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Current wars 2.0

A new era of direct electric current is set to transform your world

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Contacts

Amsterdam

Lucas Prat Bertrams
Partner, PwC Netherlands
+31-8879-25087
lucas.prat@pwc.com

Paul Nillesen
Partner, PwC Netherlands
+31-8879-29173
paul.nillesen@pwc.com

Berlin

Dr. Nils Naujok
Partner, PwC Strategy& Germany
+49-30-8870-5855
nils.naujok@pwc.com

Calgary

Helen Bremner
Partner, PwC Canada
+1-403-509-7500
helen.bremner@pwc.com

Dallas

Thomas Flaherty
Principal, PwC US
+1-214-746-6553
tom.flaherty@pwc.com

Todd Jirovec
Principal, PwC US
+1-214-746-6525
todd.jirovec@pwc.com

DC

Peter Bertone
Partner, PwC US
+1-703-682-5719
peter.bertone@pwc.com

Dubai

George Sarraf
Partner, Strategy& Middle East
+961-1-985-655
george.sarraf@pwc.com

Düsseldorf

Dr. Joachim Rotering
Partner, PwC Strategy& Germany
+49-211-3890-250
joachim.rotering
@pwc.com

Dr. Marcus Eul
Partner, PwC Strategy& Germany
+49-211-3890-225
marcus.eul@pwc.com

Jakarta

Lenita R. Tobing
Partner, PwC Indonesia
+62-21-521-2901
lenita.tobing
@strategyand.id.pwc.com

London

Andrew Clark
Partner, PwC UK
+44-20-7393-3418
andrew.clark@pwc.com

Steve Jennings
Partner, PwC UK
+44-20-7212-1449
steven.m.jennings
@pwc.com

Madrid

Oscar Barrero
Partner, PwC Spain
+34-915-684-9934
oscar.barrero.gil
@es.pwc.com

Mexico City

Eduardo Reyes
Partner, PwC Mexico
+52-55-5263-8957
eduardo.reyes.bravo
@pwc.com

Milan

Giorgio Biscardini
Partner, PwC Italy
+39-02-7250-9205
giorgio.biscardini
@pwc.com

Moscow

Dmitry Mordovenko
Partner, PwC Russia
+7-919-999-0624
dmitry.mordovenko
@pwc.com

Mumbai

Girish Shirodkar
Partner, PwC India
+91-22-6669-1000
girish.shirodkar
@pwc.com

Paris

Laurent Saint Martin
Partner, PwC France
+33-6-8513-4843
laurent.saintmartin
@pwc.com

San Francisco

Christopher Dann
Principal, PwC US
+1-415-653-3491
christopher.dann
@pwc.com

São Paulo

Ivan de Souza
Partner, PwC Brazil
+55-11-3674-8736
ivan.de.souza@pwc.com

Shanghai

Huchu Xu
Partner, PwC Greater China
+86-21-2323-2020
huchu.xu@pwc.com

Sydney

Chris Manning
Partner, PwC Australia
+61-2-8266-0000
chris.manning@pwc.com

Tokyo

Kenji Mitsui
Partner, PwC Japan
+81-3-625-1200
kenji.mitsui@pwc.com

About the authors

Laurent Saint Martin is an advisor to executives at Strategy&, PwC's strategy consulting business, for energy and utilities clients. A partner with PwC France based in Paris, he specializes in strategic transformation planning, B2B digital services development, and growth and product strategies.

Adrian Del Maestro is a specialist in the energy industry for Strategy&. He is a director with PwC UK. He is based in London, where he oversees the firm's global research capabilities in the energy practice.

Guillaume Jean specializes in R&D and innovation for Strategy&. A manager with PwC France based in Paris, he specializes in growth strategies for corporations. He is a member of PwC's accelerator team, which supports high-growth startups.

