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Unlocking the Potential
of District Cooling
*The Need for GCC
Governments to
Take Action*



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EXECUTIVE SUMMARY

Under the right conditions, district cooling can offer numerous advantages over conventional cooling in the Gulf Cooperation Council (GCC).¹ The technology has inherent advantages for areas of high cooling density—densely populated areas with a heavy demand for air-conditioning. By pooling the demand for cold air in dense urban areas, district cooling is more cost efficient over the long term than conventional cooling options at the individual building level. District cooling is also more reliable, more energy efficient, and has less negative environmental impact than standard approaches to air-conditioning. With the GCC countries likely to grow rapidly and urbanize further in coming decades, district cooling could save these countries from investing substantial sums on new power stations.

However, current market structures make it difficult to recognize and capitalize on those benefits. In many cases, power prices are overly low, making district systems appear viable only at very high levels of cooling density. Market distortions make conventional air-cooling technologies appear more competitive. Property developers often fail to appreciate the advantages of combining their cooling demand and are wary of the technology because district cooling requires significant initial investment. The region's district cooling sector has also done itself no favors through its frequent poor planning of cooling loads and its inconsistent cost recovery models.

Governments can remove these obstacles by treating district cooling as a utility. They should designate appropriate zones of sufficient density for district cooling and include the technology in urban planning. Governments should also regulate tariffs to ensure fairness for cooling providers, property developers, and the end-consumers. In addition, governments need to set service standards and define technical codes for the operation of district cooling. Governments can also get involved in providing district cooling as they do with other utilities. With resolute government intervention, district cooling can achieve its potential as a cost-effective and sustainable way to cope with the region's hot climate.

KEY HIGHLIGHTS

- District cooling offers significant advantages in cost, environmental protection, comfort, and operational efficiency over other cooling technologies when used in sufficiently dense areas.
- Properly employed, district cooling could provide around 30 percent of the GCC's forecast cooling needs by 2030. This would prevent the region from having to build 20 gigawatts in new electricity-generating capacity, and save 200,000 barrels of oil equivalent per day in fuel.
- For district cooling to achieve its full potential, GCC governments must employ utilities-style regulation to address structural issues that bias the market against district cooling.

THE DISTRICT COOLING CHALLENGE

Commercial and residential well-being in the Gulf region depends on air-conditioning. Summer temperatures in the GCC countries frequently exceed 45 degrees Celsius, with high relative humidity. However, governments have not regarded the provision of air-conditioning as a matter requiring public policy and planning, as they have with other utilities such as power and water. These countries have instead permitted an unregulated market to determine when and where to use different cooling systems, and to decide how to pay for them.

The time has come for GCC governments to consider market and governance reforms that can lead to far more efficient technology choices. This is because the market has provided a suboptimal pattern of solutions. In particular, district cooling—a network-based centralized cooling system—has not been deployed efficiently. Under favorable circumstances, district cooling offers significant cost, comfort, and operational efficiency gains when compared to other technologies. District cooling has not been used sufficiently where it is appropriate, and it has been used where it is inappropriate. As GCC countries continue to grow economically, this misuse of an important technology will prove costly.

The cost of cooling

Air-conditioning in the GCC is an expensive necessity. The cooling capacity in the region today has cost approximately US\$50 billion to install.

It accounts for 50 percent of annual electricity consumption, a yearly fuel opportunity cost of roughly \$20 billion. Air-conditioning accounts for 70 percent of peak-period electricity consumption and is the chief determinant of the region's power requirements.

Between now and 2030, cooling demand in the GCC is expected to nearly triple (*see Exhibit 1*). Meeting this demand will cost the GCC approximately \$100 billion for new cooling capacity and over \$120 billion for new power capacity if it maintains its existing pattern of technology deployment. By 2030, air-conditioning will account for 60 percent of additional power generation required in the region, and the fuel needed to power air-conditioning will be the equivalent of 1.5 million barrels of oil per day.

