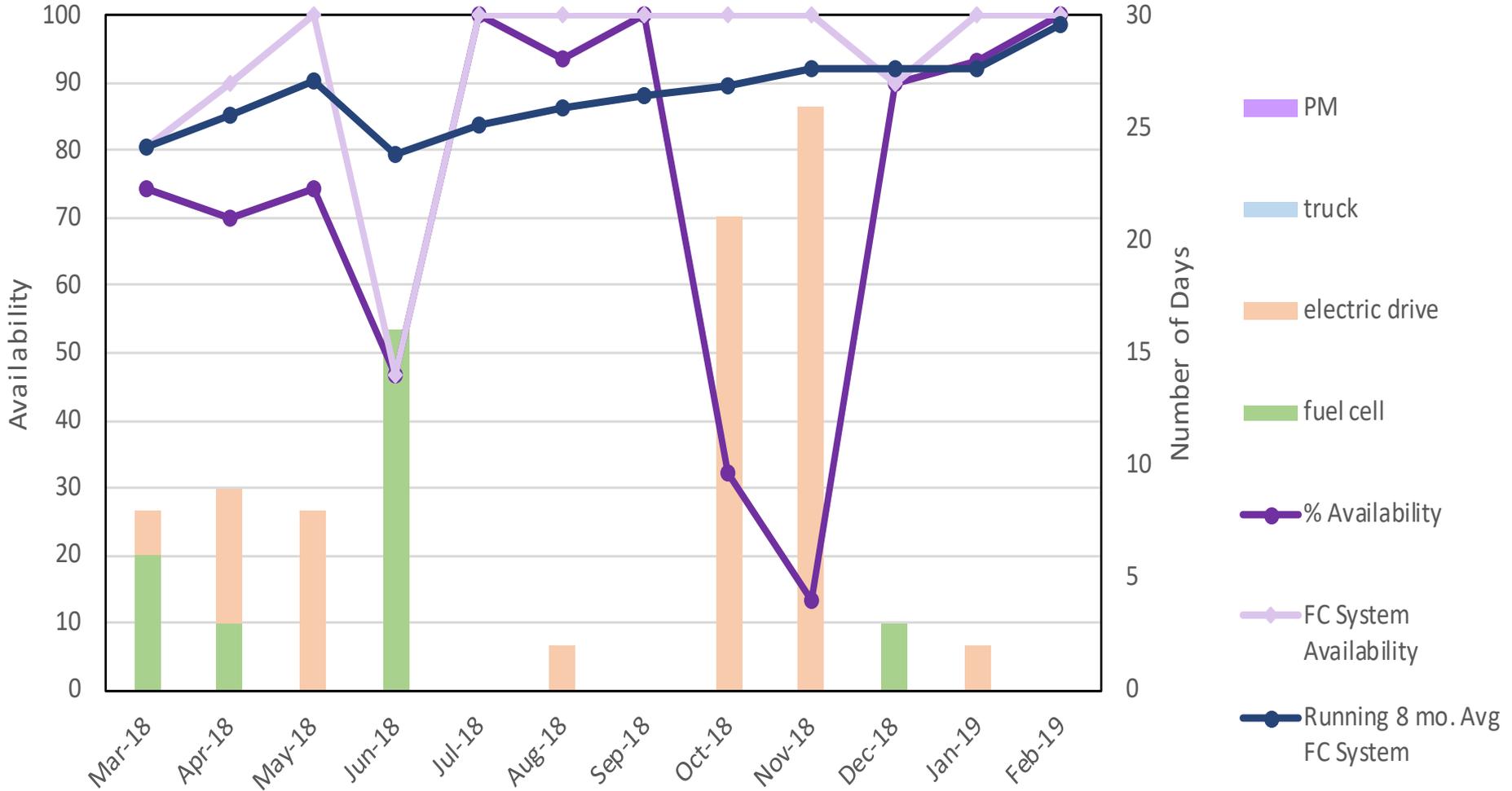


Last 8 months as of Feb 2019

