White paper

Microgrids
Weathering the storm

In October 2012, Hurricane Sandy walloped the Caribbean then combined with a Noreaster to knock out power to millions along the eastern coast of the United States. When superstorms like Sandy make landfall in major population centers such as New York, New Jersey, and Connecticut, power outages can have a devastating impact on the local economy and people's lives, and restoration can takes weeks if not months.

While the real cost in damages from Hurricane Sandy have yet to be fully understood, estimates already place it at around $50 billion - second to Hurricane Katrina as the most costly storm in United States history.

If there's a bright side to events like these, it is the wakeup call it provides to utilities, regulators, and communities, alerting them to the need to modernize the power grid to improve stability and reliability and harden it against disasters, both natural and manmade.

Microgrids:
A key component of power reliability

Microgrids are small, self-sufficient power grids that serve a group of consumers such as a university campus, military base, or municipality. The microgrid can draw power from the main grid or it can operate in "island-mode" where it neither draws power from the main grid nor supplies power to it.

The microgrid concept is not new, but during the age of industrialization, centralized grids serving a large number of consumers from a primary power source made more economic sense. It simply wasn't feasible for most municipalities, colleges, hospitals, or other entities to build their own power plant. While they might rely on power sources such as a diesel generator for mission critical needs during energy disruptions, these sources weren't considered a cost-effective solution for everyday energy needs.

The technology needed to make microgrids feasible for everyday use, such as that needed for power storage and stabilization, has reached a point where it is commercially viable and available.

Likewise, utilities had no compelling motivation to invest in microgrid technologies. To them, the microgrid represented a potential loss of revenue when power was supplied from a local source. It also represented a potential expense since the utility would be responsible for the hardware, software, and communications technology required to connect the microgrid to the main grid. Finally, there were concerns over stability of the grid. What if the microgrid contained a high penetrations of renewables, creating fluctuations in power quality that extended to the main grid?

A confluence of two trends has brought the concept of microgrids to the fore. First, Hurricane Sandy and other “superstorms” of the last decade have highlighted, in painful and expensive ways, the need to protect consumers from the devastation caused by such natural disasters. Second, the technology needed to make microgrids feasible for everyday use, such as that needed for power storage and stabilization, has reached a point where it is commercially viable and available.

Today, both utilities and industry recognize the need to collaborate to make the microgrid a reality.

When discussing microgrids, the customer is more than just the end consumer, the household or business that consumes power. Customers also include the political leaders, regulators, business executives, and others who serve the end-consumer. It is often these intermediary “consumers” that initiate the microgrid discussion as they search for ways to ensure a reliable and safe supply of power to their constituencies.