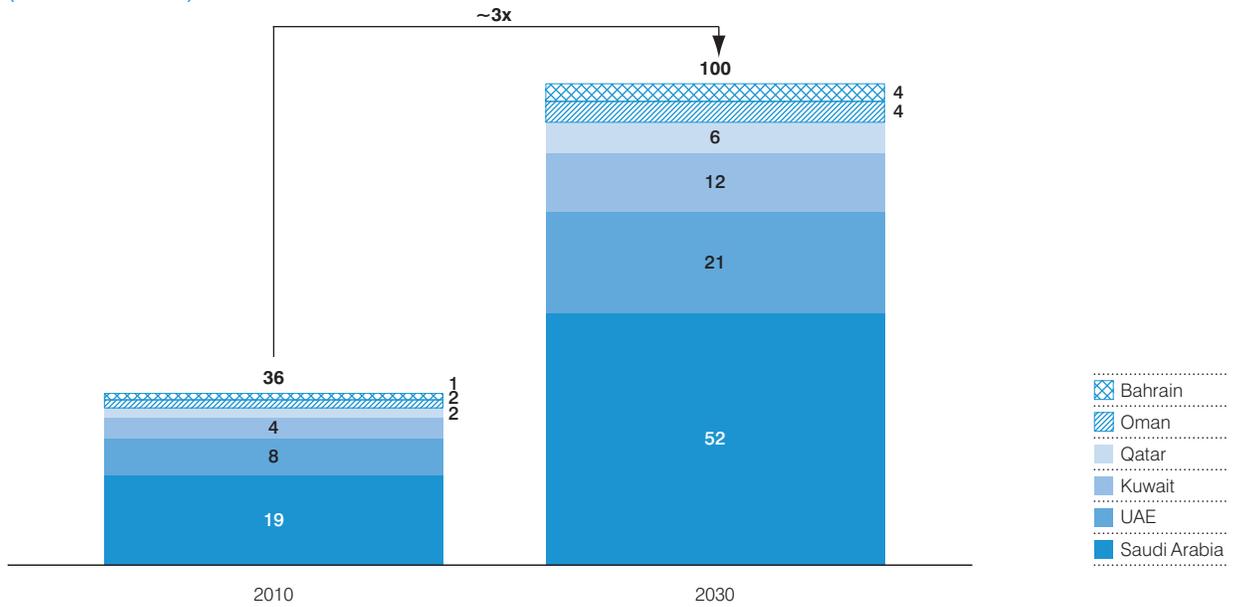
The case for district cooling

District cooling makes economic sense in areas of high cooling density. At present, district cooling is one of three main systems used for air-conditioning in the region. The most localized of them is conventional window units or split systems. These provide air-conditioning at the level of a single room, apartment unit, or small building. Large buildings use another system, central air or water-cooled chillers. These tend to be placed on a building's roof or in the basement. The least localized system is district cooling, in which a central plant supplies chilled water through a network of pipes to multiple buildings within a local area (*see Exhibit 2*).

District cooling features two significant differences when compared to more localized systems. First, the network of pipes that circulate chilled water from the central plant to buildings is an important additional cost. Second, district cooling consumes water. The amount of water consumed is relatively small

Exhibit 1
Cooling Capacity Growth in the GCC May Triple by 2030

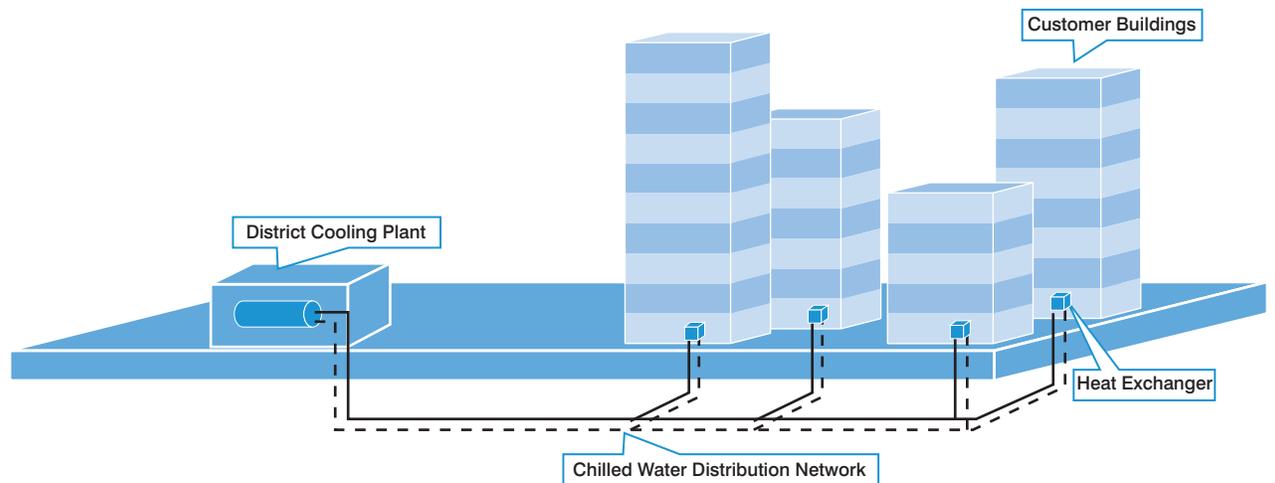
GCC PEAK COOLING DEMAND
(IN MILLIONS OF RT)



