

THERMAL

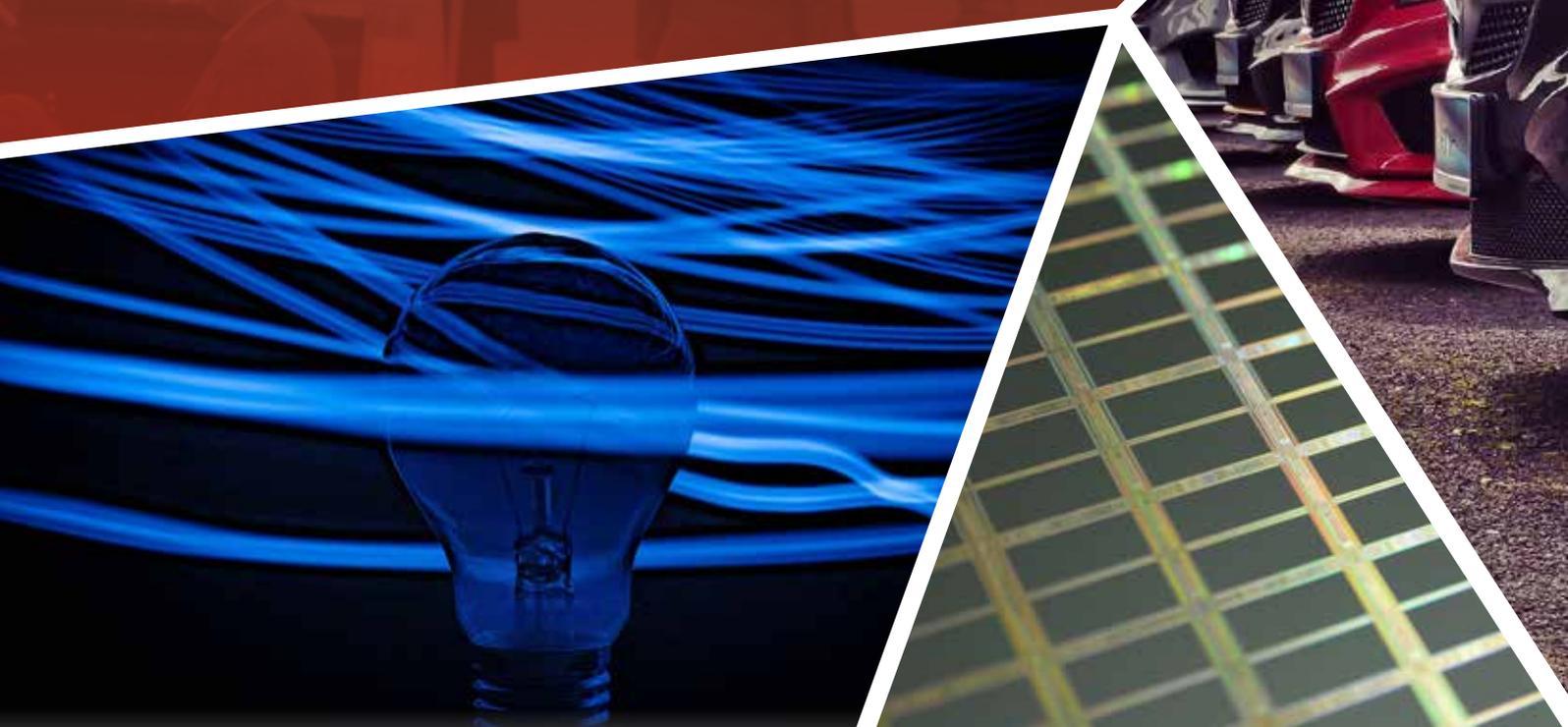
MANAGEMENT EXPO

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**SETTING THE STANDARD:
UNDERSTANDING THE
ROLE OF REGULATION ON
THE DEVELOPMENT OF
THERMAL MANAGEMENT
TECHNOLOGIES**



SETTING THE STANDARD: UNDERSTANDING THE ROLE OF REGULATION ON THE DEVELOPMENT OF THERMAL MANAGEMENT TECHNOLOGIES

The interface between regulation and innovation is something which both challenges and drives technological development. On the one hand, the capacity to innovate must align with existing standards and regulations which have been pre-determined by a governing body. On the other hand, increasing demands for better technologies in all facets of industry continue to develop and set the parameters of products' capabilities, and thus regulations related to their design and usage evolve. This twofold approach creates a paradigm of co-dependency in the technological development landscape.