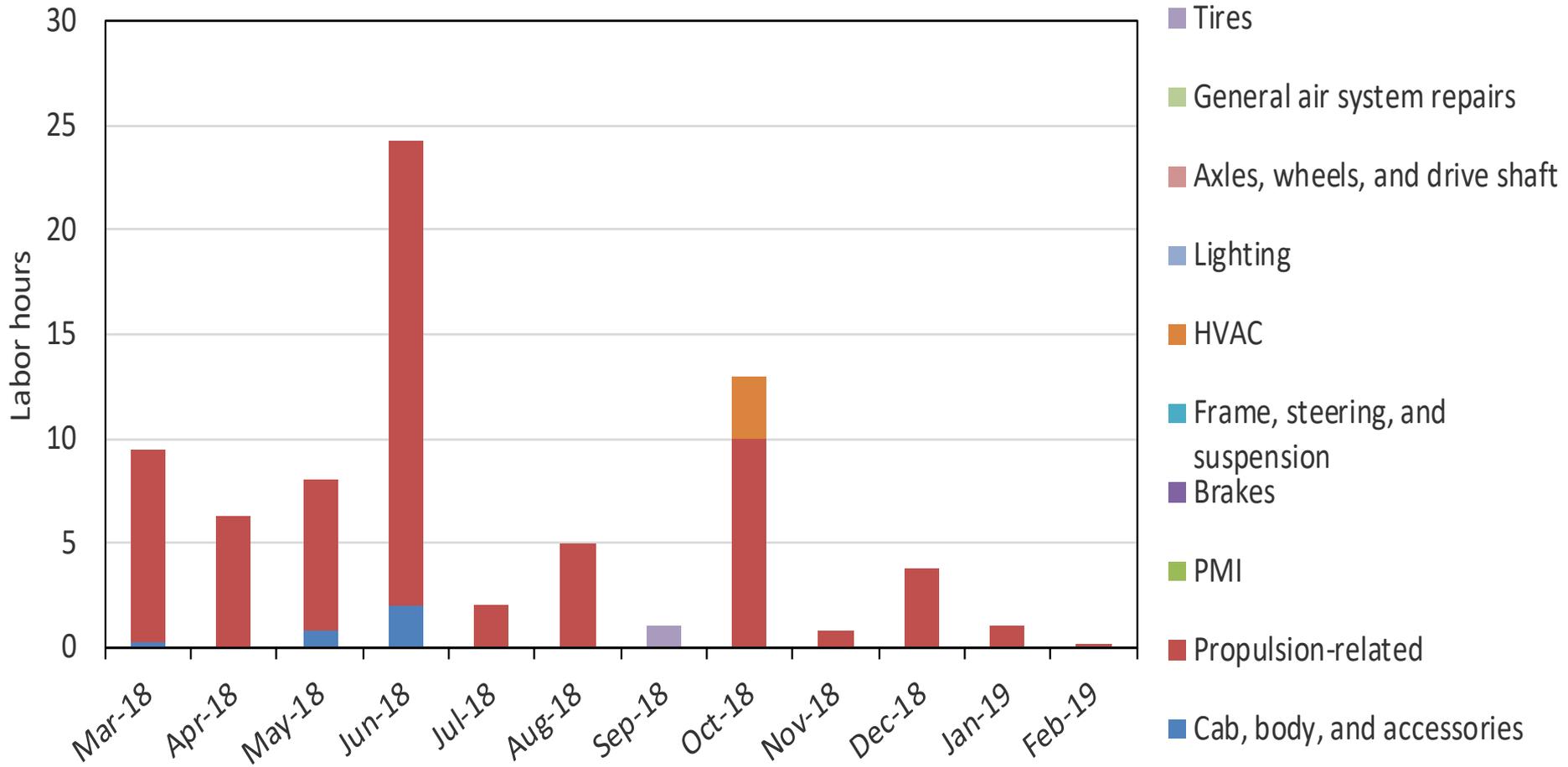


FCET is planned for service everyday