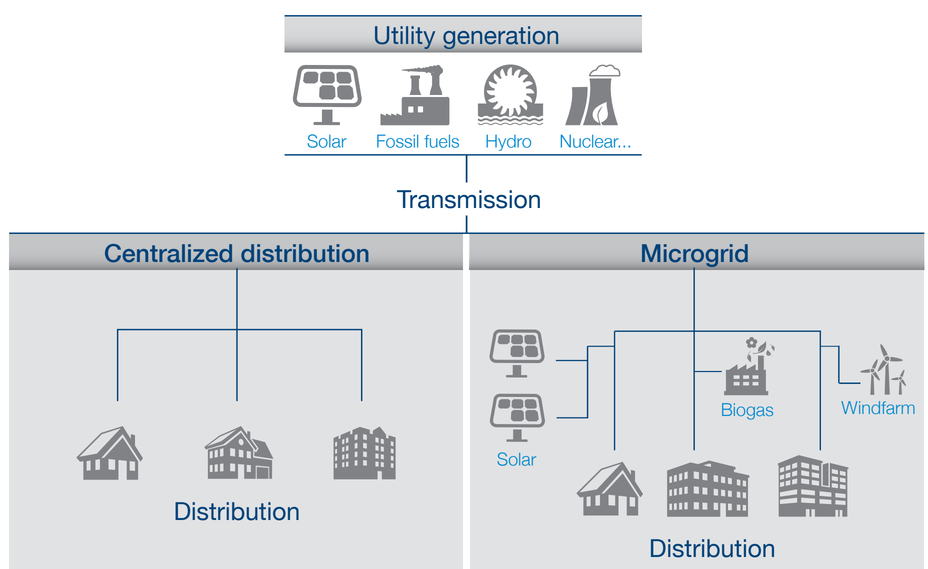
Reliability

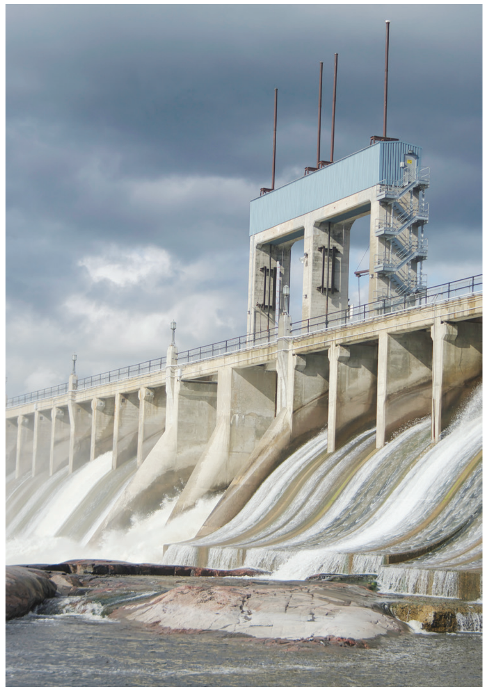
The driving force for microgrids

The compelling impetus for the discussion is most often reliability. How can we ensure our community, place of business, or entity is insulated from an extended power outage in case of a natural (or manmade) disaster?

The reliability benefits of the microgrid are clear. When the main grid loses power, the microgrid can switch to island mode. As long as there is an adequate source of power at the local level (diesel generator, wind turbine, fuel cell, PV, etc.), the power continues to flow while the rest of the community is enveloped in darkness. Of course, mission critical resources such as hospitals have maintained their own backup power source for years. The modern concept of a microgrid simply takes that idea to a larger group of consumers and makes it more feasible for everyday use.

Microgrids improve reliability by providing the flexibility to operate in centralized or island mode




The microgrid's hidden benefits

As community leaders progress in their microgrid discussions, these intermediary consumers often discover a number of additional benefits:

Meeting renewable mandates – Many regions around the world have set aggressive renewable portfolio targets. For example, Illinois has determined by law (HB 1458) that it will obtain 25 percent of its energy from renewable sources by 2025. According to the Department of Energy, Illinois currently derives only 11.54 percent of its energy from renewable sources. It's almost certain that aggressive targets like these won't be reached through utility-scale renewable power generation alone. Support will be needed from the private sector as well as public institutions like universities. Microgrids allow commercial and industrial entities to make pragmatic investments in renewable energy, starting with a low penetration of renewables but expanding as their microgrid evolves.

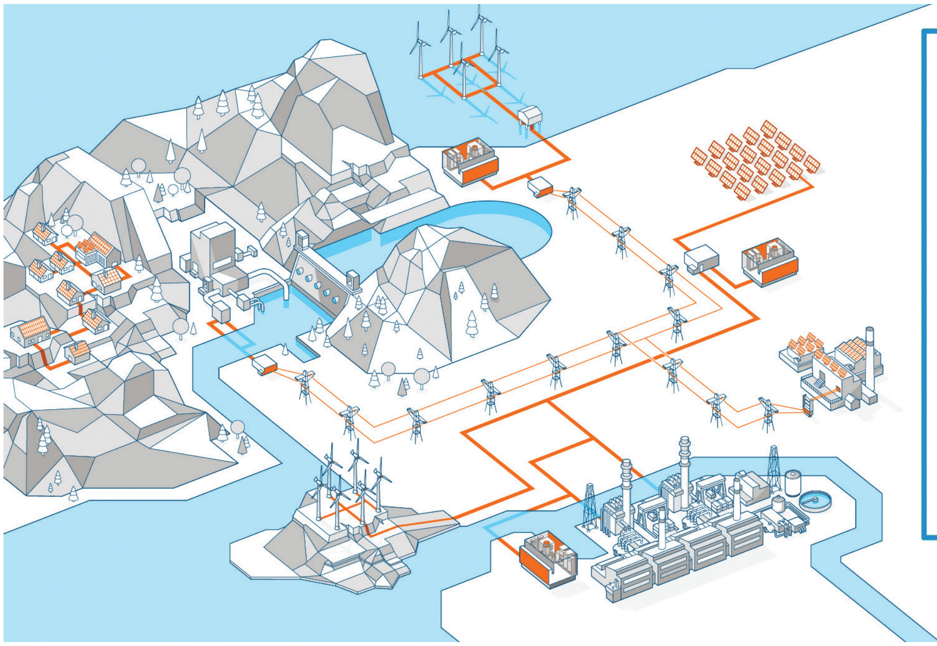
Hedging against rising fuel costs – While many industrialized countries have to balance the higher cost of renewables against readily available fossil fuels, the opposite is true in some regions of the world. In developing regions that lack reliable fossil fuel infrastructure, or where political forces can disrupt supply and drive up prices, it may be more economically feasible to build a microgrid around a renewable source such as solar. Grid advancements that allow these remote regions to maintain some self-sufficiency as well as incorporate readily available sources of renewable energy, such as solar and wind, can bring huge economic benefits.

