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Cooling our world

**How to increase
district cooling
adoption through
proven regulation**



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About the authors

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EXECUTIVE SUMMARY

As the planet warms, global demand for air-conditioning is projected to triple over the next 30 years, much of it in developing countries. Providing cooling is expensive, demanding power generation surges during the day for workplaces and at night and the weekend for residential spaces. Although the International Energy Agency (IEA) anticipates that improvements in the energy efficiency of traditional cooling technologies can prevent unsustainable electricity demand, developing countries could also adopt district cooling. The way that district cooling works is by aggregating demand, ideally among multiple buildings that combine residential and commercial spaces. When applied appropriately, district cooling is more energy-efficient than traditional cooling solutions, more cost-effective for customers, and it reduces peak power requirements. Moreover, district cooling works well with solar and other increasingly common renewable-energy technologies.

Gulf Cooperation Council (GCC)¹ countries were early adopters of district cooling, and can act as exemplars for other countries. Strategy& analysis shows that district cooling can serve 40 percent of new-construction communities, and up to 10 percent of buildings can be retrofitted in the GCC countries, with similar potential impact elsewhere. We determined that using district cooling for future additional cooling demand in developing countries could lead to over US\$1 trillion in energy savings worldwide through 2035.

Governments play a critical role in the adoption of district cooling, as it requires significant planning to aggregate demand, protect customers, and ensure that economic benefits are equally distributed along the value chain. Governments can create a favorable district cooling market by crafting a holistic regulatory framework based on GCC countries' experience, introducing different elements simultaneously:

- Mandate the use of district cooling in applicable situations
- License operators, providers, and retailers
- Set technical and service standards
- Develop contractual frameworks
- Establish competitive tendering processes
- Regulate prices

1. The GCC countries are Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates.

SOARING DEMAND FOR COOLING

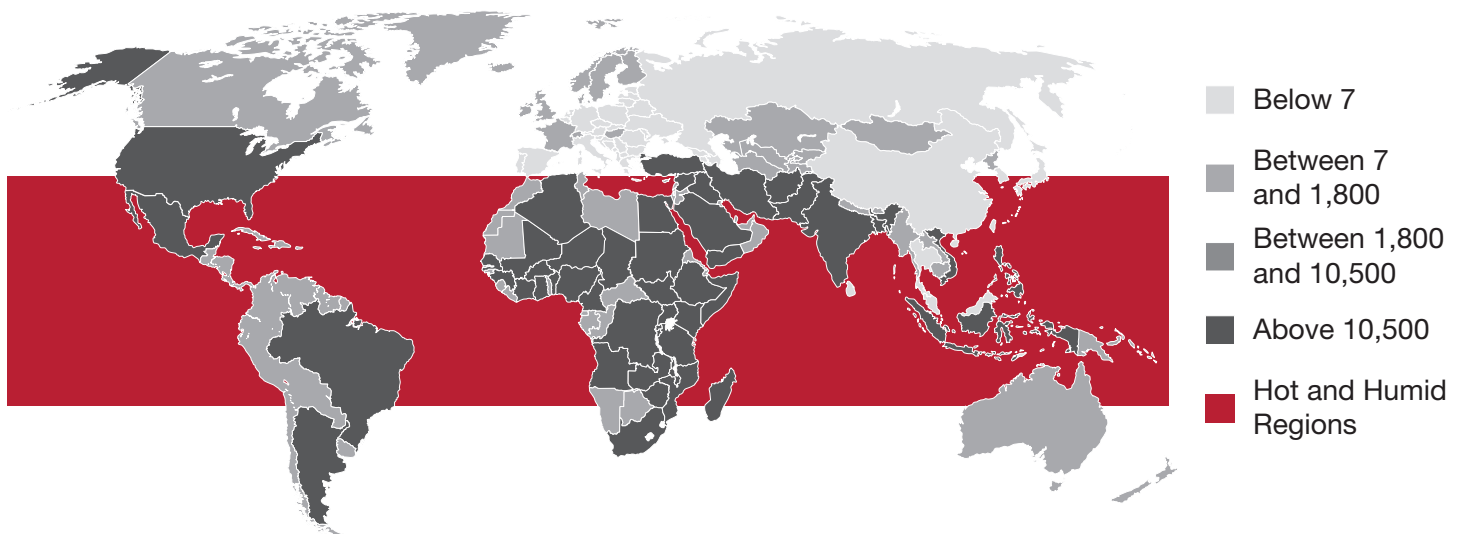
The demand for comfort cooling is a growing global challenge. A recent report by the IEA discussed the various factors contributing to this demand, starting with population growth.² The global population will rise from 7.7 billion in 2019 to 8.7 billion by 2035. Around 90 percent of that growth will be in developing countries in hot and humid regions with higher cooling needs (see *Exhibit 1*). Greater household disposable income and higher living standards in large, developing countries such as China, India, and Indonesia will bring a surge in the use of cooling systems. Rapid urbanization is also a factor. Appliances and machinery generate heat when used and increase the local temperature, creating urban “heat islands” that are significantly warmer than the surrounding rural areas.

