Dear reader,

Emissions legislation is a significant factor in the drive towards the electrification of both on- and off-highway vehicles. The large increase in the market for off-highway vehicles (OHVs), notably in emerging economies, creates some potentially huge opportunities for off-highway vehicle companies - in particular for the penetration of electrified vehicles into these markets. However, there are considerable economic and technological challenges which must be overcome to achieve this.

Interact Analysis’s new report – The off-highway vehicle market - 2019 – provides an in-depth examination of the issues, challenges and possible solutions in this exciting area. This whitepaper gives some insight into the topic.

I trust you will find it to be of interest. For more information on the report, click here. And if you want to carry on the conversation with me in person, get in touch on the details below.

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1. Key Points

• Major increase predicted in electrification of OHVs between 2017 and 2028

• Emissions legislation is the main driver behind increase

• Developing economies offer the greatest opportunities where electrification of OHVs is concerned

• Two major challenges are: proving the economic viability of fully electrified or hybrid machinery, and developing effective strategies to penetrate markets in developing countries
2. Overview

In the United States and the European Union, OHVs have been a significant source of air pollutant emissions. In 2011, OHVs were responsible for 20–45% of particulate matter originating from Internal Combustion Engines. In response, increasingly stringent emissions regulations have accelerated not only developments in electrified passenger vehicles, but also in OHVs. In 2018, the EU launched the world’s most stringent emissions standards for OHVs.

The global electrification penetration rate for OHVs is forecast to increase from 38.7% in 2017 to 55% in 2028. This represents a significant investment opportunity for electric motor and vehicle battery manufacturers. China is the largest market for OHVs, and will continue to be so until at least 2028. India will be close behind. The potential for electrification in these markets is considerable.

Emissions legislation is the main driver behind the electrification market. In the off-highway vehicle market - 2019 report, Interact Analysis give a detailed assessment of active and planned emission zones on a global level, together with zones where there are diesel bans and where there are plans for zero emission construction. This information is key to electrified OHV market planning.

The countries with the worst air pollution (particulate matter scores) in cities are China and India. Other emerging economies also perform badly, as they do not have active low emission zones. If these countries were to restrict emissions, this could act as an important drive toward electrified off-highway equipment, but the challenge lies in the fact that these are the very countries least able, economically, to transfer to newer technology, thereby depressing the demand for electrified equipment.

Economic viability is the principal challenge. Size, vehicle type, and application are the prime considerations where electrification viability is concerned. Lift trucks are currently the best established OHV type in terms of electrification. Arial Work Platforms (AWP) are predicted to see the highest CAGR during the forecast period of 9.3%.

The type of OHV naturally has an impact on its suitability for electrification. Small equipment such as lift trucks and wheeled loaders, and equipment used inside is currently far more prevalent in the full electrification market. Large equipment, such as earth-movers, is unlikely to be fully electrified in the forseeable future, but progress has already been made with hybrid systems, where fuel consumption can be cut by 30% in the near to medium term, and 50% in the longer term.

The market dynamics of electrification revolve around the total cost of ownership (TCO), the heaviness of the machine, the nature of the work done, the speed with which energy is consumed, and the speed of recharging batteries. There is also competition from the internal combustion engine (ICE) as this technology gets more and more efficient.

Whilst the Lithium-ion batteries is unlikely to be able to be used in full electrification of large machines, such as large excavators and tractors, serious research is happening in the field of hydrogen fuel cells, which should have the potential to power large machinery.

A major area, and a serious challenge for electrification of OHVs, is the charging infrastructure. The report looks at solutions to this issue, particularly in relation to where vehicles are working on sites in remote areas, away from the grid. In the commercial vehicle market, vendors have found that selling a complete solution – including charging infrastructure – has enabled new revenue streams. There is opportunity here for off-highway machine builders to do the same, as currently very few machine builders have focused on infrastructure solutions in a way which caters for the needs of the construction industry³.

3. Vehicle analysis

A look at some of the major types of OHVs

**Excavators**
An excavator is a large tracked or wheeled machine sitting on a heavy chassis, on which there is a cab, boom and bucket which can rotate through 360°. An important function of the excavator engine is to drive the hydraulic oil pumps which operate the boom and bucket arm. The largest vehicle segment of the global excavator market is occupied by the mini excavator.

**Lift Trucks**
The lift truck, or fork-lift truck is one of the most common pieces of industrial equipment used for moving materials. Lift trucks are powered by petrol engines, diesel engines, and, in many cases, by electric motors. Lift trucks have the highest electrification rate among all vehicle types considered in the report.

**Underground LHDs**
Load Haul Dump (LHD) machines are used in underground environments, such as mines, where they are used to load and transport ore and minerals. Major features are their compact build, and their power. They can be manually or automatically operated. With an automatic system, the operator can remain above ground and simultaneously control up to three LHDs, thus increasing both productivity and security for personnel. The case for switching to electrified LHDs is clear. Zero emissions underground, cleaner air, and less noise and heat are clear benefits for workers in these environments.

**Loaders**
Loaders, are four-wheel-drive machines used primarily to load loose materials onto or off lorries, using a front-mounted bucket. A hydraulic lift-arm assembly raises and lowers the bucket. The wheeled loader, or common digger, is the largest vehicle segment in the global loader market.

**Aerial Work Platforms**
An Aerial work Platform (AWP) is a machine used to enable people to reach inaccessible areas, usually at a height, often, but not solely, for maintenance and construction work. The main feature is the articulated arm, which raises the platform. There are different types of AWPs, for example spider lifts, scissor lifts, articulating boom lifts and cherry pickers. The global AWP market experienced very strong growth in 2018, with unit shipments growing 22.6% over 2017.