Research conducted by an independent expert committee into the impact of regulation on technological innovation found that, "It will be important for regulatory design and implementation to take account of the role that technological innovations will play when they become part of wider systems – interacting with individuals, with societies and with the natural world."

Thermal management technology is not exempt from this. The industry is projected to reach 17.08 billion USD by 2026, and as such aligning innovation with regulation will be central to effective development.

In this article, Thermal Management Expo explores how the development of thermal management technologies is impacted by regulation, engaging with key industry stakeholders to understand opportunities for innovation within this.

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UNDERSTANDING THE IMPACT OF INNOVATION

Increasing demands for thermal management across industries are pushing the boundaries for technological innovation, with the market expected to increase at an annual growth rate of 7.68% between 2022 and 2027. Be it transportation, electronics or energy storage (to name a few), the desire to create more efficient technology across industries largely relies on the ability of a product to implement effective cooling solutions.

Although on the surface thermal management may not appear to be directly impacted by regulation, those relating to the technologies which they are present within largely dictate their developmental trajectory.

Indeed, Cara Martin, Chief Operating Officer of Optimized Thermal Systems – a company specializing in heat transfer, product innovation and system integration – said, "The role of legislation and new regulatory change is a huge driver for our work and the type of product development that goes on". Keeping up to date with these drivers will be critical to maintaining technological and business success.

The thermal management technology industry is projected to be worth **\$17.08 billion by 2026**

INCREASING ENVIRONMENTAL REGULATION IS A KEY DRIVER FOR THE THERMAL MANAGEMENT INDUSTRY

REGULATION DRIVING THERMAL MANAGEMENT TECHNOLOGY

One of the key regulatory drivers for thermal management technology is environmental sustainability. Regulations surrounding this topic are increasing in the US and internationally. In December 2021, the United States Environmental Protection Agency (EPA) finalized the standards surrounding greenhouse gas emissions for passenger cars and light trucks manufactured between 2023 and 2026.

The purpose of setting and enacting these standards is to reduce the harmful impacts to society and the environment of poisonous gasses emitted by petrochemical transportation, estimated to account for 29% of the US's greenhouse gases emissions.

Jim McCarthy is the Senior Chief Engineer at Eaton, and his team works on exhaust thermal management and reducing emissions in commercial vehicles. He stated that, "The commercial vehicle market for diesel engines requires a major tightening for exhaust emissions over the next five years. Specifically, there is a need to reduce Nitrous Oxide (NOx) by 90% while simultaneously saving CO2".

This is a significant area for thermal management. According to Jim, diesel aftertreatment systems are temperature sensitive and as such exhaust thermal management is key for "getting the aftertreatment system hot" and once it is hot, "keeping it hot" in order to stay within the high NOx reduction region for near zero NOx output.

With emission reduction standards now pushing the transportation industry towards adapting their technologies to align with requirements to reduce pollution, innovative thermal management technologies such as those developed by Jim's team will play a crucial role in enabling these goals to be met. "I believe that regulations help promote cleaner technologies with an emphasis on improved efficiency in order to reduce the need for fossil fuels," Jim said. Here, it is clear that regulations are driving the development of thermal management technology.

Technological requirements of thermal management driving regulation.

Aside from creating more environmentally friendly components for petrochemical engines, the automotive industry is seeing another major impact bolstered by emissions standards; the boom in electric vehicle (EV) market.

Already seeing exponential growth, the EV market is expected to account for over 60% of new car sales by 2030. With approximately two thirds of the electric vehicle market being made up of battery electric vehicles (BEV), the need to scale up battery production is now

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Jim McCarthy - Senior Chief Engineer, Eaton

more important than ever. It is reported that 'current announced production capacity for 2030 would cover only 50% of required demand in that year'. This is a significant area for thermal management technologies.

Further, battery growth is not restricted to applications in the automotive sector. The era of clean energy and decarbonization is upon us, with the shift from fossil fuels moving to energy storage, a market expected to grow 17 times its current size by 2030.

With the volume and applications of batteries growing, performance demands of these technologies are too. "As we have increased the use of batteries as energy storage devices, we are also looking for those types that are lighter and smaller but also provide more energy", said Dr. Judy Jeevarajan, Vice President and Executive Director, Electrochemical Safety Research Institute (ESRI) at Underwriters Laboratories. Her work at Underwriters Laboratories focuses on advancing safer energy storage through science, focusing on electrochemical safety for the benefit of the technology and wider society.