Note: RT = refrigeration tons.
 Sources: MEED; GWI; national statistics; World Bank; Booz & Company analysis and forecast

Exhibit 2
How District Cooling Operates

DISTRICT COOLING SERVES MULTIPLE BUILDINGS IN A LOCAL AREA



Note: Water is chilled in the district cooling plant and supplied to customer buildings through the network of pipes. The chilled water is fed into the building's own cooling system through the heat exchanger, and then fed back to the cooling plant in a closed loop where it is chilled again and redistributed.
 Source: Adapted with kind permission from Euroheat & Power, ECOHEATCOOL Work package 5, Possibilities with more district cooling in Europe, Brussels, 2005-2006

because of closed-loop operation. The possibility of using treated sewage effluents as water supply can limit having to draw on fresh or desalinated water.

By offsetting network costs, district cooling offers three main benefits: a low energy requirement, more efficient capacity use, and peak-period saving potential.

1. *Low energy requirements.* District cooling typically consumes 40 to 50 percent less energy for every refrigeration ton hour than conventional in-building technologies. This advantage stems partly from the more efficient chiller technology used in district cooling. It also comes from district cooling plants' ability to maintain a steady level of efficiency over time, because of their specialized operations and maintenance. By contrast, conventional cooling units tend to undergo marked efficiency degradation.

2. *More efficient capacity use.* District cooling typically needs around 15 percent less capacity for the same cooling loads than distributed cooling systems at the unit level. Unlike conventional air-conditioning, district cooling has two advantages that make it more efficient in capacity deployment: load diversity and flexibility in capacity design and installation.

A district cooling system tends to serve diverse loads—such as residences, offices, and commercial establishments—that do not require simultaneous cooling. District cooling is more efficient because it aggregates peak demand from these diverse loads. By contrast, single-building systems have to be designed to meet each building's or unit's peak needs.

The difference is substantial. Aggregated peak loads can be up to 25 percent less than the sum of all individual peak loads.

District cooling is also flexible in its capacity design and installation. The central cooling plant can increase its capacity incrementally to match growing loads. By contrast, the capacity of single-building cooling systems is rarely adjusted once the building has been constructed. Given this lack of flexibility, property developers are usually generous in determining the capacity of in-building systems, allowing a broad margin of error. As a result, it is common for single-building cooling systems to have excess capacity of 30 to 50 percent.

3. *Peak-period saving potential.* District cooling offers a thermal storage capability that can smooth out power requirements over the course of a day, thereby reducing the strain on the power system at peak hours. District cooling systems can store up to 30 percent of potential output by holding chilled water in tanks. By contrast, in-building systems impose their full load on power systems at peak times.

When taking network costs into account, the net advantages of district cooling are apparent in areas of sufficient cooling density. The cost of the network depends to an important degree upon the load and configuration of the cooling system. Although the low energy requirement, more efficient capacity use, and peak-period saving potential play a role, the principal factor in determining whether the balance is favorable to the district approach is cooling density. As the ratio of cooling load to unit of land area served by district cooling increases,

so the per user cost of the network declines (*see Exhibit 3*). It is important to recognize, therefore, that district cooling is not a universal solution. It is the right economic solution *when it serves a sufficiently dense area*.