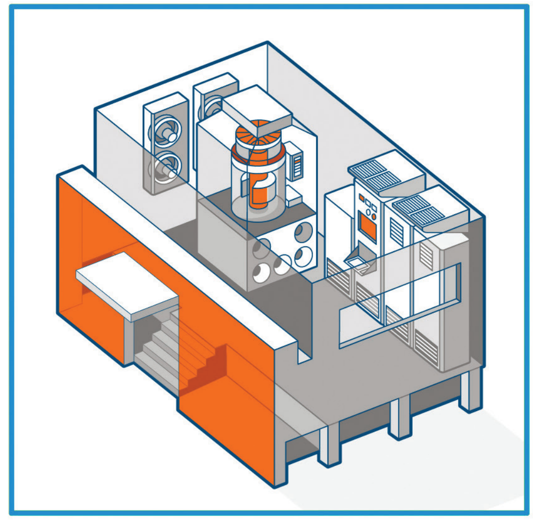
Providing power to remote areas – As difficult as it may be for people living in more developed parts of the world to imagine, there are areas that cannot be reliably addressed by the existing grid infrastructure. For example, a remote mining operation in the Antarctic or an island separated from the mainland by many thousands of miles of water may not be able to access the main grid at all.

As many utilities are discovering, one of the greatest benefits to supporting microgrids is improved public relations.

Increasing security – A major outage in 2003 showed just how vulnerable the grid can be. Reportedly, a snagged power line in Ohio caused a cascade of failures throughput the northeastern US and Canada that eventually affected more than 50 million people. While cyber attacks often dominate the discussion of grid security, utilities and governments need to find ways to protect the grid from natural disasters as well as physical sabotage. Experts agree, any prolonged disruption of power, regardless of the cause, represents a threat to security and economic stability.

Winning the PR war – As many utilities are discovering, one of the greatest benefits to supporting microgrids is improved public relations. Perhaps consumers and the media don't pay as much attention as they should when a utility restores power quickly, but they sure notice it when it takes weeks to turn the lights back on after a storm. In cases such as these, having a segment of consumers that can operate independently allows the utilities to spread their emergency resources more effectively by focusing efforts on those areas that aren't supported by the microgrid. The overall outage duration is shorter and fewer consumers are affected. The improved PR that results goes a long way in offsetting any potential revenue loss.





Working out the kinks

For utilities, the greatest obstacle to microgrid adoption has been the risk to grid stability. The risk is greatest when there is a high penetration of renewables. Some renewable energy sources, most notably wind and solar, are intermittent by nature. These power fluctuations result in surges that can damage equipment and lead to blackouts. For some industries such as pharmaceutical, food, or silicon wafer manufacturing, a surge can reduce millions of dollars of work-in-process to scrap.

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Thankfully, technology advancements in grid stabilization and energy storage have addressed these concerns. By rapidly absorbing power surges from the renewable energy source, or by injecting power to make up for short term lulls, a stable voltage and frequency can be maintained in the microgrid and main grid.

Offsetting costs

Cost is another common concern expressed by consumer and utility alike. Like any capital project, implementing a microgrid involves an investment in infrastructure, including the power sources and the technologies needed to manage and connect the microgrid to the main grid.

However, the capital outlay required for a microgrid is often much less and payback significantly faster than other initiatives intended to improve the availability and reliability of power. The payback for a microgrid is often measured in years if not months, whereas the payback for a new utility-scale power generation might be measured in decades and face a barrage of regulatory hurdles before it can even begin.

A number of other factors help offset the cost of a microgrid:

Lower cost of losses – As much as 6-10 percent of energy is lost in transmission and distribution. By their nature, microgrids are local and the power consumed has less distance to travel from generation to consumer.

