KeSEBAE NEWS

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Off Road Machines Electrification

By Yvonne Madahana

The electrification of vehicles has been a driving force in reducing greenhouse gas emissions and improving energy efficiency, particularly in on-road transportation. While electric vehicles (EVs) for passenger and commercial on-road fleets are gaining traction, the off-road equipment sector is lagging behind. The slower transition in this sector can be attributed to the diverse range of equipment categories and the unique challenges associated with their electrification. Despite these challenges, the successful transition to electric power for off-road equipment could yield significant benefits, including reduced air and noise pollution, increased energy efficiency, and improved productivity. Off-road equipment encompasses a wide variety of non-stationary devices powered by internal combustion engines (ICEs) or electric motors, used primarily outside of traditional highways. This category includes machinery used in construction, agriculture, mining, and other industries. The different applications and environments in which this equipment operates present unique challenges that require significant research and development efforts for electrification. In comparison to the relatively straightforward electrification of on-road vehicles, off-road equipment faces more complex technical challenges.

DEAR READER

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A monthly Newsletter touching on topical issues affecting our environment.

KeSEBAE NEWS is a Newsletter of the Kenya Society of Environmental, Biological and Agricultural Engineers (KeSEBAE)

Inside this Issue!

These machines operate in harsh environments, frequently subjecting their components to high levels of contamination, vibration, and impact. This makes it necessary to design electric powertrains and associated systems that can withstand these harsh conditions. Additionally, the irregular duty cycles across different types of off-road equipment also make the electrification process more difficult.

The push toward electrification in the off-road sector is driven in part by increasingly stringent emissions regulations. In the United States and the European Union (EU), regulations such as the Tier and Stage emission standards have compelled manufacturers to adopt advanced engine technologies. As these regulations continue to tighten, electrification is becoming an increasingly practical solution to meet emissions targets.

For instance, California has set an ambitious goal of achieving zero-emission heavy-duty vehicles by 2045. This regulatory pressure is accelerating the development of electric off-road machinery, particularly in industries like construction and agriculture, where heavy-duty equipment is prevalent. The challenge lies in adapting existing technologies and developing new ones that can meet the unique demands of off-road applications while complying with regulatory requirements.

Technical Challenges in Electrification

Electrifying off-road equipment presents several technical challenges that differ significantly from those encountered in on-road vehicle electrification. One of the primary challenges is the need for components that can endure the extreme conditions often found in off-road environments. Unlike on-road vehicles, off-road machinery frequently encounters high levels of dust, mud, water, and physical impacts, which can damage delicate components.

To address these challenges, the materials used in constructing electric powertrains must be selected for their durability. For example, power electronics need to be sealed and roughened to prevent damage from environmental factors. Similarly, hydrogen tanks in fuel cell electric vehicles (FCEVs) must be designed to maintain integrity under impact, ensuring safety and reliability in the field.

Another significant challenge is the development of battery technology suitable for off-road applications. While lithium-ion batteries are the current standard for many electric vehicles, their performance in off-road environments needs further exploration. Researchers are investigating alternatives like solid-state batteries, which offer higher energy density and improved safety, making them potentially more suitable for heavy-duty off-road equipment. The ability of these batteries to maintain performance under extreme temperatures and during long duty cycles is critical to their success in off-road applications.

Electric Powertrain Architectures in Different Off-Road Equipment Categories

The electrification of off-road equipment has led to the exploration of various electric powertrain architectures, each tailored to different categories of machinery. Hybrid powertrains, which combine internal combustion engines with electric motors, are being adapted for off-road use. For example, Parsons et al. have proposed a series hybrid configuration with hub-mounted electric motors for heavy military vehicles, which could be scaled up for heavy construction equipment. These systems offer the advantage of reducing fuel consumption and emissions while maintaining the power and reliability required for demanding off-road tasks.

As battery technology continues to advance, fully battery-electric vehicles (BEVs) are becoming more viable for certain off-road applications. Baronti et al. have developed a battery management system (BMS) for lithium iron phosphate batteries in off-road BEVs, emphasizing broader applicability and the avoidance of bespoke hardware. This approach allows for the use of standardized components, reducing costs and simplifying maintenance.

Hydrogen fuel cells represent another promising avenue for off-road electrification. Saeks has presented an off-road FCEV configuration that includes a flywheel energy storage system for energy recovery and acceleration assistance. This system, featuring four-wheel drive and adaptive controllers for steering, is designed to manage energy efficiently and deliver exceptional results in challenging environments. The use of hydrogen as a fuel source offers the advantage of quick refueling, which is crucial for maintaining productivity in off-road operations.

