Effective Heavy-Duty Hybrid Market Development: The HTUF Commercial-Military Model

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Abstract

The Hybrid Truck Users Forum (HTUF) program, operated by WestStart-CALSTART in partnership with the US Army's National Automotive Center (NAC), has been a highly successful program to jump-start a commercial hybrid truck industry in North America. Its track record of success, and the results in terms of industry development and product launches, has benefited truck makers and suppliers as well as military planners keen on supporting a commercial manufacturing capability for advanced trucks.
The HTUF program has grown to become the key industry connection on heavy hybrid technologies. HTUF has been able to attract leading commercial fleets and every major truck maker and supplier to the process, building initially off the military's high level of interest in hybrid technology.
As a result of the HTUF process, the commercial industry is now rapidly developing early heavy-duty hybrid products in several different market applications: parcel, refuse, utility/specialty, shuttle and delivery. First assembly line production has now started and additional product launches are pending. The HTUF process has removed one to two years from the product development cycle.
Why and how does it work, and how can its lessons be extended into other emerging technologies? This paper and presentation will explore the commercialization model used by HTUF, its focus on developing early user demand "pull" to build pre-production volumes, the industry barriers it identified and how it is overcoming them, and where it is heading next in terms of market targets and capability growth in hybridization. HTUF's successes have proven a model for fast, lean and effective technology and industry development.

Keywords: hybrid, hybrid electric, hybrid hydraulic, heavy-duty hybrid, military

1. Introduction

In 2001, no major North American truck maker was publicly discussing, much less supporting, the hybridization of medium- and heavy-duty vehicles. Despite the emerging success of light-duty passenger car hybrids, most notably the Toyota Prius, the prime focus of North American truck and engine makers was on how to achieve the significant emissions reductions required under the U.S. Environmental Protection Agency's 2007/2010 engine standards. It has been estimated by several industry sources that eighty percent of the engineering talent in the truck industry was targeted on this emissions challenge. The potential increased fuel economy of a hybrid system was not perceived as crucial; the business case justifying it was murky; and the duty cycles and truck applications best suited to hybrids were not at all clear. As most truck makers would agree, they were also not sure their customers cared or wanted what a hybrid offered.

Six years later, every major truck maker has a hybrid moving to the market or in development, and several field test programs have substantiated the fuel economy and emissions benefits of both electric and hydraulic hybrid systems. Hybrid systems are showing practicality in several urban work truck applications, including pick-up and delivery, refuse and utility, and have now emerged as a potential game-changing technology for heavy-duty long haul trucks, the biggest fuel using segment on the road. Production-line built hybrid trucks will be available to fleet customers from five different truck makers within the next eighteen months based on company product announcements. Hybrids are now a “differentiator” that truck companies use to highlight their technology leadership. Compared to normal time to market, industry leaders acknowledge hybrids have moved forward at a rapid pace.

1.1 New Drivers of Change in Transportation

What has changed? Several key variables are different from 2001, most notably the concerns over energy security and the significant increase in fuel prices during that time, coupled with an increasing concern over climate change and carbon emissions. With fuel prices unstable and at their highest point in years, fleets have exhibited a tremendous openness to exploring technologies that reduce their fuel use. Fuel, after labor, is generally the highest operational cost to a commercial fleet. Fleets are exceptionally sensitive to fuel price hikes and fuel price variability. In recent years, with oil prices at and above $80/barrel, fleets have realized that they can likely no longer count on low, or stable, prices for their fuel. Hybrid technology, by increasing efficiency and reducing fuel consumption, can have a direct business case benefit for fleets.

Climate change is not yet a direct driver in a yearly purchase decision, but it is emerging as an important consideration for future planning. Most large companies incorporate climate change risk into their planning, and increasingly, sophisticated fleet operators are becoming cognizant of the need to understand their “carbon footprint” and to begin to lay out plans for stabilizing or reducing carbon emissions. As fleets explore their options, the choices that both meet required criteria (smog-forming) emissions standards while also reducing carbon are more complex. The recent Intergovernmental Panel on Climate Change (IPCC) report on mitigating the affects of climate change (IPCC Fourth Assessment Report) highlighted these key policies and technologies: More fuel efficient vehicles; Hybrid vehicles; Cleaner diesel vehicles; Biofuels; Modal shifts to rail and public transport; Non-motorized vehicles; Land use and transit planning. [1] Hybrids once again emerge as one of the key strategies, and opportunities.

However, fuel prices and climate change, along with concerns such as idle reduction and the need for increased electrical capacity in modern trucks, were insufficient conditions alone to accelerate the pace of hybrid development and the move into production. What was required was focused demand from users, targeted first applications upon which manufacturers could focus, and a process to bring together users and manufacturers in a risk-reducing partnership.