All of these factors are compounded by global warming. A hotter planet means greater demand for cooling, which means more burning of fossil fuels, leading to a worsening of the greenhouse effect — resulting in higher temperatures.

2. “The Future of Cooling: Opportunities for Energy-Efficient Air Conditioning,” International Energy Agency, May 15, 2018 (<https://www.iea.org/futureofcooling/>).

EXHIBIT 1 Most global population growth will be in hot and humid regions

Projected population growth by country, 2019–2035, in thousands



Source: Strategy& analysis

Increased energy efficiency is not enough

Although the IEA believes that the energy efficiency of cooling technologies will improve enough for electricity generation capacity to keep pace with soaring demand, the volume of additional demand may simply be too great. The IEA projects a potential increase of 80 percent in cooling efficiency by 2050, in part through interim measures such as minimum energy performance standards, better building design, and stricter building codes. However, according to the IEA, aggregate global cooling demand will double by 2035, which will require expensive new power generation capacity. This is because the aggregate number of cooling units will increase from 4.4 billion in 2019 to 6.9 billion in 2035, up by approximately 57 percent. More than half of this increase will come from the growth in residential split air conditioners that are the least efficient when compared to other cooling technologies.

The amount of power capacity required for cooling will grow faster than the number of units, from 14 terawatts (TW) in 2019 to 25 TW in 2035. Global energy use for cooling will increase from 2,200 terawatt-hours (TWh) in 2019 to 4,000 TWh in 2035. Nearly 70 percent of this increase will come from the residential sector, where the need for comfort cooling is the greatest.

District cooling has a role to play

Although technological improvements to increase energy efficiency in cooling units are important, district cooling has a significant role to play in reducing the overall energy usage from cooling. This is because district cooling systems aggregate demand and have the most efficient technologies that can cool high-density developments using less energy than even the most optimized stand-alone systems.

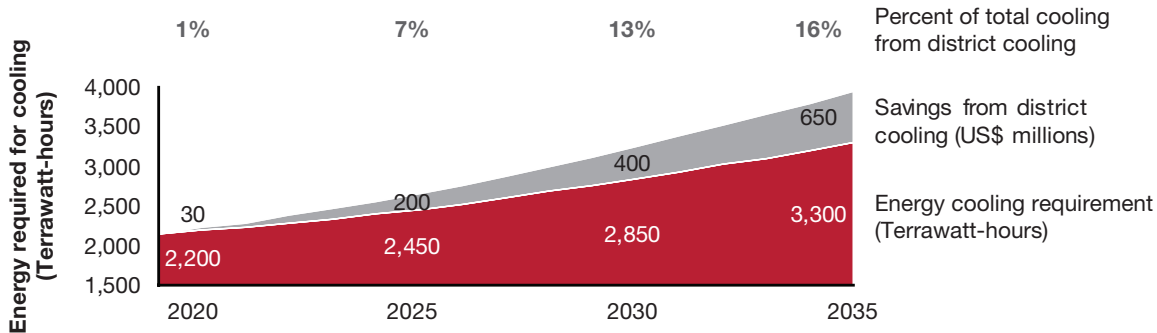
The greatest benefit of district cooling is increased energy efficiency. District cooling systems consume 20 to 30 percent less power than the most efficient conventional cooling solution, and 60 to 80 percent less power than the average conventional cooling system. This means district cooling can use additional electricity generation infrastructure efficiently. District cooling can reduce peak power capacity by up to 30 percent on average (with an additional 20 percent reduction that can be unlocked through thermal energy storage). This advantage, known as “peak shaving” can help power companies avoid over-investing in power generation, transmission, and distribution infrastructure.