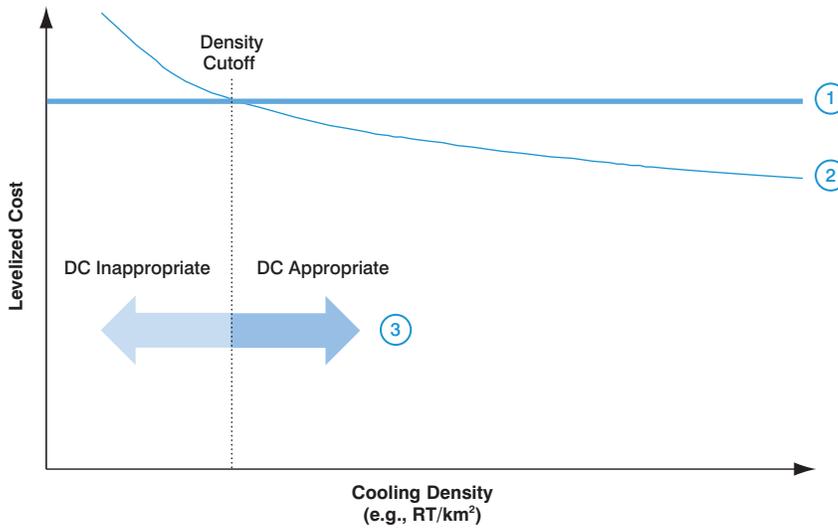
Based on existing development plans and estimated density patterns, district cooling could play an important role in GCC countries. By 2030, we estimate that district cooling could optimally serve 30 percent of the cooling requirements of the GCC (*see Exhibit 4*). The consistent use of district cooling in areas with appropriate levels of cooling density offers quantifiable advantages and qualitative benefits over current use patterns. In quantifiable terms, district cooling can lead to:

- A regional reduction of 20 gigawatts in new power capacity requirements—the equivalent of 10 large power plants.
- A reduction in the GCC's power plant fuel consumption of 200,000 barrels of oil equivalent per day by 2030.
- A region-wide decrease of 31 million tons per year in CO₂ emissions—equal to one-third of today's emissions rate in the United Arab Emirates or in Kuwait.

From a qualitative perspective, district cooling offers more reliable service because of ongoing professional operation and maintenance. The system is quieter than conventional cooling. It is also more visually appealing because it is located remotely rather than on the roof of a building. The result is that property developers have more flexibility in the use of space. They can, for instance, install rooftop pools or penthouses in place of unsightly chilling equipment.

Exhibit 3
District Cooling Is Most Suited to High-Density Areas

COST OF COOLING TECHNOLOGIES VS. COOLING DENSITY



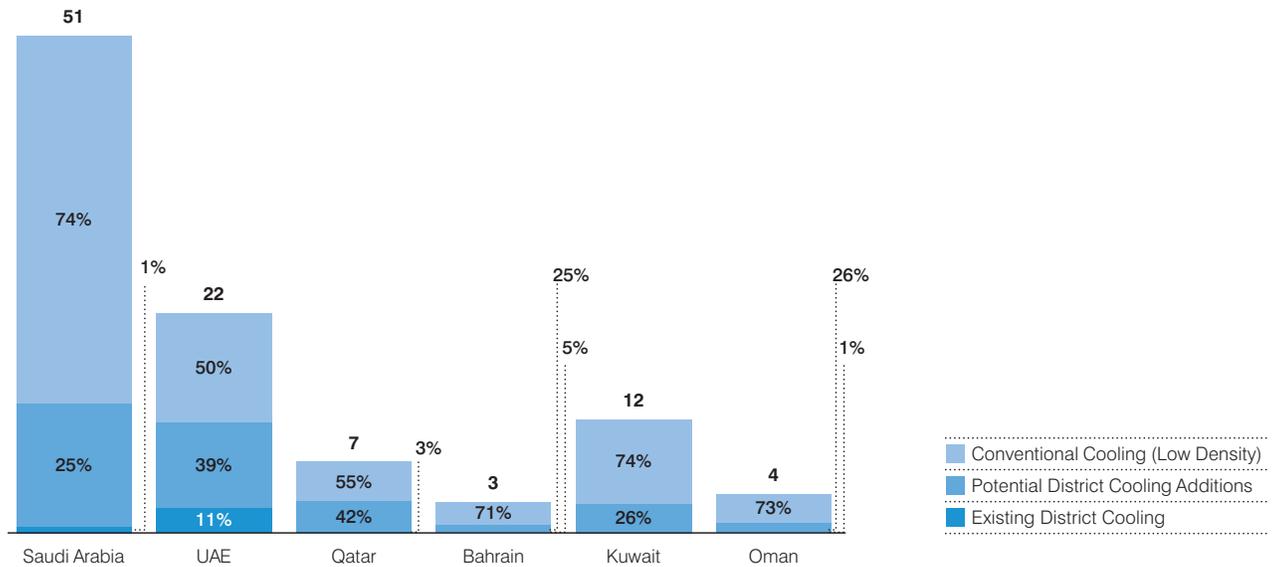
- ① Conventional cooling costs do not depend on cooling density
- ② District cooling costs decrease with increasing cooling density because of lower relative network costs
- ③ District cooling is more cost effective than conventional cooling only where cooling densities are above the "density cutoff"