Additional revenue streams – In some regions, energy markets allow microgrid operators to sell the excess power generated, making the microgrid a potential source of revenue. In addition, the heat generated from the source powering the microgrid can be used to create an additional stream of revenue for a business. For example, steam might be used to power up additional generators, or hot water could be used for absorption chilling.

Greater fuel choice – While wind turbines and diesel generators are probably the two most common sources of power for established microgrids, there are many choices available. New technologies and new discoveries are driving down the cost of natural gas in some areas. Solar is becoming more efficient and less costly. While fuel cells are still relatively expensive, they are low maintenance and research continues to find new ways to make them commercially viable. Leveraging a biomass fuel source may allow the company to claim carbon credits. These and other sources of energy can be combined as the consumer's needs, technology, and market dynamics evolve.

Case study
Integrating renewables while maintaining grid stability

While increasing the amount of energy supplied by renewable sources may be a laudable goal, it isn't always easy. This is because renewable sources such as wind and solar are highly volatile, resulting in fluctuating power outputs from wind farms and solar arrays. Unless output can be stabilized, it has a negative impact on grid frequency and voltage, tripping protection relays and eventually leading to blackouts.

This was the situation on Flores Island in the Azores. Remote from the central grid in Portugal, the islands are powered by heavy fuel oil (HFO) generators and a hydro power plant. By necessity, the local utility company on Flores Island had already established a microgrid that operated independently from the main grid.

In an effort to reduce the cost of diesel power generation, the utility installed a number of wind turbines. The solution wasn't perfect, and they soon discovered they had to limit the amount of wind power injected into the system to avoid power fluctuations and blackouts. They needed a solution to stabilize the grid against fluctuations in frequency and voltage.

Stabilizing the grid requires highly dynamic power injection and absorption for a short amount of time. While common energy storage solutions can help store energy for use during peak times or low energy availability, they don't effectively stabilize the grid as they require slower response and discharge over longer periods of time. To solve these challenges, the local utility implemented ABB PowerStore™, a compact and versatile grid stabilizing generator.

The project on Flores Island was so successful in smoothing out wind power fluctuations that the operator can now run the power station without maintaining an online diesel generator. In addition, the utility has expanded the project to neighboring Graciosa Island and is looking at increasing the number of wind turbines on the islands.

In scenarios like the Azores, the remote nature of the consumer represents a unique problem – there is no main grid to lean on. However, the same type of microgrid established on Flores Island can also be developed in a more populated area. The grid stabilization offered by PowerStore prevents power fluctuations from affecting the reliability of the main grid.