Worldwide, we estimate that increased adoption of district cooling could reduce energy consumption by up to 5,000 terawatt-hours over the next 16 years, representing over \$1 trillion in cost savings by 2035, assuming energy prices of \$0.20 per kilowatt-hour (see Exhibit 2).

EXHIBIT 2

Increased adoption of district cooling could save over US\$1 trillion in cooling costs

Potential savings in energy consumption and cost from district cooling (2020–2035)



Note: Assumptions are that by 2035, 40% of additional cooling capacity is district cooling, 10% of the current base load is retrofitted by then, and efficiencies of district cooling and conventional solutions remain constant over 15 years.

Source: International Energy Agency; Strategy& analysis

District cooling also has other environmental and real estate benefits. These include:

- **Reduced emissions.** District cooling requires lower energy consumption because it is efficient, consequently reducing CO₂ emissions from existing fossil-fuel-burning power plants.
- **Increased real estate values.** District cooling frees up space on building rooftops for sale or lease because it does not require the large area taken up by air-cooled chillers.
- **Improved user experience.** District cooling offers improved availability and reliability of cooling, leading to a better experience for users, because the systems are monitored more closely.
- **Alignment with other technologies.** District cooling can assist with the introduction of other technologies. It requires large, up-front investments, centralized management, and considerable regulation, largely the same as what is required for the adoption of other sustainability and efficiency measures, such as solar power or geothermal cooling.

THE GCC EXAMPLE

Despite the advantages of district cooling, few markets have adopted this solution. In 2016, the IEA estimated that only 2 percent of global cooling requirements were met through district cooling systems or stand-alone air or water chillers (the base technology in district cooling).

The greatest challenge is often the inability of real estate developments to consolidate demand. Even those developments that do aggregate demand often still rely on low-efficiency cooling technologies. Mostly, these developments use mini splits and multi-ductless splits, which are far less efficient than other systems such as chillers and central ductless splits. In particular, split units degrade quickly in terms of their efficiency, and they are rarely maintained to manufacturers' specifications (see *"How district cooling works, page 6"*).

The GCC countries are a significant exception. Penetration rates of both district cooling and stand-alone air or water chillers are higher than in the rest of the world, representing 15 percent to 25 percent of the total installed cooling capacity in the region. This high adoption rate is the result of two factors: recent real estate development, and the need to minimize the cooling load during the hot summer days, when cooling load could represent up to 70 percent of peak electricity demand in some countries.