— Conventional Cooling
 — District Cooling

Note: RT/km² = refrigeration tons per square kilometer. Levelized Cost = price required to break even.
 Source: Booz & Company

Exhibit 4
District Cooling Has Great Potential in the GCC

GCC FORECAST COOLING REQUIREMENTS, 2030
(IN MILLIONS OF RT)



Sources: MEED; GWI; national statistics; World Bank; Booz & Company analysis and forecast

THE OBSTACLES TO DISTRICT COOLING

Despite these advantages, district cooling is unlikely to reach its full potential under current conditions. The structure of the property and cooling markets in the GCC masks the economic benefits of district cooling. At no single point in the chain of transactions for a property do the economic advantages of district cooling become fully apparent. Indeed, there is no ability to capture them through a discrete purchase decision. There are four reasons for this lack of economic transparency: non-aggregated development decisions, non-economic utility pricing, cost misperceptions, and the risk of early investment.

1. *Non-aggregated development decisions.* Developers of individual buildings make decisions in a manner that discourages consideration of district cooling. Several developers are likely to construct multiple buildings in an area suitable for district cooling, construction that occurs over a period of several years. Each developer installs cooling based on the scope and schedule of its individual building programs. Even if the developer is aware of the advantages of collaborating with neighboring developers to share a district cooling network, it is usually easier, faster, and cheaper to proceed with in-building systems. Consequently, district cooling appears to be a reasonable alternative only for large complexes that can justify the investment and that are not required to align their plans with those of other developers.
2. *Non-economic utility pricing.* The low electricity tariffs in the GCC obscure the economic advantages

of district cooling. As a result of these supported tariffs, property market participants, whether developers, investors, or buyers, mistakenly believe that district cooling works economically only at very high densities (*see Exhibit 5*). Participants perceive fewer benefits than if cooling costs were based on the actual cost of power. These low tariffs also mean that the perceived density cutoff, at which district cooling appears more advantageous than conventional cooling, is greater than it really is. This effect is exacerbated when residents pay a lower tariff for electricity than for district cooling utilities, which is the case in some GCC countries. This in turn leads to investment decisions that are economically inefficient.

3. *Cost misperceptions.* The methods developers use to pass on cooling costs to end-users make district cooling appear artificially expensive, while flattering conventional cooling. Thus, a technology that actually saves money for the

ultimate user comes across as being pricey because of different approaches to cost recovery. District cooling providers typically cover the capital cost of the chilling capacity and network through amortized recurring payments. On top of the recurring capacity payments, providers also ask consumers to pay a metered usage fee. Consequently, users of district cooling are reminded periodically of the full cost of their air-conditioning.