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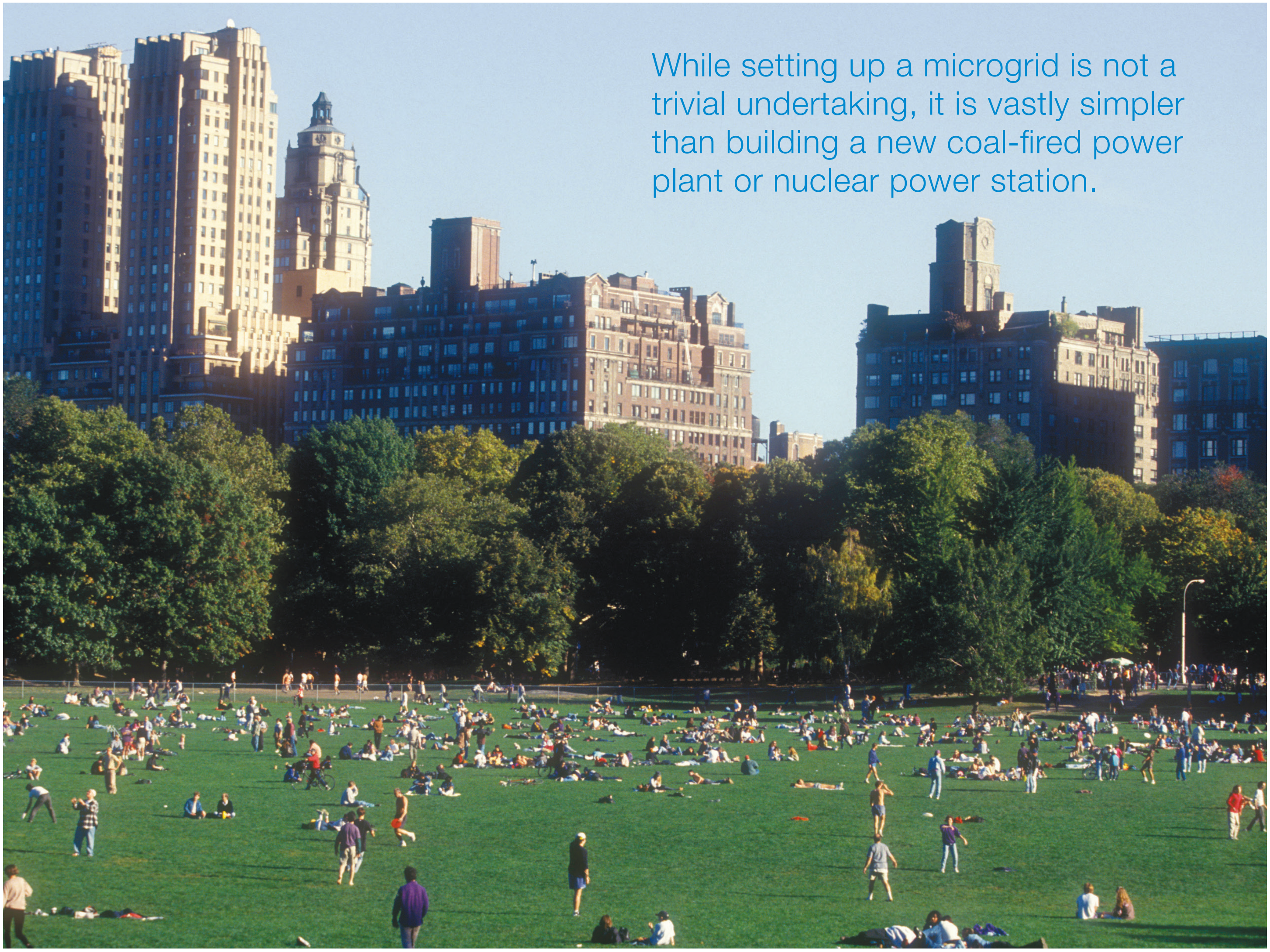

Steps to implementing a microgrid

While setting up a microgrid is not a trivial undertaking, it is vastly simpler than building a new coal-fired power plant or nuclear power station. Even so, several steps need to be followed during planning and implementation to ensure maximum efficiency and reliability.

Step 1: Conceptualizing

This is perhaps the most important step for any microgrid project. When this step is skipped or not given the attention it deserves, it is a leading cause for project failure. In this phase of the project, leaders need to define and prioritize objectives.

They need to ask questions such as:

- What is our main objective and what are our secondary objectives? Increasing renewables? Self-sufficiency during times of power disruption? Decreasing the cost of energy?
- What are our targets? For example, if the main goal is to increase the amount of energy supplied by renewable sources, which sources? By when? By how much?
- What are our budget constraints?

Setting realistic goals is important, but it's okay to think big at this stage. A dose of realism will be injected into the process during the next two phases when the project leaders work with industry experts to determine what is possible – and how much it costs. For now, community leaders should dare to dream.

Step 2: Modeling

The goals set in step one will determine what the microgrid needs to succeed. For example, if the primary goal is to decrease reliance on the central grid by adding a solar array or wind turbines, the microgrid will need to address stabilization and possibly storage as well.

At this step, it's important to involve experts from suppliers like ABB who have experience in helping organizations meet their goals with microgrid technologies. These experts can help design the microgrid and use sophisticated forecasting tools to determine whether the microgrid, as designed, is likely to hit targets.

Financial modeling is another important part of this step. ABB experts help customers work out the many "what if" scenarios involved, determining the best mix of energy sources and balancing goals against budget and timelines.

Step 3: Deployment

At this stage, all the pieces of the microgrid solution start coming together. However, most microgrid projects are multi-year initiatives and involve the building of some basic infrastructure, such as additional power sources. Working with an organization like ABB that provides these solutions as well as a single point of contact throughout the lifecycle of the project to manage timelines and budgets can help ensure project success.

Step 4: Stabilization

During the final phase, renewable sources must be stabilized and adjustments made for the actual load demands and availability of energy. Any instability can cause the very issues with reliability the microgrid is intended to address. In addition, instability puts personnel and property at risk.

Where do we go from here?

At the end of the day, microgrids address two key problems. First, they help ensure safe and reliable power to communities and industry, even in the face of disaster. Second, they solve some of the challenges involved in high penetration renewable energy. As an added bonus, they have a number of secondary benefits including providing additional revenue streams, improving security, and helping utilities win the PR war.