Energy Recovery

One of the key benefits of electrifying off-road equipment is the potential for energy recovery, which can significantly improve overall efficiency. In off-road equipment like loaders, abrupt stops during operations can generate electricity through regenerative braking. This technique has been successfully implemented in machines like the John Deere 644K Hybrid Wheel Loader. However, the rolling resistance in off-road environments is typically higher than in on-road scenarios, which limits the amount of kinetic energy that can be recovered.

Excavators present multiple opportunities for energy capture. For instance, when the boom is lowered, the potential energy can be stored and used later. Researchers have explored various methods to capture this energy, including using an Energy Storage System (ESS) composed of batteries and capacitors. The integration of hydraulic systems with electric powertrains is also being investigated, as these systems can quickly capture and convert potential energy into electricity.

Another area of exploration is the recovery of heat from turbocharged engines, which can be converted into electricity using turbine-generator systems or thermoelectric generators. This technique could be applied to a wide range of construction and agricultural equipment, further enhancing energy efficiency.

Promises and Concerns of Off-Road Equipment Electrification

The electrification of off-road equipment offers numerous benefits, but it also presents certain challenges that need to be addressed. Electric motors are inherently more efficient than internal combustion engines, offering superior torque capabilities that are well-suited for demanding off-road applications. The reduction in moving parts also means less wear and tear, leading to lower maintenance costs. Additionally, electric drivetrains facilitate regenerative braking, which not only reduces wear on mechanical brakes but also contributes to energy recovery, further improving efficiency.

While the initial cost of electric off-road equipment may be higher than that of traditional ICE-powered machinery, the long-term benefits can outweigh these costs. Lower operating costs, reduced fuel consumption, and decreased maintenance requirements can result in a lower total cost of ownership (TCO) over the equipment's lifespan. Furthermore, the ability to operate in emission-sensitive areas and during noise-restricted hours can increase productivity, offering a competitive advantage in certain industries.

The flexibility in design that electrification brings is another significant advantage. Electric off-road equipment can be designed with optimized space utilization, offering a variety of layout options that are not possible with ICEs. This flexibility can lead to improved ergonomics, safety, and operational efficiency. Additionally, electric equipment is not susceptible to power loss at high altitudes, where reduced oxygen levels can limit the performance of ICEs.

Proposal for Electrification

Given the diversity of off-road equipment and the varying operational environments, a one-size-fits-all approach to electrification is not feasible. Instead, a more tailored approach is necessary, with specific strategies for different types of machinery.

One practical approach is the retrofitting of existing vehicles with electric powertrains. This method allows for the continued use of equipment that is still within its service life while transitioning to cleaner energy. Retrofitting could include the use of range extenders, with existing Tier 4 diesel engines functioning within optimal regions to maximize efficiency and minimize emissions. This approach is particularly relevant for industries where equipment has long service lives, such as agriculture and construction.

To support the operation of plug-in hybrid electric (PHEV) or battery electric (BEV) off-road equipment, the development of on-site charging infrastructure is essential. Renewable energy sources (RES), such as solar or wind power, offer a sustainable way to power these vehicles. For example, solar-powered charging stations, already in use for light agricultural vehicles, can be scaled up for heavy-duty equipment. Wind power is another viable option, particularly in areas with consistent wind patterns.

The integration of smart charging systems with vehicle-to-grid (V2G) capabilities can further enhance the efficiency of off-road equipment electrification. By repurposing second-life batteries (SLBs) as energy storage systems (ESS) in charging stations, costs can be reduced while extending the useful life of these batteries. Proper placement of charging stations and the use of mobile chargers powered by mobile ESS can address the logistical challenges of charging equipment in remote locations.

The electrification of off-road equipment is a complex but promising avenue for reducing emissions and improving energy efficiency in industries such as construction, agriculture, and mining. While there are significant technical and economic challenges to overcome, ongoing research and development efforts are paving the way for a cleaner and more sustainable future.

By leveraging advancements in battery technology, hybrid systems, and renewable energy sources, the off-road equipment sector can achieve significant reductions in its environmental impact while maintaining the performance and reliability required for demanding applications. The tailored approach to electrification proposed in this article offers a pathway to achieving these goals, ensuring that the transition to electric power is both practical and effective across a wide range of off-road machinery.

References

Zhang, W.; Wang, J.; Du, S.; Ma, H.; Zhao, W.; Li, H.; (2019). Energy management strategies for hybrid construction machinery: Evolution, classification, comparison and future trends. Energies 2019, 12, 2024.

Parsons, M.B.; Mepsted, G.O.; (2014). Development of off-road hybrid-electric powertrains and review of emerging battery chemistries. In Proceedings of the 5th IET Hybrid and Electric Vehicles Conference (HEVC 2014), London, UK, 5–6 November 2014; pp. 1–7.