Executive summary

At the end of the 19th century, Thomas Edison, the scientist and inventor, and Nikola Tesla, an electrical engineer and inventor, were both researching how electricity could be transmitted and used. The two men struck out in different directions, with Edison becoming a proponent of direct current (DC) and Tesla focusing on the design of alternating current (AC). The resulting rivalry became known as the "Current Wars." It was an argument that Tesla eventually won, and AC became the system of choice for transmission and distribution of electricity into our homes to this day. But Edison's DC system is making a comeback. That's because of fundamental shifts in the way energy is generated, distributed, and harnessed amid a global push on renewables (solar, in particular) and the emergence of new technologies (especially in batteries and storage).

Electricity generation is becoming decentralized, with distributed generation systems producing power closer to the consumer. Unlike conventional power stations, from which electricity is transported over long distances, microgrids now allow electricity to be distributed locally using DC as well as AC. Microgrids are small technological ecosystems that can supplement or replace a central power grid.

DC's applications and cost benefits are becoming more tangible. Using proprietary analysis, we have calculated that businesses across multiple sectors could, in aggregate, reduce energy costs — both capital and operating costs — by as much as 30 percent over a 25-year period.

Companies and investors should ensure they have the right set of capabilities and strategies in place to fully capitalize on DC's benefits.

Four drivers underpinning DC adoption

In this report we have identified four drivers of the adoption and growth of DC.

1. A shift in both electricity generation and customer usage

Electricity generation relies increasingly on so-called decentralized renewable energies — that is, energy generated locally in various ways, including from solar panels, as opposed to power generated at a central location. Moreover, solar panels generate electricity in DC. So, as electricity generation through solar grows — and it grew from 34 terawatt hours (TWh) in 2010 to 253 TWh in 2016, according to the International Renewable Energy Association — so too is the amount of DC power generated likely to grow.

Solar panels do not generate a steady stream of electricity for the obvious reason that the sun does not shine continuously — at least not in all climates. This means that more energy storage will be needed to manage fluctuations in this type of power supply. That's where storage technology comes in: lithium-ion batteries, supercapacitors, fuel cells, and flow batteries, all of which are efficient for storing DC. Given that production of these technologies is still at an early stage, we estimate that the installed capacity of such batteries is enough to soak up only around 1 percent of all solar power currently generated. The potential for more storage is clear.

In the meantime, everything from LED lighting in homes and businesses to electronics (computers, smartphones) is increasingly being run on DC. Yet thanks to Tesla's legacy, offices and homes are typically connected to national AC grids. This is why laptops, for example, need an AC-DC converter embedded in a power cable to run on AC. Finally, the growth of microgrids is enabling greater use of DC. Its component parts are solar power, the use of home appliances that can accept DC, and new forms of power storage, all connected by cables. An example of a small microgrid would be a home with features including the ability to use an electric car's battery to provide current to the home, as well as vice versa (*see Exhibit 1, next page*), and an example of a large one would be a town with facilities and offices connected to such a network. Cofely (a subsidiary of Franco-Belgian group Engie, formerly GDF Suez) and Bosch of Germany are among the companies building DC microgrids specially designed for industrial zones. More are coming.

2. New infrastructure needs: Long-distance transmission and EV charging

Electricity is increasingly being sent across national borders in Europe, a process accelerated by liberalization of markets generally. Southern Germany gets much of its electricity from France, for example, requiring efficient transmission over long distances. In China and India, governments are building transmission lines across very long distances to connect communities with power. The same thing is happening in Africa, where similar projects will eventually also connect countries there with Europe.