2. HTUF Process for Change

The Hybrid Truck Users Forum (HTUF) was designed to fill the market-technology gap and to speed commercialization of medium- and heavy-duty hybrids. HTUF is operated by WestStart-CALSTART, a non-profit, fuel and technology neutral advanced transportation technologies consortium, in a unique partnership with the U.S. Army Tank-Automotive Research, Development and Engineering Center (TARDEC) – National Automotive Center (NAC). The NAC is the Army’s outreach arm to the commercial transportation industry, and it is charged with both understanding the capabilities of the commercial vehicle industry and working to increase the capabilities of the commercial industry to build advanced vehicles and technologies that can support emerging Army and military needs. HTUF was devised as a nimble, fast-track process to speed hybrids to market by focusing attention on and aggregating the needs of the key players who could change an industry’s direction: the users themselves.

2.1 Partnership with the Military

The NAC’s involvement with and strong support of WestStart-CALSTART’s HTUF program is based on the core needs of their mission and enlightened self-interest: if a commercial industry capable of building medium and heavy-duty hybrids can develop, it will result in higher volumes and lower unit prices for all involved, including the U.S. military. The Army realized that while its mission for vehicles represents one of the most extreme use cases, it could not afford to be the only driver of the market. Alone, while it represented a significant number of total vehicles (more than a quarter million), it could neither entice sufficient competition and volume to support a sustainable market nor the investments needed for a broad industry capability.

From WestStart-CALSTART's perspective, the military interest served another critical role: credibility for the technology in heavy-duty applications. At the launch of the first HTUF efforts, there were no significant commercial industry efforts underway in heavy-duty hybrids except in transit applications. A few truck makers had explored hybrids in the 1990s, but saw their efforts ahead of the market and in advance of what the maturity of the core technology, particularly energy storage, could then support.

On the other hand, the military, particularly the Army, had been making key investments in hybrid technology for their future combat vehicles and for tactical wheeled vehicles. Several prototyping and demonstration efforts were being fielded and tested, and the military was exploring hybrids as one of the key future technologies for reducing fuel use and providing field electrical power generation. Even before the Iraq invasion, military commanders were extremely concerned about their logistical footprint, in particular that of transporting fuel to deployed forces. The single biggest weight carried into battle remains fuel, at a delivered cost that can reach hundreds of dollars per gallon in the most remote missions. Increasing fuel efficiency in military vehicles remains one of the ways of reducing or mitigating this logistical burden. [2]

The Army's strong interest in hybrids as one of their future technologies was a key factor in convincing fleets, and some manufacturers, to reconsider hybrids. For fleet users who had experienced past launches – and mislaunches – of new technologies and alternative fuels, the military involvement was critical to give them confidence to take part in a process around hybrid commercialization. It did not convince them that hybrids would work for them: but it convinced them that it was worth taking a look.

2.2 Focus on End Users – The "Users" Forum

There have been users groups developed in the past for several functions, particularly for standards setting, but what made – and makes – the HTUF process unique is its focus on developing targeted market demand, or "pull", around core, first-mover fleets in key applications. Truck makers and system suppliers had heard from users through their normal marketing channels, but had not seen strong enough evidence from their feedback that there was a sufficient market for hybrids, or increased fuel efficiency in general, to justify investment, particularly when resources were needed for emissions reductions.

From the users perspective, they were feeling "cherry-picked" by suppliers and truck makers. Many noted that they were tired of being approached to buy something that did not fit their business case or their need. They were open to a process that allowed them to work together to signal to industry what common performance improvements would be valuable to them. More importantly, as the user forum developed, would be that fleets working in HTUF took a critical next step: signaling jointly to manufacturers what they would commit to purchasing if it met their requirements.

The focus on end users is a powerful tool. If the right users are involved, particularly those who represent a meaningful percentage of important market segments, then the manufacturers have a strong inducement to pay attention to the interests and the signals from these groups.

2.3 Targeting Beach Head Early Markets – Working Groups

HTUF found early in its process that it needed to go beyond a general collection of users to be effective, however. It needed to build committed groups of fleets around the most promising early market applications that showed the greatest potential to support a hybrid product. It's important to note that these early markets are not the only markets for hybrids. Rather, for a time- and resource-constrained industry, they represent the best early targets of development and investment.

HTUF performed initial research and market surveys to determine these first markets, talking with fleets and manufacturers. The initial markets identified were relatively broad categories, but nonetheless discrete in their chassis and driveline needs. They were chosen based on several criteria:

- the duty-cycle fit of the application with the benefits of hybrids (urban, stop-and-go driving combined with high idling were the first measures);
- the sales volumes represented by the application (it needed to be more than a specialized niche);
- the cost of work trucks in the application (the higher the overall cost, the lower the impact of the expensive first hybrid systems as a percentage of vehicle cost);
- the ability to pull together significant market power (having access to major national and large regional fleets so that groups could be small but still represent meaningful volume).

From this research, HTUF in 2002 identified four main early market targets – separate from urban transit buses – for medium- and heavy-duty hybrids, as seen in Table 1.