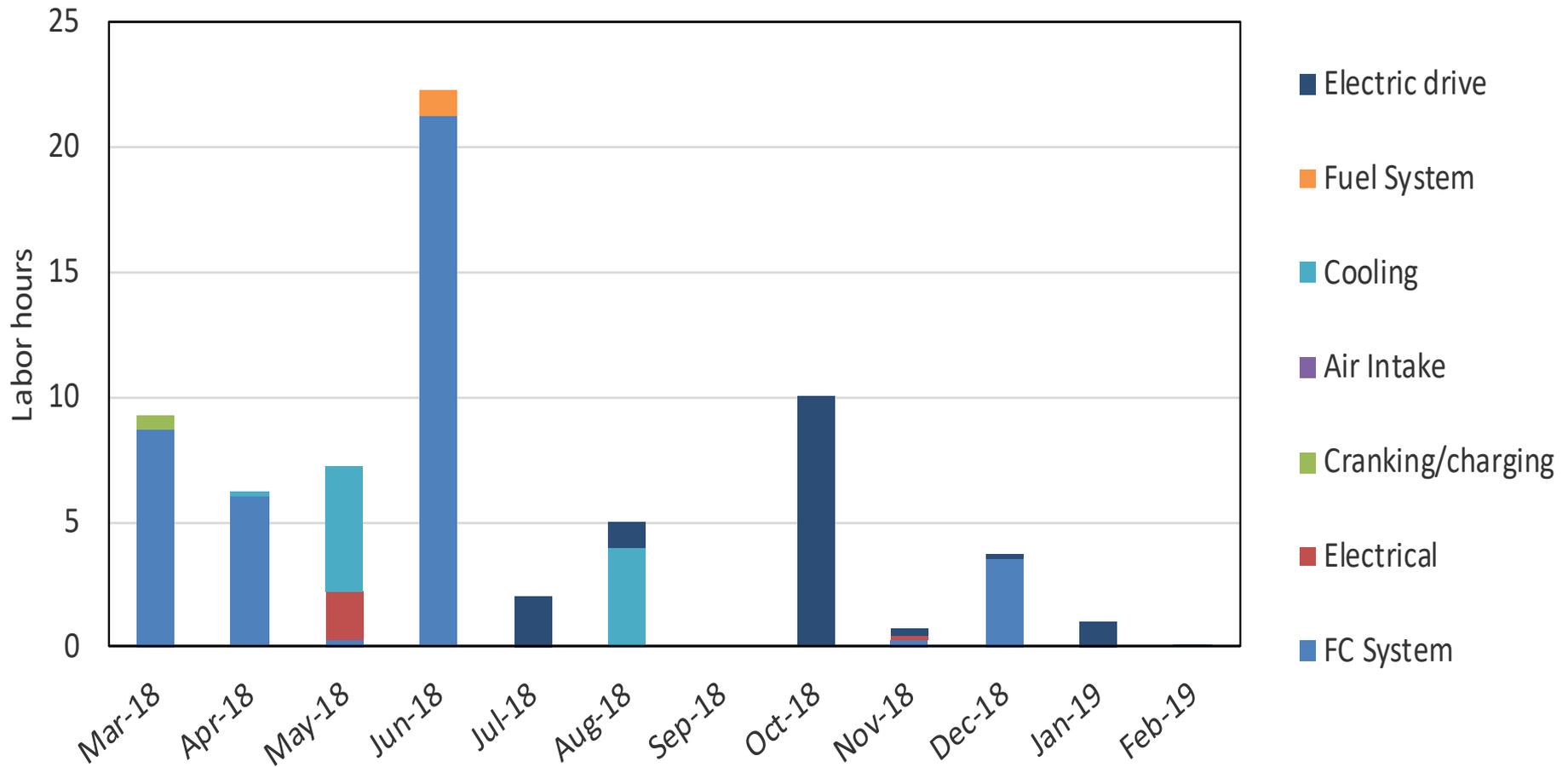
Technical Accomplishments and Progress: Availability by Month