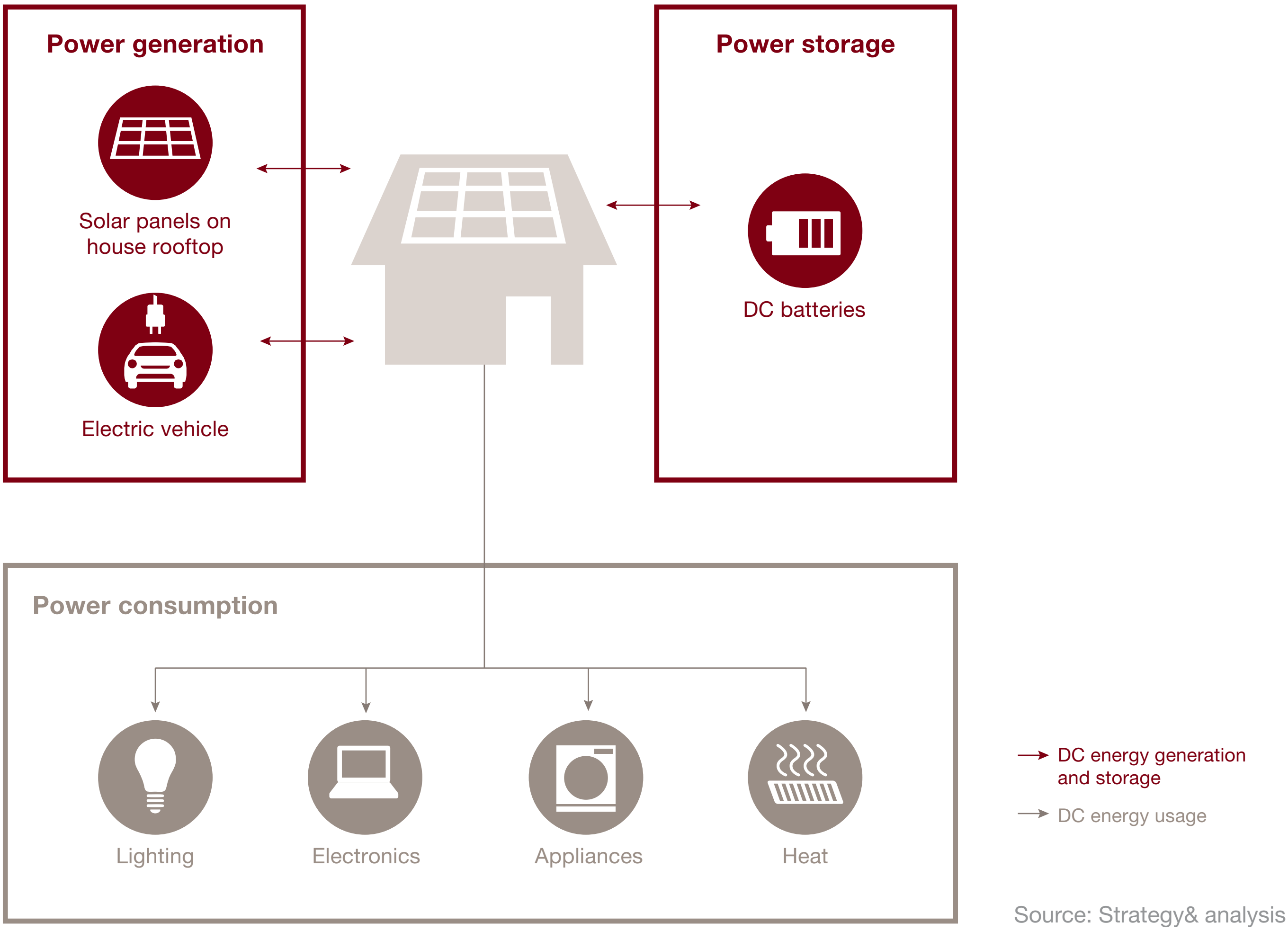
The technology that works well in this context is high-voltage direct current (HVDC) because DC travels along a transmission line smoothly with minimal energy leakage and loss, in contrast to high-voltage alternating current (HVAC), with which energy leakage and loss is an inevitable by-product of AC's irregular pulse. With less energy loss, there is also less need to invest in grid stabilization, which is a typical feature of long-distance transmission systems at the moment. Such is the optimism over the potential for HVDC that MarketsandMarkets, an India-based energy research group, expects the installed capacity of HVDC systems to double from its current level of 43 gigawatts by 2022.

Expansion is also expected in charging infrastructure. As adoption of electric vehicles (EVs) grows, so too does the use of DC superchargers — devices that can charge a vehicle battery in a matter of minutes rather than hours. Tesla — the company, not the engineer — is building hundreds of new DC supercharging stations in many countries. The broader deployment of DC charging infrastructure for EVs will reduce the level of power losses typically associated with conversion from AC to DC.