Table 1: HTUF Hybrid Beach Head Markets

Application	Description
Class 7/8 Refuse collection trucks	Extreme stop and go, urban cycle; high fuel use; operate in neighborhoods; already expensive vehicles
Class 4-6 Urban delivery trucks -package/parcel delivery	Stop and go duty profile; operate in urban regions; fuel use savings; best for companies with desire for high environmental image; low cost of existing trucks a concern
Specialty Truck Applications -Class 5-7 utility "bucket" trucks -telecom/cable -Other speciality/PTO applications	Generally higher-end trucks; high idling time at work sites; heavy use of PTO; some value in on-board energy generation; duty-cycle involves stop and go and other "cycling" duties
Class 5-8 Urban delivery trucks -beverage, food delivery -regional heavy delivery	Can be heavy-duty but operated only in urban, "cycling" duty-cycles; not long haul; warehouse to store delivery

Together with this data, HTUF also learned from manufacturers what would be required to speed hybrid commercial introductions. The biggest gap was the demand and financial support needed by manufacturers to move from prototypes, typically one or two vehicles, to the pre-production level, which in the truck world is generally between ten and fifty vehicles. These pre-production levels would allow manufacturers to both deploy sufficient vehicles to get meaningful field performance results, and would also allow them to understand the issues involved in full production manufacturing of the components and their integration on an assembly line.

These basic conditions – targeting high profile applications, pulling together first-mover fleet users, and setting pre-production as a goal – became the guiding principles of the HTUF process over the following years.

With these principles, the next step was taking action. Fleets in each of these applications have formed action-oriented Working Groups via the HTUF effort. Each Working Group comes together with a specific objective: to assess whether a sufficient benefit exists, or is likely to exist, for hybrids to justify their purchase. As a part of each Working Group's toolkit, the fleets work together with HTUF's staff to identify the best chassis or platforms to focus on in each application, to develop their most important and common performance requirements, to assess the business case for a hybrid in their application and to then work with manufacturers and suppliers to determine if a hybrid system can meet their needs. If these first conditions are met and the case is promising, the next step is to commit to a purchase and assessment of pre-production trucks. As Figure 1 suggests, this process has been successful enough to support six Working Groups and several supporting efforts.

Figure 1: Current HTUF Working Groups as of 2007

The partnership with the military is of high value at this stage of the process. The Army has several tools to help focus in on key needs in their vehicle platforms, and HTUF has adopted many of these tools, most notable of which is the Key Performance Parameter, or KPP. The KPP helps identify the absolute necessity for the vehicles to meet their current – and new – mission. By focusing fleets on their "must-have" requirements, and prioritizing them in a selection process each Working Group undertakes, manufacturers get a clear sense of where they must focus their prime development and functionality efforts, saving time and resources and speeding development.

Equally as importantly to the military, by operating Working Groups that include military vehicle users, and also by sharing these requirements with the NAC staff, emerging military requirements can be considered and included in design considerations. A good example involves the power generation requirement of the Utility Working Group's hybrid KPPs (discussed in Section 3), which directly supported the Army's desire for power generation aboard their future vehicles.

Today, Working Groups are active in six different applications and need areas, including long haul Class 8. This illustrates not only the power of the HTUF process, but also the rapid evolution of the technology to now address market segments and applications not originally considered. In addition, an entirely new forum is in development which will focus on commercial construction equipment.

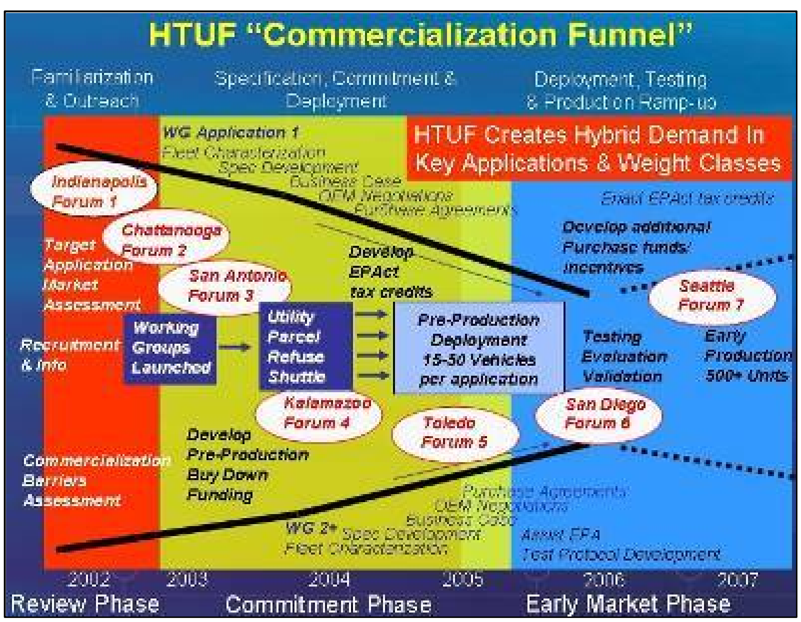


Figure 2: HTUF Initial Commercialization Funnel

The HTUF process now had its strategy design and focus. Put together, for the first six years, this became the "Commercialization Funnel" (seen in Figure 2) that laid the groundwork for all initial HTUF activities. This funnel guided market development, deployment and pilot truck activities until 2007. It was punctuated by yearly national forums, or meetings, that allowed fleets and manufacturers to measure progress achieved and next steps required.

