

The background features a diagonal arrangement of puzzle pieces. Each piece contains either numbers (e.g., 0,1; 2,3; 4,5; 6,7; 1; 2; 3) or small diagrams with arrows indicating direction or flow. The pieces are arranged in a way that suggests a larger puzzle being solved.

Electrification in the Industrial Sector: The Missing Piece of the Puzzle

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The transportation, building, and industrial sectors account for 65% of all greenhouse gas (GHG) emissions in the U.S. Switching to electricity as a power source can help reduce the environmental impact of these operations — but there's a caveat: how we generate the electricity makes a big difference in the carbon footprint.

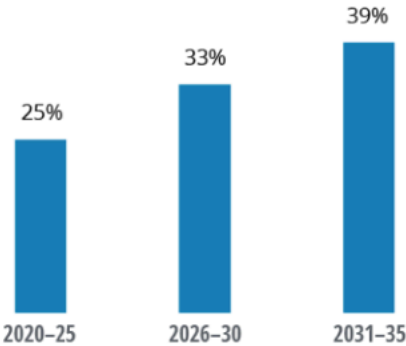
The environmental benefits would be less impactful than advertised if the electricity comes from fossil fuels. On the other hand, using power from renewable sources (e.g., solar, wind, hydro) will achieve a much higher environmental impact. And here comes the good news:

McKinsey projects that renewables could produce over 50% of the world's electricity by 2035 — at a cost lower than the power generated with fossil fuels. The price reduction and the more stringent greenhouse gas emission regulations mean switching to electricity for everything from vehicle fleets and equipment to space heating will make business sense.

In particular, electrification's financial and environmental benefits are mounting for the industrial sector, which consumed 149 million terajoules in 2017 — the most energy used compared with other verticals.

Fleet electrification adoption targets set by US manufacturers

Fleet electrification adoption



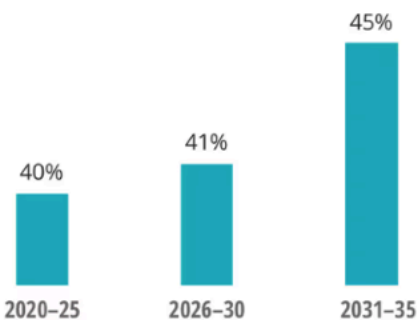
Question: Please provide more details about your organization's goals and timelines for electrifying energy use for transportation fleet.

Source: Insights from the Deloitte 100 Percent Renewable Transition Survey.

Deloitte Insights | deloitte.com/insights

Industrial processes electrification target set by US manufacturers

Processes electrification adoption



Question: Please provide more details about your organization's goals and the timeline for electrifying energy use for industrial process.

Source: Insights from the Deloitte 100 Percent Renewable Transition Survey.

Deloitte Insights | deloitte.com/insights

Source: Deloitte Insights

This paper delves into the benefits of electrification in the industrial sector, what the fine prints are, and how to make electrification feasible and profitable.

The benefits of electrification in the industrial sector

McKinsey predicts industrial companies can replace almost 50% of the fuel used today with electricity to power various equipment and types of machinery. This shift will create significant financial and environmental impacts, especially with electricity from renewable sources.

Here are the benefits of electrification in the industrial and manufacturing context:

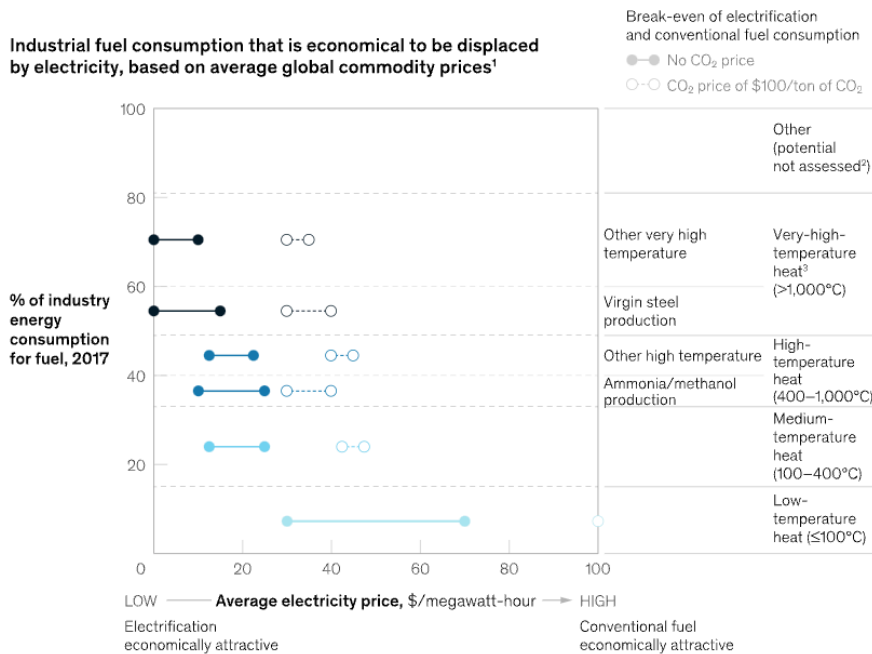
- Lower operating costs: Electrified equipment classes have fewer moving parts and fluids, making them cheaper to operate and maintain than their diesel-fuel counterparts.
- More predictable budget: The power costs of electricity (especially from renewable sources) are less volatile than gasoline and diesel.
- More diverse applications: Electrified equipment doesn't produce pollutants during operation and is easier to maneuver, making it ideal for indoor applications.
- Increased fleet management efficiencies: A Deloitte survey found that most industrial manufacturers aim to electrify 40% of their fleets by 2035.

- Adherence to emissions standards: Country-level emission regulations and local access policies will make reducing fossil fuel consumption non-negotiable.
- Meeting ESG standards: Consumer preference for environmentally responsible products will impact the entire supply chain. Lowering emissions in the production and fulfillment processes can mean the difference between keeping and losing a contract.

In short, electrification isn't just for tree huggers. It delivers substantial operational and financial benefits to make a good business case for CFOs and decision-makers.

Low electricity prices, or a significant CO₂ price, increase the financial attractiveness of electrification.

Industrial fuel consumption that is economical to be displaced by electricity, based on average global commodity prices¹



Source: McKinsey and Company

How electrification can succeed in the industrial sector

If electrification delivers so many financial and environmental advantages, why isn't everyone already doing it? The reality is that realizing the promises and potential of electrification in the industrial space has way more caveats than simply flipping the switch.

Here are the key challenges and considerations.

Power sources, distribution, and storage

The environmental impact of electrification depends heavily on the resources used to generate power. The ability to access reliable renewable sources is crucial to reducing emissions. Plus, using electricity from fossil fuel plants won't maximize the cost-saving benefits or shield the operation from oil price fluctuations.

But renewable energy sources also pose some challenges. Unlike fossil fuel plants that can be built almost anywhere, solar and wind farms or hydro-power stations are location-dependent.

If you purchase renewable energy from a source hundreds of miles away, you need the infrastructure to transmit the power. However, the grid is already strained in many populated areas and has become less reliable in times of high demand.

What if you can generate solar or wind power on-site? The sun won't shine 24/7, and the wind won't blow around the clock, so you must have a power storage solution to ensure uninterrupted operations.

Batteries can help solve the distribution and storage problems and will play a critical role in electrification. They're also essential for untethering

equipment like forklifts and warehouse robots from the wall socket so they can perform their intended functions.

But today's monolithic battery solutions aren't as environmentally friendly as many presume. Operators often have to replace the entire pack even if just one cell fails — tossing out the good ones with the bad.

Given the significant environmental harm of the lithium mining and production process, such inefficient use of battery materials can undo the positive impact of an electrification solution.

Another challenge concerns operational flexibility and agility. Today's batteries can only charge from and discharge at a single voltage. You can't have a single battery solution power an array of equipment requiring different input voltages. Stocking batteries of different types will significantly complicate inventory management and expose companies to supply chain risks.

The cost of equipment and user adoption

The battery in your smartphone may not seem like a big deal, but developing a custom battery solution for industrial equipment is, in fact, expensive, time-consuming, labor-intensive, and potentially hazardous. The challenges increase the R&D scope significantly, which makes it much harder for smaller companies to throw their hats into the electrification ring and build innovative solutions.