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Off Highway Trucks

OHTs, or dump trucks are designed to be used in mining, and in inhospitable, off-road heavy construction environments. They are simple machines, very reliable, and long-lasting. The biggest increase in demand for OHTs has been in Oceania, South America, Middle East and Africa, owing to mining developments.

Bulldozers

Bulldozers have continuous tracks, not wheels. This is necessary to give the machine the required grip for it to be able to use its front-mounted blades to move or push large quantities of material such as soil or rubble. The bulldozer market is booming in emerging economies where there is major road infrastructure development.
4. Drivers and Challenges for OHV Electrification

Emission legislation and standards are the main drivers behind electrification in all vehicle types, on-road or off-road. As ever-stricter emissions standards come into force around the world, OHV manufacturers will be forced to respond. Most low-emission zones are currently in Europe, where we will see bans on petrol and diesel passenger vehicles from 2025 in some areas. India and China have committed to similar bans from 2030 and 2040 respectively. The report goes into significant detail on current and projected emissions legislation and targets on a global scale, and describes limited plans already in the offing for building, using zero- or reduced-emissions construction equipment.

The pointers are clear that electrification of OHVs will happen, but the challenges are considerable. A major obstacle lies in the fact that it is the poorer, emerging economies that have the greatest potential for market growth in electric off-road vehicles, but they are the least able to afford the investment both where establishment of low emission zones, and acquisition of electrified machinery are concerned.

TCO is currently a barrier to electrification of OHVs. Only when the cost of electrification technology drops to the point where it can compete with the ICE will TCO become a driver. At that point the longer term financial benefits will become all too apparent. Electric motors do not require the service attention of engines, such as oil or filter changes. Lower weight, rapid-charging batteries with greatly increased charge-life will be developed. However, electrification technology is still in its infancy, and does not yet have the track record or reputation for durability and reliability that would encourage widespread investment. But the green shoots of growth in this sector are there. Volvo Construction Equipment has a hybrid wheel loader, affording up to 50% improved fuel efficiency. They also have in the development stage a fully electrified self-driving load carrier for which they are predicting a 95% reduction in carbon emissions and a reduction of up to 25% in the TCO.

Another barrier is the charging infrastructure for OHVs. There is considerable potential for technological development in this area, particularly in the field of renewable energy. There are opportunities here for electrified machine manufacturers to develop this technology and offer it in tandem with their machinery.

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5. OHV Type and Its Impact on Electrification

Energy solutions vary for different classes of OHV vehicle. Here we are looking at vehicle size, function, and the environment in which it operates.

Electrification is already well-established where small, compact equipment is concerned. Lift trucks and mini excavators fall into this category. Machinery of this kind that is used in sealed environments, eg in warehouses, is largely electrified, for reasons of safety and for the purpose of creating a healthy environment for workers. Specialised underground mining equipment, such as LHDs have also seen some electrification, and this will increase in the near future. Medium-sized equipment, such as wheeled loaders is likely to see full electrification in the next 2 to 5 years. In the longer term, 6 – 10 years, larger equipment will see hybridization, with electrification of mechanical attachments enabling the down-sizing of diesel engines.

6. Market Dynamics Overview

Duty-Cycle integration: The challenges here revolve around the energy storage method, limiting machine consumption of that stored energy and the ability to quickly generate or replace that energy again. Economic Viability: The total cost of ownership has to be proven for there to be a large increase in the marketability of electrified machinery. Once the TCO of electrified machinery reaches parity with equivalent diesel-powered equipment, electrified machinery should be the machinery of choice for reasons mentioned earlier in this paper, notably the simplicity of maintenance compared with the ICE.

The ICE will continue to be used in off-highway machinery for some years, but falling production prices of batteries and electrified equipment, coupled with the fact that the World Bank has forecast that crude oil prices will remain relatively static until 2030, i.e. will not fall, create a favourable landscape for the marketing of electrified equipment. In fact, while our report forecasts that prices will stay stable, there are reports which predict a rise in crude oil prices up to 2030, which would be even more advantageous for the electrification market.
7. Full Electric - Lead Acid v Lithium-Ion

The report goes into considerable detail regarding the different battery options available for OHVs, examining them in terms of research and development, economics, and suitability and efficacy in different scenarios. Lead-acid batteries (LABS) have for years been the main power source for small electrified machinery, such as lift trucks. They are popular and cost-effective, but have disadvantages, for example they have a much longer charging time than lithium-ion batteries (LIBS), and are susceptible to damage if they are over-discharged. LIBS can withstand 80% discharge. They have advantages over LABS in a number of respects, but they are currently 50% more expensive in the initial outlay. However, the price of LIBS is predicted to drop by 30% by 2023, which should mean their greatly increased penetration of the market.

Development of hydrogen fuel-cell technology is still at a relatively immature stage, but serious research and product development is happening with a technology which has the potential to provide electric power of a sufficient magnitude to drive the largest off-highway machines. Some on-road vehicles, such as buses, are already powered by hydrogen fuel cells.

8. Conclusion

There is huge potential for the widespread electrification of off-highway vehicles. Electrification will carry with it benefits in terms of clean air, efficiency, and safety. The onus is on ensuring continued technological development in this sector, and and the development of an effective market strategy to ensure economies across the world recognise the advantages of this technology, and respond accordingly.

To download a brochure and sample pages for Interact Analysis’s market report: The off-highway vehicle market – 2019, click here.

To carry on the conversation with Jan Zhang, Interact Analysis’s Research Director for off-highway vehicles, get in touch with her directly: jan.zhang@interactanalysis.com | +86 (21) 2050 1835
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We offer a number of market intelligence services based on primary research. Our industry expertise combined with vast experience in statistical analysis provides you with reliable, trusted intelligence that enables you to make decisions with confidence.

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