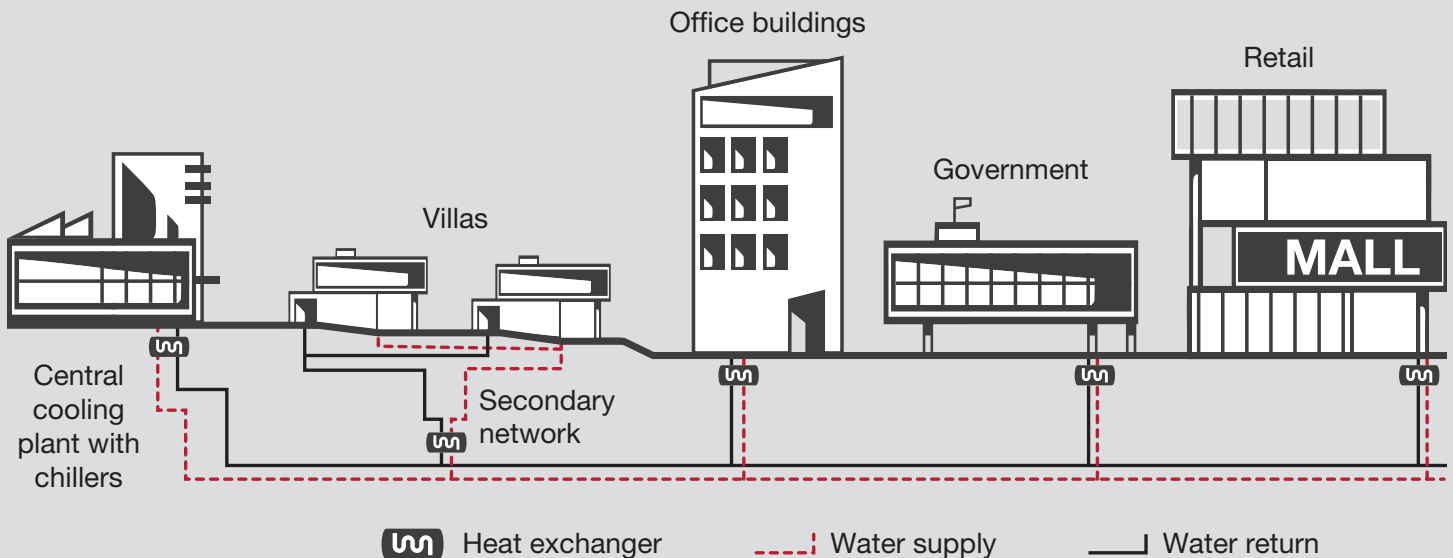
There remain many opportunities for the increased use of district cooling in GCC countries. Our forecasts of urban plans show that district cooling is a feasible solution in about 40 percent of new-build communities. The percentage is even higher for the mega-developments in GCC countries, which are ideal candidates for district cooling. Also, up to 10 percent of the current building stock in the region can be retrofitted by connecting to nearby district cooling plants with available capacity.

How district cooling works

District cooling systems use a single centralized plant to provide chilled water through a distribution network to multiple buildings. Each building has its own heat exchanger and uses the chilled water to

provide cooling as needed. The system is a closed loop in which water is fed back to the cooling plant to be chilled again and redistributed (see *Exhibit 3*).

EXHIBIT 3
A typical district cooling system



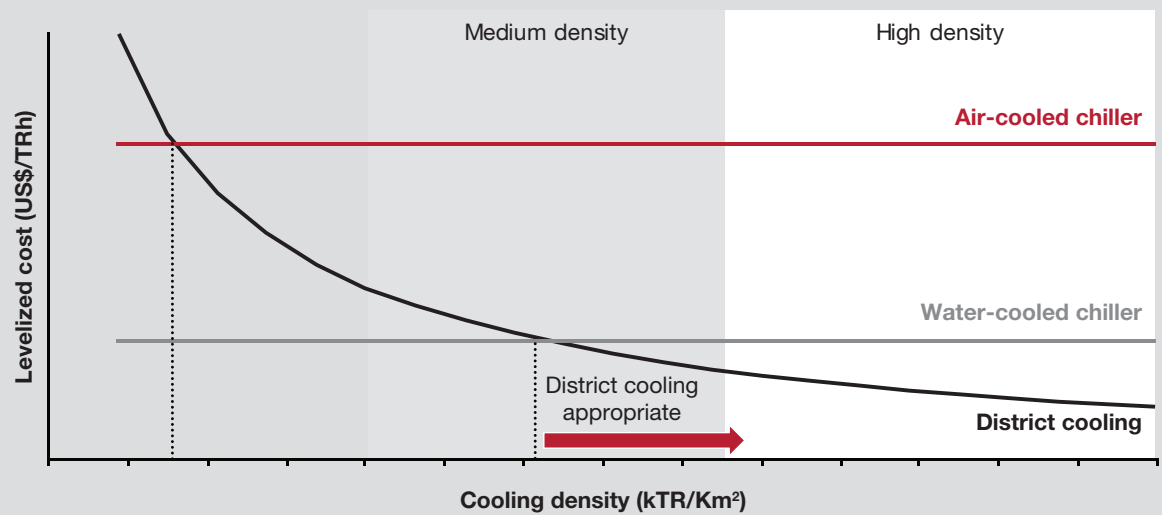
Source: Strategy& analysis

A key advantage of district cooling comes from aggregating demand, ideally among multiple buildings that combine residential and commercial spaces. The result is a higher cooling density — a measure of the maximum amount of energy required to cool a specific area, directly related to the population density

and the type of occupied space in the area to be cooled. As cooling density grows, the unit cost of district cooling decreases, while the cost of conventional technologies remains relatively flat (see *Exhibit 4*).