Lithium-ion batteries provide an ideal solution for the demands of effective energy storage, however, despite their advantages these batteries pose major challenges in one crucial design aspect; thermal management.

These batteries in particular have a high capacity to catch fire if the cells and batteries are not designed correctly. In recent years, we have seen thermal runaway incidents involving batteries within the automotive and other markets, including aviation and electronics. The risk of this happening does not only pose a threat to the battery or product itself, but also to the environment and people.

"When you look at the requirement of a single cell going into thermal runaway and not propagating to other cells, this means that the thermal management system should be designed well enough in order to reduce the risk of thermal runaway and its propagation", said Judy. As such, it is critical for a good thermal management system to be developed in line with safety standards of the application.

Whilst working at NASA Johnson Space Centre, Judy was involved on the Non-Advocate Review Panel for Boeing following thermal propagation incidents in the Boeing 787 batteries. Here, she helped Boeing with recommendations for the battery to be designed with more stringent controls. The results from the post-event investigative studies made the National Transportation Safety Board (NTSB) bring out the recommendation to carry out single cell thermal runaway tests. This was in order to see how severe the propagation of thermal runaway to other cells in the battery would be, and to determine how the risk would be reduced.

When developing thermal management technologies, Judy noted that regulations "are not here to hinder, they are here to help the human race globally to reduce risk to humans".

With ongoing research and development of battery cooling solutions, such as immersion cooling, this example highlights how regulation is be driven by thermal management technology.

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MATERIAL STANDARDS WILL HAVE TO ADAPT TO KEEP UP WITH THERMAL MANAGEMENT TECHNOLOGY DEVELOPMENT

Of course, thermal management does not only relate to systems, but also to materials. Aside from legislation directly affecting the demand for thermal management systems, there are also materials and qualification standards which will be impacted in the execution of these technologies.

For instance, one market report states that direct-to-chip liquid cooling is becoming popular in North-American data centers. Further, liquid cooling of electronics hardware within consumer electronic devices such as smartphones is coming to the fore, with manufacturers including Samsung and Xiaomi already showing an interest in implementing this type of passive cooling into their products.

The impact of this means that current materials and qualification standards will have to adapt in line with this. For example, in the latter instance, materials will have to be requalified taking into consideration whether they are compatible with the liquid, where reformulation will have to occur should it not meet the requirement. As well as the qualification of materials, characterization and reliability will have to be implemented to determine the requirement of a customer.

Taking in to account other trends such as the growth of the thermal interface materials (TIM) market, material standards will play an important role in ensuring effective integration of thermal management.

INCENTIVIZING INNOVATION

When thinking about legislation, regulation, and standards, this can also encompass additional incentives which are very likely to play a role in the future development of thermal management technologies. Take, for example, the introduction of the investment tax credit (ITC) for energy storage.

This ITC is part of the Build Back Better Act, which aims to enable the United States to meet climate goals, create jobs, and boost the economy. The investment tax credit will be available for stand-alone energy storage system suppliers, meaning there will likely be a significant boost to this sector. Given the requirement of efficient cooling within energy storage, this will undoubtedly have an impact on the demand for thermal management technologies. Being aware of such resources will help suppliers and manufacturers gain access to valuable financial support and shape the direction of their operations.

Not only does the government provide such resources, organizations can also make moves to appeal for such incentives to be implemented through engaging with relevant government bodies. “Sometimes you want to push for government funding from the federal government to incentivize and accelerate new technologies”, said Director - Energy & Electrical Systems at Copper Development Association, John Hipchen, showing the reciprocal relationship of technology and regulation.

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LEVERAGING TECHNOLOGY AND COLLABORATION TO FULFIL REGULATORY REQUIREMENTS

With the awareness of the legislative and regulatory landscape impacting thermal management, the next step for manufacturers and suppliers should be having a clear framework in which to ensure how considerations can be implemented into business operations and the development of technology and innovation. To put it simply, Judy stated that “if you want to put something out in the market, meeting the minimum standards is absolutely necessary”. And how exactly can they do this?