The high cost of developing custom battery solutions increases the price of high-value, electrified equipment — making it hard to jumpstart the electrification process even though companies understand the significant long-term cost-saving benefits.

Even if you have the budget to purchase electrified equipment, you still have to jump through another (more challenging) hoop: process and user adoption. The success of a new technology depends heavily on the customer base's ability to absorb the new paradigm. It's no exception when transitioning from business processes that historically employ fuel-burning engines.

Switching to electrified equipment could mean retooling many processes and retraining thousands of workers. You'd likely face a lengthy adoption period, which can become even more challenging if the workforce resists the changes.

Balancing the cost of equipment and user adoption with the benefits and regulatory compliance imperative becomes an impossible choice for many companies. They're stuck between a rock and a hard place, while the inaction exacerbates the environmental footprint of the entire sector.

The deceptively simple answer to accelerating electrification in the industrial sector: Don't reinvent the wheel

Electrifying the industrial and manufacturing sector seems like a tall order — uprooting everything all at once is too costly and disruptive to be productive. We need a small hinge that can move a big door.

Software-defined battery solutions address many of the challenges discussed above while amplifying the cost-saving benefits of electrification with data analytics to optimize resource usage and operational efficiency.

Let's start with power storage and distribution. The Tanktwo Battery Operating System (TBOS) enables operators to replace underperforming or non-functioning cells without tossing out the entire battery pack.

A TBOS-powered battery pack allows maintenance personnel to mix and match cells of any age, chemistries, and characteristics without impacting performance. It not only helps minimize downtime but also maximizes resource utilization with minimal wastage.

Then, we have the inventory challenge — how can you streamline supply chain management by stocking just a handful of battery models instead of tens or hundreds to power different types of equipment?

Software-defined batteries also hold the answer. TBOS supports modular battery packs — the Tanktwo Smartpak can stack to form battery packs of any size and deliver any power level required without any cabling between units.

Moreover, the batteries can charge and discharge at any voltage from 4V to 400V and use cells of any chemistry. They provide operators with the utmost agility to run multiple types of equipment with a streamlined inventory while mitigating the impact of supply chain fluctuations.

Next, we must solve the high cost of electrified equipment. Today, equipment builders spend large sums on custom battery pack development. TBOS supports plug-and-play, API-like battery solutions to shorten R&D and lower product development costs. Equipment can be available at a lower price point without compromising reliability, performance, or safety.

The key to unlocking the fastest path to user adoption

But the most advanced equipment won't have any impact if they aren't adopted and integrated into the industrial processes. **The shortest path to adoption is simple: Retrofitting existing fossil fuel-powered equipment with a battery pack.**

While this approach is impossible with current battery technologies focusing on monolithic, custom battery packs, it is a piece of cake with a software-defined battery solution. Retrofitting equipment can even help streamline type approval and accelerate electrification.

Operators can use software-defined batteries to eliminate over 90% of costs associated with equipment and user adoption because they don't have to purchase new equipment or retrain the workforce. Our technology allows them to adapt their electrification strategy to the environment for which the equipment is built and the processes in which workers are trained.

The solutions shorten the adoption timeline and lower the break-even point so companies can realize the cost-saving benefits and ROI of electrification much faster.

The nuances of electrification for industrial companies

Decarbonization is the buzzword du jour, but there are many asterisks when the rubber meets the road. Technology isn't the only hurdle — we must consider people and processes for any business and industrial transformation to succeed.

A green tech solution must address every step of the electrification journey, including adoption. It must consider feasibility and profitability to be relevant for industrial companies. Successful decarbonization must improve efficiency to reduce environmental impacts without impeding progress.

Enterprises that build, sell, and service the critical equipment that produces our food, manufactures our goods, cures our sick, builds our houses, and maintains our roads aren't battery specialists.

This critical industry has been struggling to electrify because large, custom battery packs are expensive, challenging, and risky to build. Our software-defined battery solutions make it radically easier to power equipment that isn't supported by a mass market.

However, in the aggregate, the economic contribution of these small and medium enterprises eclipses the value of the auto industry. It's time to enable electrification in this essential market that makes up the backbone of the modern industrialized economy.

Explore partnership and investment opportunity with Tanktwo: b@tanktwo.com