Technical Accomplishments and Progress: FCET Labor Hours by System



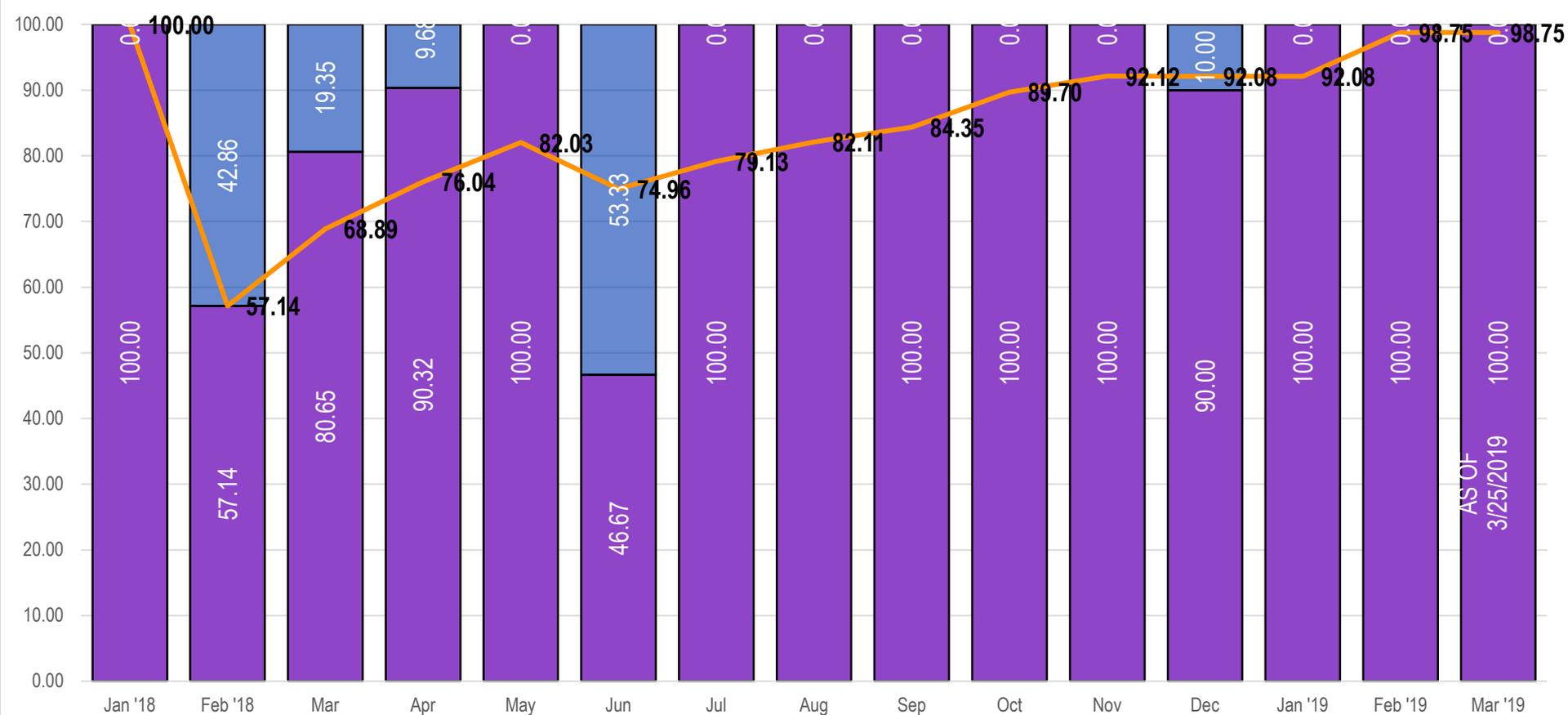
Technical Accomplishments and Progress: FCET Labor Hours by Sub-System



Technical Accomplishments and Progress: Fuel Cell Availability

FedEx FCET - Fuel Cell Availability

Availability (%) FC Downtime (%) 8mo Average Availability (%)



Accomplishments and Progress: Responses to Last Year's Reviewer Comments

1. **Approach to performing the work – Personnel turnover.**
 - The turnover in personnel has hurt the project, as commented last year. However, despite the turn over the team has been able to get the vehicle on the road for testing and complete the data collection.
 - The turnover has disrupted the priority and commitment to the project.
2. **Collaboration and Coordination – Vehicle Maintenance partner**
 - The Vehicle maintenance partner is defined as FedEx and Workhorse.
3. **Project weaknesses – Personnel turnover, Fuel Cell performance.**
 - Personnel turnover was addressed above.
 - The fuel cell performance was poor in the beginning. June had an incident. Since then it has been near perfect.

Collaborations

*Project Sponsor
Department of
Energy*

*Vehicle and Fuel Cell
Data Collection:
NREL*

*Vehicle Safety Regulations:
US Department of
Transportation*

*Hydrogen Safety Advisors:
Pacific Northwest National
Laboratory*

Hydrogen Safety Panel



Prime Recipient

Fuel Cell Manufacturer: Plug Power Inc. *EV Chassis and Powertrain
Manufacturer: Workhorse Group Inc*

Subrecipients



Remaining Challenges and Barriers

- **Reliability**
 - Support to keep the vehicle on the road.
 - Location of the Vehicle vs the location of the partners.
- **Budget Period 2**

Current status

- First Unit Validation
 - Evaluation and Documentation of the first unit.



Future Work

Budget Period 1 Milestones

- Finish Data collection
- Make a Recommendation Go/No-Go

Budget Period 2 Milestones

- Remaining fleet builds
- Remaining Fleet integration
- Continued Deployment and Operation

Summary

Approach

- Add FC / Replace GenSet

Relevance

- Availability/Reliability
- Sufficient Energy
- Safety

Progress

- Overall Availability/Reliability
- FC Reliability

Proposed Future Work

- Make a recommendation Go/No-Go
- Plan BP2

Thank You.

Questions?