EXHIBIT 4

With district cooling, the greater the density the lower the unit cost of cooling
 Cost of cooling at different densities



Note: TR = ton of refrigeration, KTR = thousand tons of refrigeration, TRh = ton of refrigeration hour. Levelized cost is the discounted value of the lifetime cost of a given system. It is generally used for utilities or other capital-intensive industries to determine the required tariff for that utility or industry to remain financially viable.

Source: Strategy&



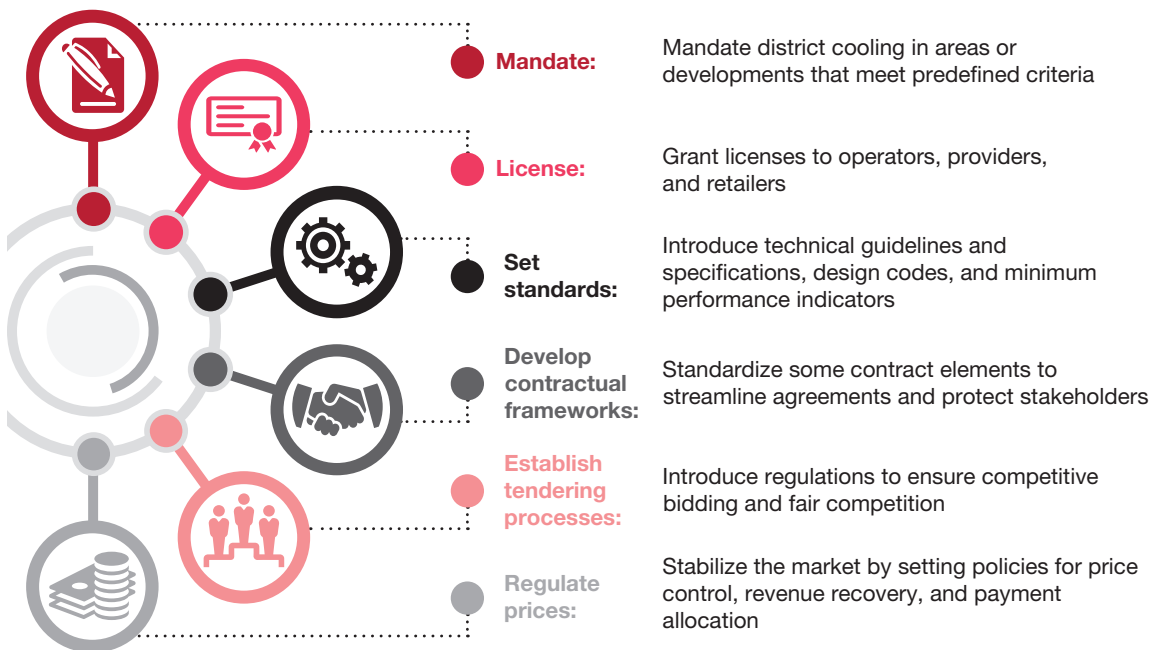
A key advantage of district cooling comes from aggregating demand, ideally among multiple buildings that combine residential and commercial spaces.

A REGULATORY FRAMEWORK FOR DISTRICT COOLING

If governments are to increase the adoption of district cooling, they will need to develop and implement a holistic regulatory framework that addresses the commercial, legal, and technical aspects of district cooling. This framework will be similar to what exists for electricity and water utilities. It is vital because the necessary aggregation of demand, protection of customers, securing of the significant capital required, management of financial and demand risks, and surmounting of other challenges will not happen through an unregulated market.

Based on the experience of GCC countries, governments in developing countries can use a six-part regulatory framework, implementing all six elements simultaneously (see *Exhibit 5*).