3. First Successes and Key Lessons

The first Working Group to form, and the first to send out pre-production performance requirements and a commitment to purchase vehicles, was the Utility Working Group. Formed in 2002 as the strategy for HTUF was set, the Utility Working Group has come to comprise more than 40 fleet users representing roughly 20 percent of the purchasing power of what is approximately a ten thousand truck per year segment.

Utility in this case refers to the specialized vehicles used by electric and natural gas utility, telephone, cable and other similar work fleet vehicles. While not the largest overall market, it is a steady, high-value market of reliable customers that makes use of the most common truck chassis made. The vision for this group was that if it could identify the requirements that could justify a hybrid driveline in their application, it could become the basis for trucks serving a multitude of other applications that use the same chassis and driveline combination.

Key to the rapid success of the Working Group was the willingness to share best practices across company boundaries, which utility companies are adept at doing since most work out of defined service territories and do not directly compete. Indeed, utilities often rely on their sister companies to provide mutual aid and support during storms and emergencies, often sharing trucks and crews in times of overload (such as hurricane and storm restoration work). Therefore, finding fleets willing to jointly discuss common needs was not an initial barrier, as it was in the highly competitive parcel delivery segment (though parcel fleets have come together cooperatively in HTUF).

However, it became quickly apparent that each utility fleet had greatly differing work rules and truck body preferences, which could have derailed attempts to find the most common requirements. In this case, the Working Group was greatly assisted by its chairman, George Survant, fleet services director of Florida Power and Light. Using his knowledge of the industry and his relationships with his peers, Mr. Survant was able to convince fleets to focus on the chassis and driveline commonalities: everything below the truck rails. This early direction alone took months of work off the timeline to reach a market commitment.

The key first milestone for the Working Group was agreeing on Key Performance Parameters (KPPs). The initial list of requirements totaled more than sixty! After discussion, down-selection exercises and negotiation, the prioritized list of KPPs shown below in Table 2 became the basis of what the fleets told industry they were willing to purchase.

Table 2: Utility Working Group Key Performance Parameters (KPPs)

Key Performance Requirement	**Additional Description**
Maintain base vehicle dimensions and core functionality	*- 65 mph top speed; Able to merge with freeway traffic* *- No decreased payload capacity* *- Able to tow trailer*
Transparent to user from vehicle and lift perspective	*- Hydraulic power for lift/tools*
Reliability equal to or exceeds baseline vehicle	*- Measured by cost to maintain/mean time to failure*
Significant increase in fuel economy	*- 50% increase desired*
Reduce emissions over diesel	*- Meet or exceed 2010 requirements*
Overall life-cycle costs less than or equal to diesel	*- Compared to baseline truck*
Reduced noise levels compared to diesel	*- Operate at work sites on stored energy*

Note that the top items on this prioritized list have nothing to do directly with hybridization. The message from the fleets was clear: they would not consider a hybrid truck that could not perform the base function and work of the truck it was replacing. Assuming it can do that, then the additional functionality justifying the hybrid included greater fuel economy, reduced emissions and noise, and the ability to function with engine off at work sites.

3.1 Smart “Seed” Funding and Pilot Production

It took more than a year of joint work in the Utility Working Group to reach the point of being ready to jointly commit to purchase pre-production vehicles. One of the key early barriers to overcome was in helping the fleets and industry reduce the risk of moving to the pre-production stage. Fleets were willing to purchase the trucks and to deploy and assess them, but were highly concerned about the high incremental costs of vehicles still in extremely low volumes. Manufacturers were signaling a willingness to invest, but could not cover the incremental cost themselves either, given limited investment resources.

This is another case where the HTUF partnership with the military, via the NAC, took significant time out of the production cycle. HTUF and its NAC partnership were able to target support funding of roughly one million dollars to the deployment effort, eventually leveraging the manufacture and deployment of 24 hybrid pre-production trucks that were placed in a North American assessment effort. The funds supported manufacturer deployment and in turn guaranteed the military first access to the collected field data and deployment experiences from the manufacturer team and fourteen separate fleets in diverse geographical locations as highlighted in Figure 3.

Figure 3: HTUF Utility Truck Deployment Locations

The data collected goes directly to help military planners understand hybrid reliability, maintainability and performance as they assess their own unique platform needs. It is a stellar example not just of dual-use technology development, but of speeding the pace of development and planning in a highly cost-effective manner with shared risk and investment. The fleet investment alone in the pilot deployment was well over $2.5-million, with manufacturer investment of comparable value.