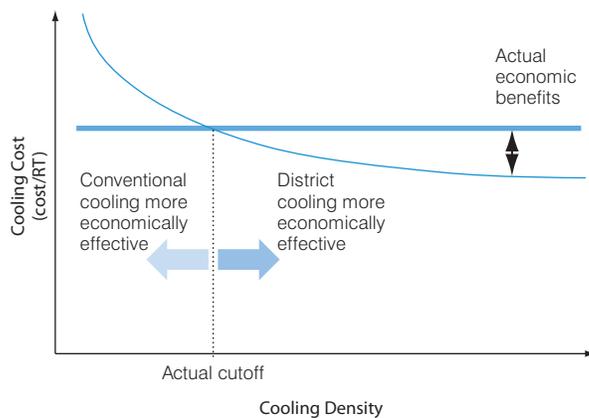
By contrast, the capital costs of in-building cooling are factored in to the purchase price or rental payments—just like all other property capital costs. There is no reason for developers to charge buyers or tenants separately for the capital cost of providing cool air. The owner or tenant therefore does not see the capital cost of in-building cooling facilities. The recurring costs of in-building cold air, mainly charges for power

usage, are also often hidden. There is usually no sub-metering for in-building cooling systems. Instead, the usage costs are averaged and recovered indirectly—either as part of the rent or through annual management fees to individual unit owners.

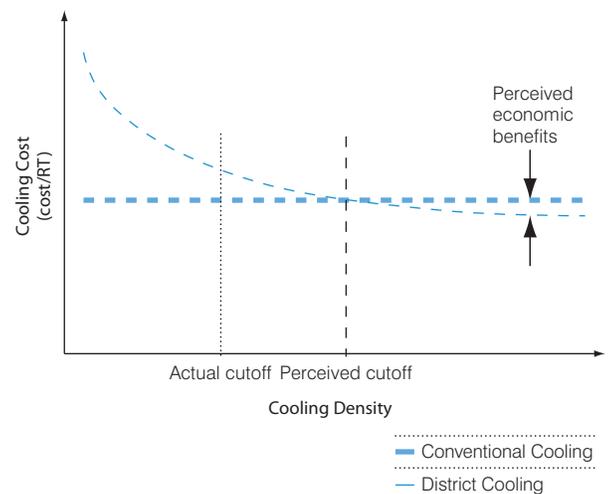
4. *The risk of early investment.* Perhaps the greatest market handicap faced by district cooling is that it requires front-loaded investment.

Exhibit 5
The Market Distorts Perceptions of District Cooling

COOLING COSTS WITH ACTUAL POWER COSTS



COOLING COSTS WITH APPLICABLE POWER TARIFFS



Source: Booz & Company

The developer has to design and invest in the plant shell and the cooling network at the beginning of the project. That means investing at a moment when there is no guarantee that the time frame, scope, and consumption levels anticipated for the project will actually materialize. The recent slowdown in real estate development has highlighted this risk. District cooling providers and property developers have found themselves burdened with expensive excess capacity and over-contracted loads. By contrast, in-building cooling is developed at the same time as the individual structures. If the building is delayed, then so is the in-building cooling investment.

In addition to these structural problems, district cooling is suffering from two self-inflicted wounds: poor load planning and inconsistent cost recovery models.

Poor load planning. District cooling providers and property developers have repeatedly overestimated cooling requirements. District cooling projects historically have been sized and developed on the strength of load estimates provided by real estate developers. Real estate developers chronically overestimate cooling load require-

ments. This is partly because developers are overly optimistic about their projects. Partly this stems from developers relying on engineering companies that typically use safety factors to be cautious. In several instances, this reliance on developer projections has led to contracted loads well in excess of actual loads. The result is unnecessary capacity costs that need somehow to be distributed among providers, developers, owners, and users.