The technological approach for addressing regulation

Manufacturers of thermal management technologies should not only be aware of current regulatory requirements, but also emerging ones. Cara Martin (Advanced Thermal Solutions), said that “many clients we work with leverage simulation upfront to understand various impacts of regulatory changes, whether it’s finding a new material or system”. Simulation is a useful tool which can be used to recognize the impact that changes in regulation will have on the requirements of thermal management technology, in anticipation of its development. Similarly, Jim McCarthy (Eaton) stated that a large portion of his organization’s work is to test, evaluate and validate the merit of new technologies on regulatory changes and real-world drive cycles: “this allows us to determine the best technology to meet regulatory and customer demand”, he mentioned. Understanding a product’s viability in fulfilling regulatory requirements is crucial to its commercialization.

Leveraging testing capabilities is one solution to ensuring that thermal management technologies meet regulatory demands. In the case of lithium-ion batteries, Judy (Underwriters Laboratories) commented, “if effective thermal analysis is carried out and people can understand how to design a very good thermal management system, they can certainly reduce the risk and fire”.

The collaborative approach to addressing regulation

Product development can often be a lengthy and stringent process, sometimes taking many years. Foreseeing how the market and regulations will change in the years to come is crucial to manufacturers ensuring that the product will meet these demands at the time it goes to market.

As well as utilizing testing technology, suppliers and end-users of thermal management technologies should seek to work with external organizations to allow for collaboration and support in ensuring the correct actions are being taken towards aligning with regulatory demands. This can include universities, external suppliers, government regulators, professional organizations and working groups.

Speaking from his experience in undertaking such partnerships, Jim said I believe that partnering with key organizations is key.... [we] take a multi-pronged approach in supporting and understanding the regulatory environment. Our global organization allows us to become familiar with emerging changes early, but also helps us to consult with regulatory bodies

and develop appropriate approaches. Our thought leadership and network of partners, along with our global R&D capabilities, allows us to meet market demands with new and innovative technologies.

An example of how this comes into effect is the work carried out by Judy’s team at Underwriters Laboratories. The Underwriters Laboratories team is carrying out a study on mitigation of the propagation of thermal runaway and in the process testing a variety of materials to study their efficacy in preventing thermal runaway and fire propagation. Manufacturers can access this to benefit their operations.

Creating such networks allows for companies to stay ahead through knowledge sharing and cooperation towards a mutual objective.

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John Hipchen, Director - Energy & Electrical Systems, Copper Development Association

WHY DO WE NEED REGULATIONS, ANYWAY?

Clearly, thermal management is both impacted by and impacts regulation. But what is the point of regulation?

Part of John’s organization’s work involves an active program in government advocacy. When speaking about the role of regulation, he mentioned that “government regulations are normally directed at efficiency and that’s had a pretty positive role in moving a lot of technology forward”. Efficiency is certainly a common thread which ties thermal management technologies and regulation together; a more efficient system is a better system. This core principle underpins the requirement of these systems and as such ties these two elements together.

When thinking about efficiency, although the value of efficiency plays a critical role in driving regulations, manufacturers may at times be faced with a trade-off whereby efficiency standards can reach too far and the gain is sometimes not worth the additional cost for the manufacturers or consumers, according to John. When developing thermal management and other technologies, this should be a key consideration in aligning innovation with regulation.

THE ULTIMATE QUESTION: ARE REGULATIONS HELPING OR HINDERING THERMAL MANAGEMENT SUPPLIERS?

Perhaps the ultimate question for providers of thermal management technology to consider is: are legislation, regulations, and standards helping or hindering development?

When we assess the role of thermal management, it leads back to the core principles of improving the performance and safety of the system or technology it serves. With the common driver for both regulations and for thermal management technology being efficiency, the conjunction of the two create an advantage for both sides. In support of this, Jim stated that, "Regulations have a positive impact and are necessary".

With the thermal management market largely being driven by the demands of the industries it supplies to, it is imperative to consider the wider picture of the industries being served when analyzing the role of regulation as a driver. Understanding what the effects of regulation will have on these will help manufacturers and suppliers of thermal management technologies to navigate the governing frameworks effectively.

As technologies develop, so will legislation, regulations, and standards, and vice versa. Manufacturers of thermal management technologies can seek to effectively position themselves for future success through the capacity to adapt and innovate, leveraging technology and collaborating with external stakeholders to achieve a common goal of meeting both the application requirement as well as the regulatory demands.

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**Cara Martin (Advanced
Thermal Solutions)**



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