This highly-leveraged, risk-sharing structure is a hall mark of the HTUF program to speed commercialization and is being employed in the follow on Working Group efforts.

3.2 Field Test Results

Using the structure described above, the Utility Working Group and HTUF opened a national solicitation for a supplier team which could build a Class 6/7 (weight range 24,000 – 33,000 pounds GVWR) hybrid utility "bucket" or trouble truck. This truck, which uses an aerial boom and manned bucket to repair and restore electrical system problems, was identified as the best first platform.

International Truck and Engine Company, with hybrid electric driveline supplier Eaton Corporation, were selected as the supplier team for the deployment. Unlike a typical technology demonstration effort, the goal of this project was to gather the fleet acceptance and performance assessment justification to allow full commercial production to proceed.

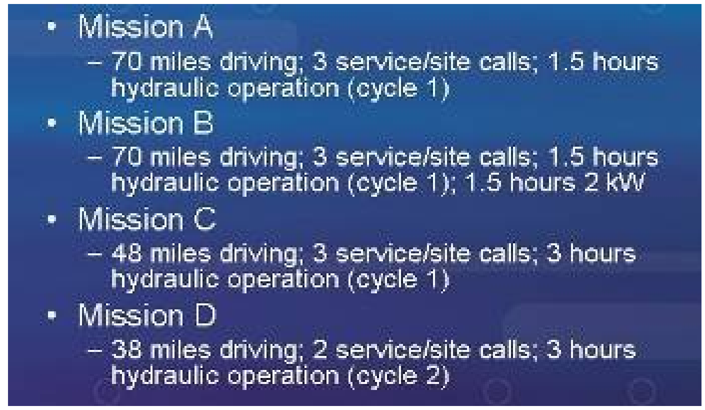


Figure 4: Utility Truck Missions – 4 Key Duty Cycles Used for Testing Performance

As defined by the HTUF process, the first stage of the pilot assessment effort would be to test a first "validator" truck in a controlled, dynamometer work cycle test to determine if it was meeting its base performance improvements against a comparable conventional baseline truck. The test involved a 26,000 pound GVWR International 4300 truck using a DT466 engine and a hybrid based on the same platform. The testing at an independent Southwest U.S. laboratory used a standardized composite truck driving cycle, known as CILCC (Combined International Local and Commuter Cycle), for the driving component of the test, together with a hydraulic operation cycle simulator for the work site portion of the full duty cycle. These were assembled into the four missions shown in Figure 4.

Figure 5: Hybrid Truck Fuel Economy by Mission

This allowed the hybrid truck and the baseline truck to equally simulate hydraulic boom operations at the work site. In the work site operation, the hybrid truck was able to perform its function with the engine off actuated by the electric motor turning the power take-off (PTO) device, while the baseline truck had to run its engine at high idle to actuate the hydraulic pump via the PTO. The results were dramatic in side-by-side operation. The hybrid reduced fuel consumption and emissions across all four duty cycle missions tested, as shown in Figures 5 and 6.

Mission Cycle ID (given in Table 8)	HC (g/mi) %	CO (g/mi) %	NOx (g/mi) %	PM (g/mi) %		Miles Driven	Hours of Operation (hydraulic + electric)
A	58	50	34	25		70	1.5
B	73	94	34	34		70	4.5
C	78	73	61	37		48	3
D	80	74	58	32		38	3

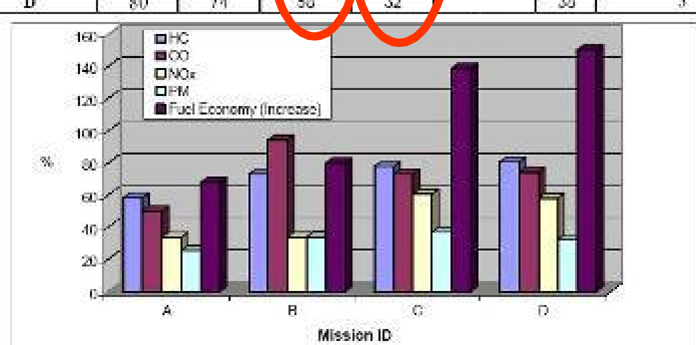


Figure 6: Hybrid Truck Emission Reduction by Mission

With the completion of controlled dynamometer testing, the pre-production trucks were then assembled and delivered to fleet customers for a year and a half field assessment project. 24 work trucks were placed with 14 different fleets, one of the most ambitious and geographically diverse pilot projects ever attempted. Each of the hybrid trucks was also matched with a baseline truck operating out of the same service center. These trucks were used to collect data on conventional truck functionality.

This broad a deployment had it share of challenges. The deployment itself took more than six months to complete, from delivery of first truck to final truck in the project. This staggered deployment made data collection comparisons difficult at first because of the "rolling" nature of the start of first information. Similarly, the uncontrolled nature of real-world use meant that baseline and hybrid trucks were rarely performing exactly the same duty; and trucks were often placed in varying applications, some of which did not make best use of the hybrid capabilities.