3. New technologies: DC innovation momentum

Technology breakthroughs are creating further momentum for DC. Circuit breakers and medium frequency transformers are generating interest in DC among railway-related businesses, because they save costs and stabilize power networks. Entities interested in them include French transport systems manufacturer Alstom, Swiss engineering

Exhibit 1
Example of a DC microgrid at the domestic level



Source: Strategy& analysis

group ABB, and the SuperGrid Institute, a collaborative research institute in which GE of the U.S., French utility EDF, and France-based cabling group Nexans are involved.

Moreover, additional innovations in DC cables are leading to more power-efficient EVs and aircraft. Companies such as Microsoft and Facebook have been installing innovative, hybrid AC-DC power systems in many of their data centers and have seen immediate savings in energy consumption of around 20 percent. Such hybrid systems also help to save space, with the same benefit seen in power stations that use DC.

4. Regulatory evolution: Public and private initiatives under way

Governments are starting to recognize the benefits of DC. State Grid, China's state-owned electricity utility, started work in 2009 on an 11-year plan to build ultra-high-voltage direct current lines that will significantly boost the availability of electricity across the country. Use and expansion of DC was enshrined in the Communist party's 12th Five-Year Plan, released in 2011. Likewise, U.S. manufacturers that are members of the EMerge Alliance — an open industry association — are setting standards to facilitate the adoption of DC power systems in commercial buildings.

Are you ready for the DC wave?

The benefits and potential savings of DC apply in a range of industries (*see Exhibit* 2, *next page*). What's more, the rise of DC will have an impact across many parts of a business, including research and development, supply chain management, and product development. Indeed, it will fundamentally affect the growth strategy of many companies. As Edison's vision for electricity transmission makes a decisive comeback, business leaders will need to factor this profound shift in power technology into their thinking. And having a strategic road map (*see Exhibit 3, page 11*) is one of several steps they will need to take to ensure they maximize their company's competitive advantage.

Exhibit 2
Possible applications and DC benefits for selected industries

Sectors	*Industries*	*Possible applications*	*DC benefits*
Energy	Utilities	Developing microgrid systems	~30% operational and capital cost savings
	Transmission	Building electricity transmission based on DC (HVDC)	~20–50% reduction in energy loss (above 400 kilovolts)
	Manufacturing	Building power station with DC output	~30% space savings
Transport	Aeronautics	Using DC electricity to propel landing gear, rather than the aircraft's engine	Fuel savings
	Automotive	EVs, superchargers	Faster charging speed (up to 10 times current capability)
	Merchant marine	Long-range electrical propulsion, lightweight embedded electrical power network	Up to 30% weight savings
	Railways	Energy-efficient DC medium-frequency transformers in trains	~60% reduction in energy loss
Defense	Naval	Long-range electrical propulsion, lightweight onboard electrical power systems	Up to 30% fuel savings
	Weapons	Creation of high-velocity weapons, plasma weapons, electromagnetic catapult	Increased military impact
IT	Data centers	Hybrid AC-DC power systems	~20% energy savings, space reduction

Source: Strategy& analysis

Exhibit 3
Road map to fully harness DC potential

Utilities	– Design and integrate DC grid architectures – Identify key R&D opportunities for DC development – Assess opportunity to develop microgrid strategies
Energy transmission operators	– Increase R&D investments in HVDC transformers – Deepen interest in HVDC technologies
DC systems manufacturers	– Assess partnership opportunities with utilities and transmission operators to maximize return on R&D investments – Innovate by developing new DC technologies
Aircraft manufacturers	– Integrate DC electrical systems in future aircraft – Define suppliers' ability to provide appropriate DC equipment to support increase in aircraft power needs
Ship builders	– Continue R&D on DC power units – Define suppliers' ability to provide appropriate DC equipment to support increase in ships' power needs
Railways	– Rethink network architecture and limit number of substations to reduce amount of maintenance and operational work along lines – Assess opportunity to upgrade train transformers
Data center operators	– Create appropriate AC-DC power supply systems business case – Improve relationships with DC systems manufacturers to benefit from further technology improvements
Businesses (commercial and industrial)	– Create appropriate AC-DC power supply systems business case – Assess opportunity to implement microgrids

Source: Strategy& analysis

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