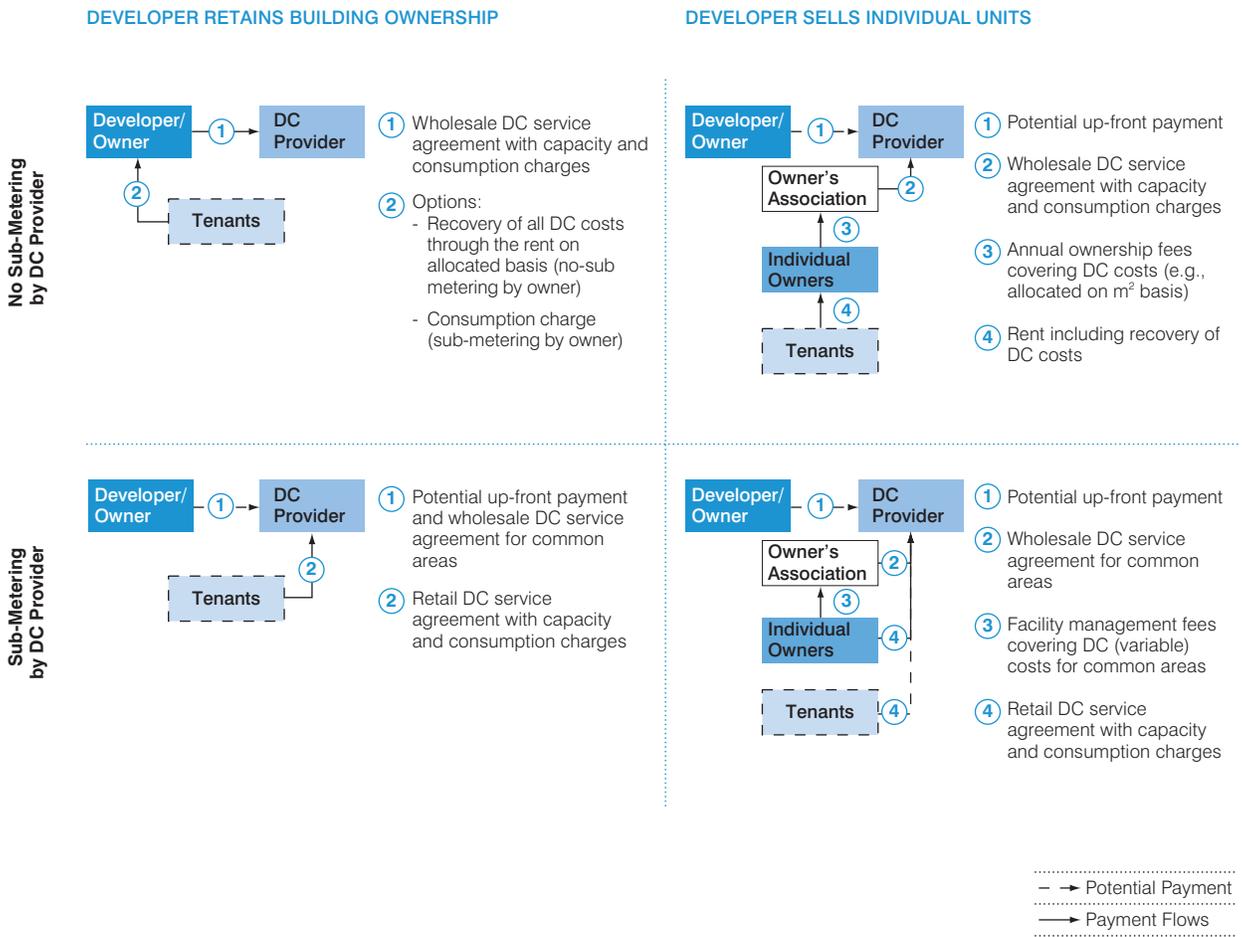
Providers and developers have also paid insufficient attention to the critical factor of cooling density. There are some examples where builders have used district cooling in low-density developments, where it is inherently more expensive than conventional cooling alternatives.

Inconsistent cost recovery models. District cooling has also damaged its own cause through complex and diverse cost recovery models. District cooling charges are handled inconsistently. The allocation of connection, capacity, and consumption costs among developers, owners, owners' associations, and individual tenants varies from project to project and building to building. There are four main models of differing intricacy and transparency, detailed in *Exhibit 6*.

One bone of contention has been the allocation of capacity charges. Real estate developers have made this inherently difficult aspect of cost recovery worse by seeking to pass on charges to buyers or tenants. Tenants and purchasers have moved into properties only to find themselves hit with large bills for cooling costs. Often these bills have only a small relation to residents' actual consumption of cooling. Instead, much of the cost comes from fixed capacity charges. Shifting the capacity costs onto the shoulders of the tenants or buyers as quickly as possible is attractive for developers as it allows them to reduce their capital costs. The danger for buyers or tenants is that they often do not understand the magnitude of those charges when they sign on the dotted line to buy or lease a property.

The result can be unfair arbitrage on property prices—developers can sell the property for an artificially low price that saddles the unwitting buyers with recovering the developer's investment in district cooling. The recovery of capacity charges has led to multiple disputes involving real estate developers, owners' associations, owners, tenants, and district cooling providers.