Nonetheless, over the course of the one year of data collected to date, the findings are impressive. The trucks, with only one or two anomalies, have demonstrated remarkable reliability. The average across all 24 trucks is a very high 99.26 percent availability of the hybrid system over the past year. [3] Fleet acceptance has been very high for the truck ease of use and performance. And fuel consumption has been reduced markedly in most uses. Indeed, the hybrids get better fuel economy than the baselines in all applications as Figure 7 illustrates. However, a key learning from the deployment to date is that to get the maximum benefit from the hybrids, and therefore to justify their currently high cost, fleets must work to place them in urban, high stop-and-go driving applications that also make high use of the engine-off operation of the aerial device. The greatest fuel reductions came from trucks that made the most service calls and use of their aerial device on those calls.

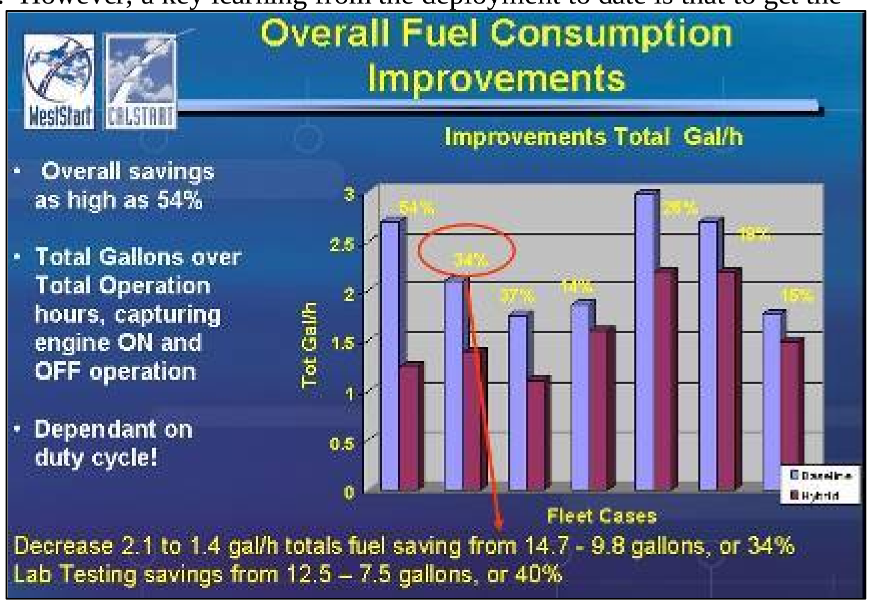


Figure 7: Utility Pre-Production Hybrid Trucks "Real World" Fuel Consumption Improvements

3.3 Outcomes of the Process – First Commercialization in Target Segment

As a direct result of the test results and first successes with the 24 truck pilot project, the supplier team of International and Eaton was able to launch a next-phase 100 truck deployment, which started production in late 2006. These next 100 trucks, known as "production-intent" vehicles, were produced on the International production line and used the system design and packaging changes learned from the pilot effort. These new trucks rolled off the line as hybrid chassis and from there were delivered to the body manufacturers for final installation of work bodies and systems.

Of the 100 trucks, approximately half were utility bucket truck hybrids, while half were already showing different variants, including "cube" delivery trucks, refrigeration units, "wrecker" trucks, stake-side trucks and even heavy parcel delivery. While different, each used the base engineering and driveline design stemming from the hybrid utility bucket truck design, allowing the manufacturers to efficiently leverage their investment (see Figure 8 for examples).

Once these trucks are delivered by fall 2007, International and Eaton have now publicly announced their production readiness to produce hybrid systems. International will offer the Durastar hybrid medium-duty truck in fall of 2007 as a production vehicle, which can be ordered and supported from any North American International dealership. Following close behind, the PACCAR group, which owns Peterbilt and Kenworth trucks, has announced that it will enter production of similar medium-duty hybrids in 2008.

Figure 8: Multiple Applications Can Be Addressed by Single Hybrid Chassis

One of the early beneficiaries of this first launch of the commercial markets can be, appropriately, the military. Over the next several years, HTUF will undertake with the NAC a multi-tiered strategy with the military to speed hybrid benefits from the commercial world back to military users. Stage 1 will involved placing commercially-based hybrids into military user hands domestically, in U.S. base, guard and homeland security applications. Stage 2 will involve expanded data sharing and planning to see how hybrid capabilities can be inserted into tactical and other military support vehicles that are forward deployed. The last stage, several years into the future, is really at the core of the partnership: to allow the military to tap the industrial capabilities of the commercial industry to build advanced hybrids to more cost-effectively support military hybrid needs in combat and other rigorous applications. The ultimate benefit of these efforts is a self-sustaining commercial capability, able to support commercial and military needs.