SAIAE and PASAE Conference 2024

AfroAgEng
PAN AFRICAN SOCIETY FOR AGRICULTURAL ENGINEERING

SAIAE & PASAE International Symposium

23 - 25 October 2024

Engineering within the Agricultural Environment.

The South African Institute of Agricultural Engineers, (SAIAE) and the Pan African Society for Agricultural Engineering (PASAE) are proud to invite interested parties to its International Symposium. As mentioned in the previous announcement, this year's edition will be coinciding with the SAIAE's 60-Anniversary, which will ensure a milestone Conference. The SAIAE and PASAE international event will be PASAE's 6th International Conference.

The international event will take place from **23 - 25 October 2024** at the Houw Hoek Hotel, in the scenic Western Cape province of South Africa. Please note the date has been changed since the first announcement.

This announcement highlights and provides details on the call for abstracts, registration, and accommodation costs, physical and virtual (online) attendance, sponsorship, registration, the Symposium deadlines and much more!

The Culmination of 60 years of Agricultural Engineering Excellence in Africa with SAIAE & PASAE!

SECOND ANNOUNCEMENT: Call for Abstracts, Registration, Symposium Costs and Sponsorship!

Call for Abstracts

The SAIAE and PASAE Council hereby invites engineers, technicians and other interested parties working in the Agricultural Engineering field to submit abstracts to be considered for presentation at the Conference. Contributions should address relevant current Agricultural Engineering methods/techniques, tools, innovations, or projects in one of, but not limited to, the following fields/topics:

Abstracts should be no longer than 300 words and include a suitable title as well as a photo and contact details of the corresponding author of the paper, (template attached). It can be submitted to senzo@saiae.co.za or londiwe@saiae.co.za with the subject line "Symposium Abstract" by 16 August 2024.

Abstract Topics

- 4th Industrial Revolution
- Agricultural Mechanisation
- Aquaculture & Hydroponics
- Circular Economy
- Climate Change
- Energy Management
- Farm Road Design
- Food Engineering & Post-Harvest Management
- Soil Conservation
- Renewable Energy
- Food & Fibre Production Processing
- Big Data and Internet of Things (IoT)
- Hydrology & Dams
- Irrigation Design and Management
- Use of Artificial Intelligence in Agricultural Engineering
- Packaging & Packing Facilities
- Primary Production
- Precision Agriculture
- Structural Engineering in Agricultural Production and Processing Systems
- Surface and Subsurface Drainage System in Agriculture
- Water Supply & Water Resource Management

Symposium Sponsorship

Several sponsorship opportunities and exhibition space are available. The sponsorship options can be found by following this link: SAIAE & PASAE Symposium Sponsorship Request Letter.

Some of the sponsorship options on offer consist of the following:

- Platinum (main) sponsor.
- Gold sponsor.
- Silver sponsor.
- Bronze sponsor.
- Technical tour sponsors.

Companies or organizations are invited to contact SAIAE's Business Manager Mr Senzo Masikane to discuss the various sponsorship options senzo@saiae.co.za.

Registration

To register for the SAIAE & PASAE Symposium, please contact Mr Senzo Masikane - senzo@saiae.co.za or Ms Londiwe Mbambo – londiwe@saiae.co.za to receive the registration form or click on the following link: SAIAE & PASAE Symposium Registration Form. A registration portal will also be available on the SAIAE website for delegates to utilize.

Event Activities

The Symposium will take place over 3 days, with 3 nights' accommodation at the Houw Hoek Hotel from the 23rd to the 25th of October 2024. The Symposium will kick off with registration from 07:00 on the 23rd of October and the symposium proceedings will start at 09:00 with exciting presentations and technical tours, concluding at 15:00 on the 25th of October. Delegates are invited to bring along their spouses or partners to enjoy the experience with the Agricultural Engineering community in this beautiful location in South Africa with many nearby tourist attractions.

Accommodation

Accommodation is offered on a single bedroom and sharing basis (Two delegates per room). A letter of invitation from SAIAE is available for delegates that require this for their employers and for visa purposes.