EXHIBIT 5
A regulatory framework for district cooling



Source: Strategy&

Mandate the use of district cooling in applicable situations

The use of district cooling can become mandatory where it is appropriate. Perceiving insufficient demand, developers opt for conventional cooling systems, or build district cooling systems that are underutilized. For this reason, governments have an interest in requiring the use of district cooling when it is appropriate. Regulators should work closely with urban planners and identify promising areas based on an analysis of master plans and respective cooling load densities.

License operators, providers, and retailers

The regulator ought to license district cooling operators, providers, and retailers, to ensure they have sufficient capabilities and know-how to operate in the sector. Licensing allows regulators to control the number and quality of service providers, which can make the market viable. They can do so by defining key conditions such as license duration, sanctioned activities, accounting rules, and other considerations. Regulators would retain the right to grant or revoke licenses and investigate abuses. They should be able to take other necessary steps to ensure that customers enjoy high-quality service and effective competition and pricing.

Set technical and service standards

Regulators will have to set standards that establish requirements for providers and customers. Technical standards will cover topics such as planning, system design, distribution, metering, and operations. There must also be clear metrics for monitoring performance over time. Service standards will have to establish baselines for the availability of cooling services to customers.

Develop contractual frameworks

To allow for the smooth introduction of district cooling, there should be a process of standardizing contractual frameworks and streamlining communication and interactions among the parties. Although regulators often lead these changes, the government and legislatures can also be involved depending upon the national legal framework. The development of the contractual framework will protect customers' rights and reduce the legal expenditures for providers, and mitigate the number of complaints and disputes in the market. Contractual frameworks are important because they harmonize the different interactions among stakeholders and ensure that obligations among contracted parties are fair and equitable. Agreements would cover charges and fees, contract capacity, planned interruption of services, invoicing and payment, and discontinuation of cooling services, among others.

Establish competitive tendering processes

Defining minimum requirements during the tendering of district cooling systems and ensuring competitive tendering is also key. This is necessary to eliminate monopolistic or oligopolistic behaviors and ensure a baseline of healthy competition in the market. The actual tendering process would be the responsibility of the procuring company that can offer an entire district cooling system or individual components (generation, distribution, and billing and collection) separately. The procuring company could be a real estate developer or government entity. Although competitive tendering may lead to longer processes, the benefits outweigh the costs. These include increased transparency, lower barriers to entry for new companies in the sector, and more competitive prices and higher-quality service to customers.

Regulate prices

Price regulations are necessary to safeguard the rights of customers and ensure a stable market in which developers and providers are able to charge a fair rate of return for their offerings. These regulations are needed in three areas: price control to ensure healthy competition and fair pricing for district cooling services in the market; revenue recovery to ensure that prices paid by customers reflect the true underlying cost of the service; and payment allocation to ensure that charges are equitably distributed among paying entities (see *“Three dimensions of price regulation”*).

Three dimensions of price regulation

Price regulation schemes have to cover three dimensions.

Price control

Ideally, the tendering process will lead to market forces and competitive bidding, resulting in the lowest possible cost to customers. However, in situations where that does not happen, a regulator could intervene and regulate prices. Regulators would follow various price-control options, similar to those used for monopolistic utilities such as gas and electricity providers. Depending on how the market for district cooling develops, the regulator would increase, or decrease, the degree of market interventions over time.

Revenue recovery

District cooling transactions can involve multiple entities with different roles. On the supply side, providers generate, distribute, and sell chilled water. Billing and collection companies that meter chilled water consumption subsequently invoice and collect charges from customers. On the demand side, some customers buy in bulk, such as developers that require chilled water to cool multiple units. Other customers are individuals, such as unit owners and tenants, who pay for the cooling required for a single unit. Regulations are necessary to harmonize all revenue recovery and ensure that customers' payments reflect the true cost to serve.

Typically, the fairest and most transparent revenue recovery mechanism breaks basic cooling service charges into the following key categories:

- A connection fee covering part of the capital expenditure of the system and ensuring that the district cooling provider recovers a portion of its initial capital investment
- A recurring fixed capacity charge linked to the district cooling capacity to ensure that the provider will recover the remaining portion of the initial capital investment over time. This charge is independent of the actual cooling energy consumed.