4. Next Steps – Full Commercialization and More Efficient Trucks

This focus on rapidly launching pre-production volumes, validating performance and business case, and spurring competition and production, will remain the model for the parcel, refuse, bus and Class 8 Working Groups. The Working Group model still has several years to go to work its course in hybrid commercialization, but HTUF is already turning to the next stages required to both fully bring hybrid technology into the mainstream, and to build the key enabling technology framework for advanced hybrids and more efficient conventional trucks.

4.1 Incentives

One key facet of the strategy is to work with fleet users and industry to knock down the cost barriers holding back initial hybrid volumes. It truly is a “Catch-22” dilemma: hybrid truck incremental cost is too high because volumes are still low in the early years; yet one of the key ways to reduce costs is to increase volumes. To that end, HTUF has focused significant effort to drive the first several thousand hybrid truck purchases; data indicates between three and five thousand units per year will enable sufficient price reductions to justify purchase based on the business case alone.

However, additional assistance is required in order to reach this market point sooner rather than later, and keep hybrid momentum moving. To that end, HTUF has organized, with partners Environmental

Defense, a Hybrid Incentive Working Group. While still based around the needs of fleet users, this Working Group is open to manufacturers and suppliers.

To date, the group has helped to secure, and now to push into actual practice, federal tax credits under the Energy Policy Act of 2005 (EPAct 2005). Though fleets and others point out these credits are too minimal and insufficient alone to spur the purchase of early hybrids, they were the first statutory acknowledgement of the uniqueness of medium- and heavy-duty hybrids. The Working Group is working a multi-level strategy to help secure better incentives on the federal level, while also working with states and regions to encourage and secure matching or supporting incentives at that level. It is the belief of the Working Group that no one source will be sufficient, but multiple aligned incentives may be enough. Guiding principles for effective incentives have been developed and are being shared with states and other agencies. Ironically, the incentives needed are only for a three to five year time period – enough time to increase initial volumes to the tipping point and reduce price to the point where the premium is paid for by the benefits delivered by the trucks – primarily from fuel savings.

4.1 Advanced Hybrids and Trucks

Once the driveline of a medium- and heavy-duty vehicle is hybridized, it enables advanced capabilities that further reduce fuel consumption and emissions. Plug-in hybrids are one key example. Once the core hybrid driveline is commercialized, then the framework for adding energy storage, grid connection and greater engine-off operation is made possible.

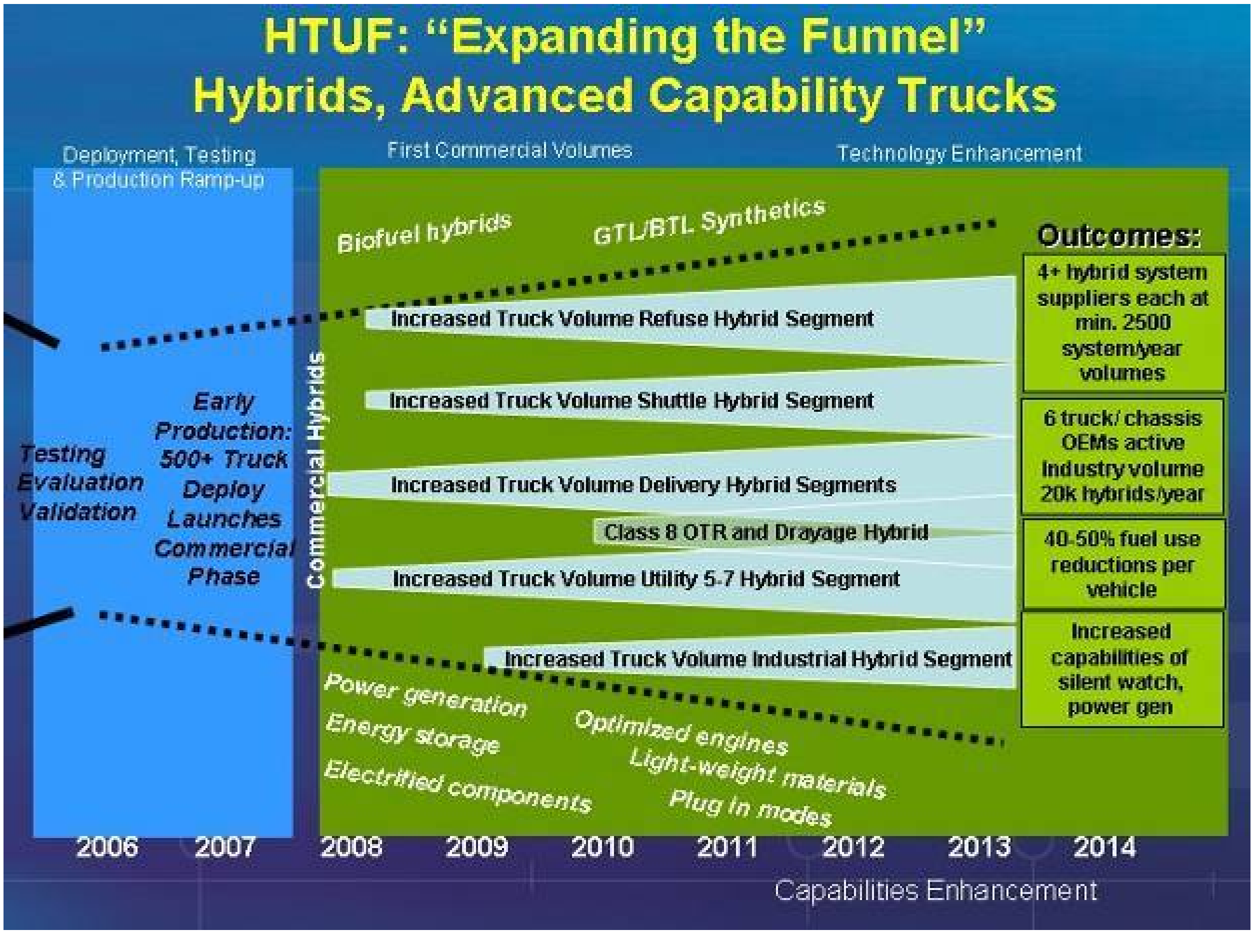
However, there are still technical barriers for trucks and buses that are not the same for passenger cars. For instance, there is no commercially-available electrically-driven air conditioning, steering pump or other components yet in the truck world. There are expensive prototypes, but no systems that can hold up to heavy-duty vehicle duty cycles. This is a core area of need, because their availability not only enables more-effective hybrids, they make for more efficient conventional trucks as well. By removing belt-driven scavenger loads from the main engine of a truck, greater fuel economy can be achieved, together with the potential for engine down-sizing or increased payloads.