The technology exists to make microgrids a reality in many communities, but those looking to develop a microgrid will still encounter a number of regulatory hurdles, such as prohibitions on utilities owning their own power generation sources. Many of these regulations are left over from the era of centralized power generation and need to be reevaluated in the context of today's power sources and market dynamics. Entrepreneurs, utilities, and business and community leaders must work together to create an environment that allows microgrid initiatives to move forward.

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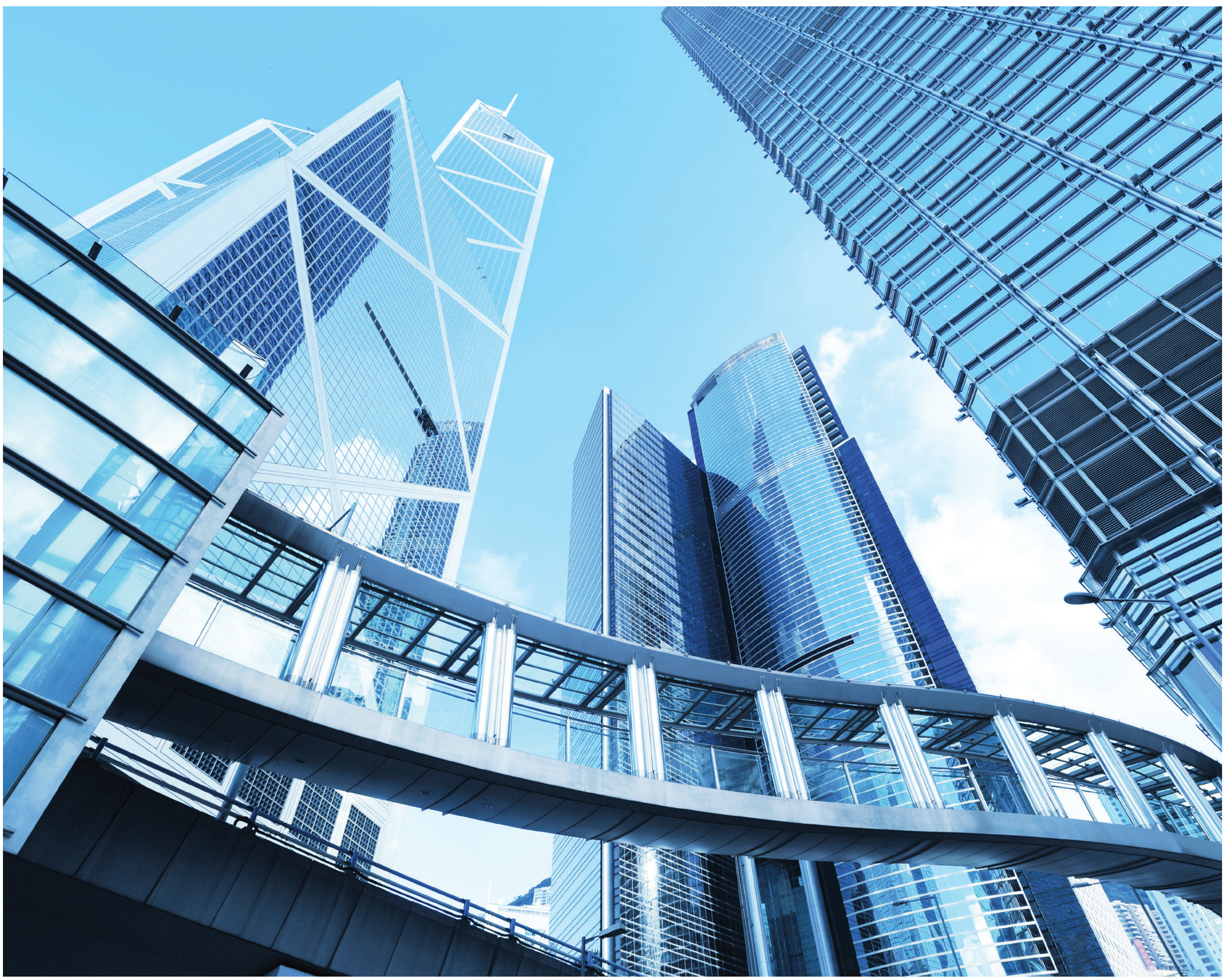

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