The main hotel accommodation is the Houw Hoek Hotel [3-Star] - [https://houwhoekhotel.com/]. The alternative accommodation options are as follows:

-The Caledon Hotel and Spa [4-Star] - https://www.tsogosun.com/hotel/the-caledon-hotelspa/?utm_source=google&utm_medium=businesslisting&utm_campaign=hotel_the-caledon-hotel-spa

-The Arabella Hotel Golf & Spa [5-Star] - https://www.southernsun.com/arabella-hotel-golf-and-spa

Symposium Costs

The registration fees and accommodation costs for the Symposium can be found in the below table:

Conference Fee				
	Conference Fee Only	Conference Fee Incl. Accommodation (3 Nights)		
		House Hoek	Caledon	Arabella
Member Single	$ 390	$ 612	$ 715	$ 1028
Member Sharing	$ 390	$ 582	$ 935	$ 704
Non-member Single	$ 500	$ 720	$ 822	$ 1126
Non-member Sharing	$ 500	$ 660	$ 705	$ 812
Student Fee	$ 195	$ 362	-	-
Day Fee (per day)	$ 195	-	-	-
Virtual member	$ 270	-	-	-
Virtual non-member	$ 390	-	-	-

Partner/Spouse Activities

The Symposium will have an array of relaxing and spectacular activities catered for delegate partners or spouses. The activities that are on offer are as follows:

Day 1 (23 October):
-Franschhoek Wine Tram,
-Babylonstoren Wine Estate,
-Spa @ Caledon.

Day 2 (25 October):
-Table Mountain Cableway,
-Boat Cruise,
-V & A Waterfront

To book an activity or should you require additional information, please contact Ms Londiwe Mbambo – londiwe@saiae.co.za

Virtual Option

We are pleased to inform you that the SAIAE & PASAE Symposium will have a virtual option. Delegates will be able to join us virtually from anywhere in the world to be part of the Symposium and enjoy the presentations that will be at hand.

The fees for the for the virtual option are as follows:

- Virtual members: $ 270
- Virtual non-member: $ 390

Technical Tours

The Symposium Technical Tours set to take place on the 25th of October (Last day of the Symposium) are to be announced in the coming weeks!

Shuttle Services

We are pleased to inform you that shuttle services will be available for delegates travelling between the alternative accommodations and the conference venue.

Important Dates

Symposium Registration Period Opens:	03 May 2024
Abstract Submission Deadline:	16 August 2024
Authors notified of abstract acceptance:	30 August 2024
Preliminary Symposium Programme:	09 September 2024
Proof of payment for all registrations:	04 October 2024
Symposium Commences:	23 October 2024
Symposium Closes:	25 October 2024

The Symposium is supported by the following organizations:

- University of KwaZulu-Natal / Inyuvesi YaKwaZulu-Natali
- UFS
- South Africa National Convention Bureau
- Wesgro
- CIGR
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- Royal Academy of Engineering
- University of Venda – Creating Future Leaders
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Symposium Endorsement

To endorse or support the Symposium, please contact Mr Senzo Masikane -senzo@saiae.co.za.

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- Irrigation and Water Resources
- ICT Systems
- Engineering Education and Practice For Climate Change

KEY DATES:

Abstract Submission:	30 SEPT 2024
Paper Submission:	13 OCT 2024
Payment Deadline :	07 NOV 2024

CHARGES

Members: KES 15,000 ($150)
Non Members : KES 20,000 ($200)
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The JEAE Editorial Board wishes to invite interested researchers with complete work in any relevant topic, to submit their papers for publication in the next editions of the Journal.

Manuscripts may be submitted online or via email to:

Chairperson, JEAE Editorial Board via Email: jeae@kesebae.or.ke or Online via: https://kesebae.or.ke/journal/index.php/kesebae/about/submissions

Criteria for Article Selection

Priority in the selection of articles for publication is that the articles:

a. Are written in the English language
b. Are relevant to the application of engineering and technology in agriculture, the environment and biological systems
c. Have not been previously published elsewhere, or, if previously published are supported by a copyright permission
d. Deals with theoretical, practical and adoptable innovations applicable to engineering and technology in agriculture, the environment and biological systems
e. Have a 150 to250 words abstract, preceding the main body of the article
f. The abstract should be followed by the list of 4 to 8 "Key Words"
g. Manuscript should be single-spaced, under 4,000 words (approximately equivalent to 5-6 pages of A4-size paper)
h. Should be submitted in both MS word (2010 or later versions) and pdf formats (i.e., authors submit the abstract and key words in MS Word and pdf after which author uploads the entire manuscript in MS word and pdf)
i. Are supported by authentic sources, references or bibliography

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Please transmit the same via Email: info@kesebae.or.ke

NOTE: A payment will be made to the author of each selected article

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Membership Category	Annual Subscription (KES)	Admission Fees (KES)	Reinstatement Fees (KES)
Fellow	5,000	1,000	2,000
Member	2,000	1,000	2,000
Ass. Member	1,000	1,000	2,000
Aff. Member	500	1,000	2,000
Student	300	100	-

Membership Renewal

Members of all grades are requested to renew their **2024 membership as follows.**

Membership Category	*Annual Subscription Fee (KES)*
Fellow	**5,000**
Member	**2,000**
Ass. Member	**1,000**
Aff. Member	**500**
Student Member	**300**

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