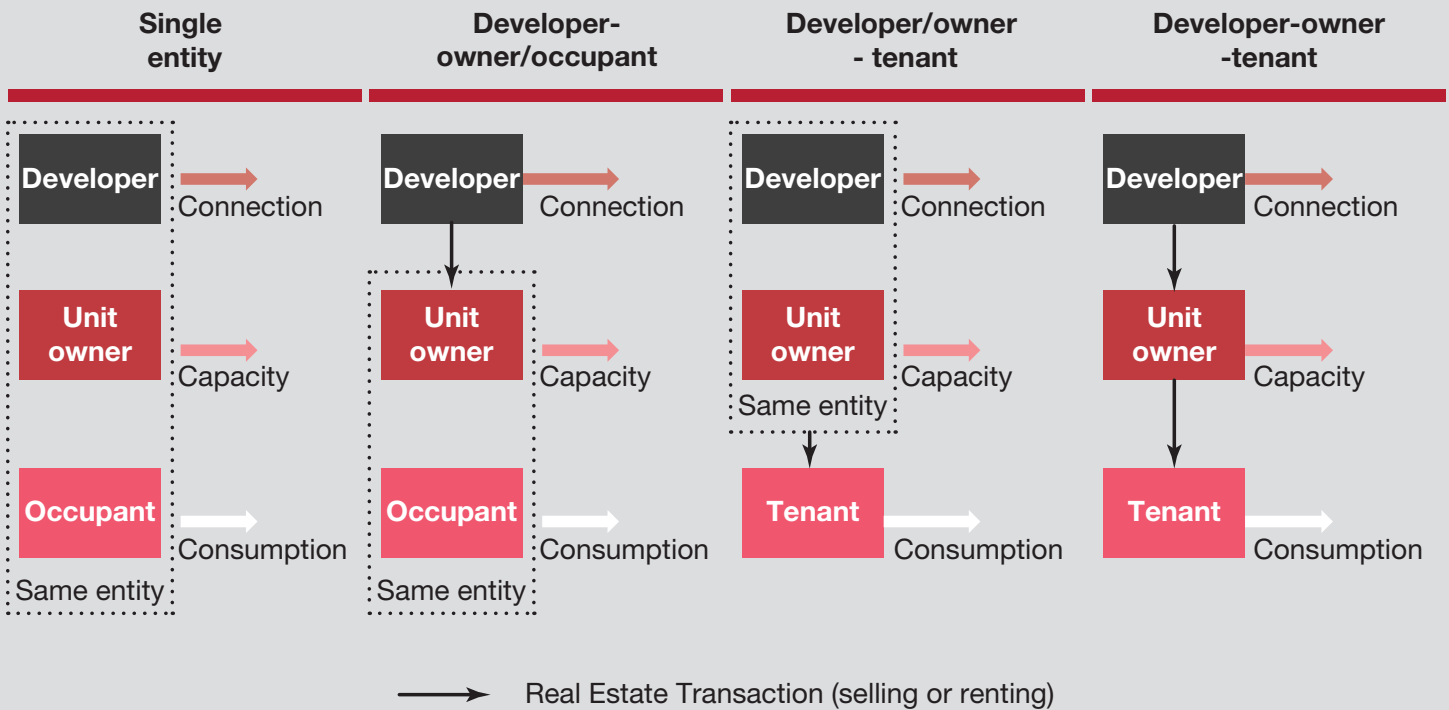
- A consumption charge that depends on the cooling energy consumed and usually covers the cost of ongoing system operations.

Payment allocation

Price regulation could establish how to allocate the three categories of district cooling charges (the connection fee, the recurring fixed capacity charge, and the consumption charge) among paying entities. Payers include real estate developers, unit owners, and leasing tenants. There are several ways to distribute charges among those groups, depending on the ownership structure of the actual real estate unit (see Exhibit 6).

EXHIBIT 6

Payment allocation for cooling is based on different real estate ownership structures



Source: Strategy&

CONCLUSION

As developing countries worldwide face growing demand for comfort cooling, merely improving the energy efficiency of the existing solution will probably not suffice. There is a need for developing countries to increase the adoption of district cooling at a national level. To ensure that this occurs to the maximum possible extent, these countries should emulate GCC countries by drafting and implementing district cooling policies.

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