Other key technical improvements include lighter weight, higher energy batteries and ultra-capacitors, on-board power generation, light-weight component and chassis materials, and advanced engine combustion schemes. Specifically because a hybrid drive system allows the main engine to work differently, and usually to work less or work in a narrower power range, cleaner and more efficient engine designs are possible, such as Homogenous Charge Compression Ignition (HCCI). Such engines are more difficult to use if they must cover the full range of a conventional truck's power needs, but may be possible when functioning in a more limited power range coupled to a hybrid system.

Finally, the combination of hybrids with low-carbon biofuels is a highly promising arena for petroleum and climate change reductions. The efficiency of a hybrid combined with the petroleum offset of biofuel blends creates a "multiplier effect." Together they can be powerful tools for rapidly addressing climate impacts in heavy transport.

HTUF has laid out a new roadmap for its efforts, building off its initial "commercialization funnel" but now expanding that funnel to support the expansion of volumes and capabilities in hybrids. As Figure 9 shows, this new seven year plan involves incentive generation, expansion of market demand and integration of advanced technology into hybrids so that by 2014, we have achieved a robust, sustainable market in heavy-duty hybrids, made up of multiple truck maker products selecting from multiple driveline suppliers, addressing a suite of enabling technologies, and fundamentally changing truck efficiencies and economics for years to come in conventional as well as hybrid drivelines.

Figure 9: The HTUF Pathway for Advanced Hybrid and More-Efficient Trucks



5. Conclusion

The HTUF model for commercialization had been effective by targeting the highest potential, lowest-risk applications for medium- and heavy-duty hybrid use, and then organizing first-mover fleets in those applications to work together to develop common performance requirements and business case needs. By aggregating this early demand, HTUF creates market "pull" to move hybrid technology to its next critical stage of development: pre-production vehicles.

This model alone has taken a year or more off the production cycle of hybrid trucks. However, HTUF has added additional value to the process. By "seeding" these targeted pre-production efforts with a small amount of funding in a partnership with the National Automotive Center, HTUF has helped reduce the risk of fleet and manufacturer participation. By further sharing the results of these pilot pre-production deployments, HTUF has helped speed production capability as well as competition in these segments. By raising the profile of the hybrid business case, sharing performance results and requirements with fleets and manufacturers, and finally helping to raise and spread incentives targeted at medium- and heavy-duty hybrids, HTUF is acknowledged to have shaved one to two total years off the development and production cycle of hybrid trucks. In the midst of the significant engineering demand experienced by truck makers to meet 2010 engine emission requirements, the speed of hybrid development coming at the same time has been nothing short of remarkable. It speaks highly to the value of the hybrid technology itself and to the further need for increased fuel economy gains and climate change strategies in heavy vehicles in the years following 2010. HTUF believes the gains made in the core technologies that support hybrids, coupled with continuing technology development in advanced capabilities, will enable significant fuel economy and carbon-reduction gains in both conventional trucks and hybrids over the coming seven years.

6. References

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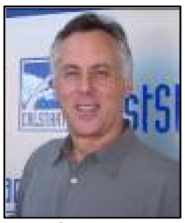

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