Exhibit 6
Four Typical Cost Recovery Models and Contractual Structures



Note: DC = District Cooling.
 Source: Booz & Company

THE NEED FOR GOVERNMENT INTERVENTION

Given these issues, GCC countries will be able to deploy district cooling optimally only with support and guidance from the government. Like most utilities, district cooling requires a proper regulatory framework that protects developers, providers, consumers, and the broader economy. Other governments have recognized the need. Singapore, for example, has designated specific service areas for the award of district cooling concessions. It also subjects tariffs to a defined return on assets. Governments in Denmark, the Netherlands, Norway, and Poland have encouraged the adoption of district heating, a technology with similar advantages and disadvantages as district cooling. These governments employ methods such as price regulation, mandated zones of application, financial support, and state ownership of heat circulation networks.

The form of government intervention should vary from country to country, reflecting broader governance structures and policies. Regulation and licensing can provide a hospitable

and fair market framework for the efficient and sustainable deployment of district cooling. Government intervention should aim to be consistent and to cover three main areas: the designation of appropriate zones, tariff regulation, and service standards and technical codes.

1. *Designation of appropriate zones.* Governments should mandate district cooling in defined areas where density levels render it appropriate. This can be achieved by making district cooling an element of urban planning, not the haphazard result of developers' decisions. For this to happen, a systematic approach needs to be taken to assess the suitability of district cooling in new developments, simultaneous with urban planning. The power to mandate network zones implies also the power to define exclusive concession areas, to require off-take commitments from developers, and to establish the award terms for the concessions—terms that could include stipulations about allowable tariffs, service standards, and future capacity investments.

2. *Tariff regulation.* Governments should establish a consistent national tariff framework for district cooling. That means defining the allocation model of up-front, recurrent, and consumption charges to property developers, individual property owners, and tenants. Governments will have to enforce the consistent use of such charging models across projects. In particular, these models must protect individual owners and tenants from arbitrage on real estate prices. The charging models should seek to align the charges paid by users with actual cooling consumption. In some cases, price regulation will be required to provide equitable tariffs to users, while granting returns to district cooling utilities commensurate with industry risks.

3. *Service standards and technical codes.* Governments should define the basic levels of reliability and performance required of district cooling providers. They should accompany these requirements with technical codes to ensure quality

in the design and installation of assets. There is also a need for codes governing the operational interface between district cooling providers and building owners. Clarifying these rules of competition can give district cooling the chance to become a competitive industry.

A further option for GCC governments is to become economically involved in the market, thereby directing the expansion of district cooling as an economic actor rather than simply as a rule-setter. Governments can do this by assuming one or more of three potential roles: Network Owner, Single Buyer, or Universal Retailer.

Of these, the Single Buyer approach involves a government entity that finances network construction and assumes its ownership. This removes from district cooling companies and real estate developers the risk inherent in front-end network construction. The Single Buyer involves a government entity procuring district cooling systems on a competitive

basis through a process similar to that used with regional integrated water and power plants. The Universal Retailer option uses a government entity to manage retail pricing and administration of district cooling. This allows governments to offer uniform district cooling tariffs and to aim tariff support at certain groups of residents in line with its social policy.

Governments can perform these economic roles singly or in combination. Indeed, in the GCC, governments typically perform all three for electricity and water services. Each role imposes administrative burdens and risks. Governments should become economically involved only if doing so is commensurate with gains in overall efficiency and welfare. The appropriate degree of government participation will depend on country-specific circumstances. These include the degree of price distortion introduced by price support for power tariffs and the expected density of future urban development.

CONCLUSION

District cooling offers significant benefits to the GCC as it plans for an increasingly urban future. The technology provides environmental protection, comfort, operational efficiency, and cost advantages over other cooling methods. However, governments must take purposeful action to reap the rewards of district cooling. The long-term potential capacity and fuel savings alone

justify government intervention to prevent this important technology from staying on the sidelines as GCC economies grow over the next two decades. By treating district cooling as the utility it is, incorporating district cooling into urban planning, and perhaps taking an active role in its provision, governments can allow this promising technology to play its part in the development of the GCC.

Endnotes

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

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