Cooling as a Service (CaaS)

LAB INSTRUMENT ANALYSIS
September 2019

DESCRIPTION & GOAL —

A pay-per-service model to decrease energy consumption and greenhouse HFC gas emissions from cooling systems in cities around the world, by making more efficient cooling technologies more accessible to customers.

SECTOR —

Energy efficiency

PRIVATE FINANCE TARGET —

Certified clean cooling equipment providers, finance providers, and cooling customers, including hospitality, hospitals, commercial and industrial building owners, and agro-industry service/commercial.

GEOGRAPHY —

For early implementation: Jamaica, Dominican Republic
For flagship implementation: India, Mexico, South Africa
In the future: Brazil, Malaysia, China, Thailand, Nigeria, Senegal, Ghana, and Bangladesh

The Lab identifies, develops, and launches sustainable finance instruments that can drive billions to a low-carbon economy. The 2019 Global Lab Cycle targets four specific sectors across mitigation and adaptation: blue carbon in marine & coastal ecosystems; sustainable agriculture for smallholders in West and Central Africa; sustainable energy access; and sustainable cities.

AUTHORS AND ACKNOWLEDGEMENTS

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1. CONTEXT

Cooling demand will triple by 2050, driving significant GHG emissions growth from conventional cooling due to high energy consumption as well as leakage of refrigerant gases that are thousands of times more potent than CO_2.

Limiting cooling emissions is critical to achieving global climate goals. Space cooling accounts for 10% of global electricity consumption and adds significant fugitive greenhouse gas (GHG) emissions of refrigerants used for cooling. Common refrigerants like hydrofluorocarbons (HFCs) have 200-20,000 times the global warming potential (GWP) of carbon dioxide (CO_2). Further, global cooling demand is projected to triple by 2050 (IEA, 2018). However, phasing out HFC coolants in accordance with the Kigali Amendment has the potential to reduce warming by 0.4-0.5ºC through 2100 (K-CEP, 2019).

Improving the energy efficiency of cooling systems and shifting to cleaner refrigerants presents an opportunity to reduce energy use and GHG emissions in buildings and supply chains while delivering cost savings, improved air quality, comfort, and productivity. It is critical to align technology deployment with the Kigali Amendment to the Montreal Protocol (United Nations, 1987) which aims to phase down the use of high-GWP coolants (UNEP, 2016). Optimization of cooling equipment efficiency through improved monitoring and maintenance has the potential to save 30Gt of CO_2 by 2050, an amount equivalent to one year of emissions from 7000 coal-fired power plants (K-CEP, 2018).

Cooling has been highlighted by the UN Secretary-General as both a critical need for vulnerable populations and as a key opportunity for cleaner growth (UN News, 2019). However, deployment of clean cooling is limited by high upfront costs, uncertain returns from efficiency investments, and misaligned stakeholder incentives (UNEP, 2019). These barriers make it difficult for investors to evaluate the real costs and benefits of innovative technologies and affect the prioritization of these projects, which compete with other investment opportunities that present a better, or more familiar, risk-return profile for investors.

A servitization approach in which clean cooling is delivered as a service without upfront costs can help to address these barriers while creating long-term sustainable revenue streams for technology providers and potentially providing off-balance sheet equipment financing options for customers (UNEP, 2019).

CONCEPT

2. INSTRUMENT MECHANICS

Cooling as a Service accelerates the deployment of clean cooling technology at scale in emerging markets by lowering the upfront costs and aligning incentives for effective operations and maintenance.

2.1 INSTRUMENT GOAL

Cooling as a Service (CaaS) is a financial instrument that aims to align technology deployment with the Kigali Amendment to the Montreal Protocol and the Paris Agreement through the phase-down and ultimate elimination of inefficient and high-global warming potential cooling technology. CaaS eliminates upfront investment in clean cooling technology for customers who instead pay per unit of cooling they consume – strengthening incentives for efficient consumption. The technology provider is incentivized to install and maintain the most efficient technology possible.

The servitization model is implemented through a standardized contract[1] with a tailored solution for each customer. The payments per unit of cooling/refrigeration to the technology provider during the lifetime of the equipment more than cover the costs of installation, equipment, maintenance, electricity costs, while compensating for both risks and the time value of money.

The idea was proposed to the Lab by the Basel Agency for Sustainable Energy (BASE) and the Kigali Cooling Efficiency Program (K-CEP). BASE and K-CEP have partnered to provide resources and technical assistance through the Cooling as a Service Initiative (CaaS Initiative) which aims to mainstream the financial model in the market through:

1. Raising awareness about CaaS to technology providers, financial institutions and funds, clients, and policymakers;
2. Creation of a toolkit to support CaaS implementation including templates for financial modelling and pricing strategy, standardized CaaS contracts, and other resources;
3. Demonstration of the business model in key buildings around the world;
4. Knowledge-sharing and resources to accelerate CaaS uptake globally.

2.2 COOLING AS A SERVICE TRANSACTION

A CaaS transaction begins when a cooling system service provider signs an agreement with one or several customers. Under the contract, the provider (or a financier) owns the equipment and commits to maintenance, repairs, and utility bill payment[2] – thereby taking on the performance risk of the cooling system. The provider then has significant incentives to achieve high-quality preventive maintenance, reduce corrective maintenance costs, and improve system energy efficiency. The technology provider is also incentivized to deploy systems that are modular so that components are reusable or recyclable at the end of the CaaS contract, to facilitate upgrades throughout the contract, and in case of customer default.

Customers do not pay an upfront cost for equipment and installation, but instead pay a fee per ton hour of refrigeration[3] consumed – encompassing all equipment, operation, and maintenance costs and profit margins for the technology provider. Because this fee per unit of consumption is higher than what the customer would pay per unit of electricity with conventional cooling ownership models, the customer has a much stronger incentive to minimize their cooling consumption – thereby further lowering electricity consumption, costs, and GHG emissions.

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[1] Contract terms and conditions are designed as a service agreement rather than a lease when feasible.

[2] Where regulatory or operating conditions limit the ability of the provider to directly pay the utility bill, different payment schemes may be deployed in which the customer pays the bill directly and the technology provider covers the full cost of electricity through a reimbursement.

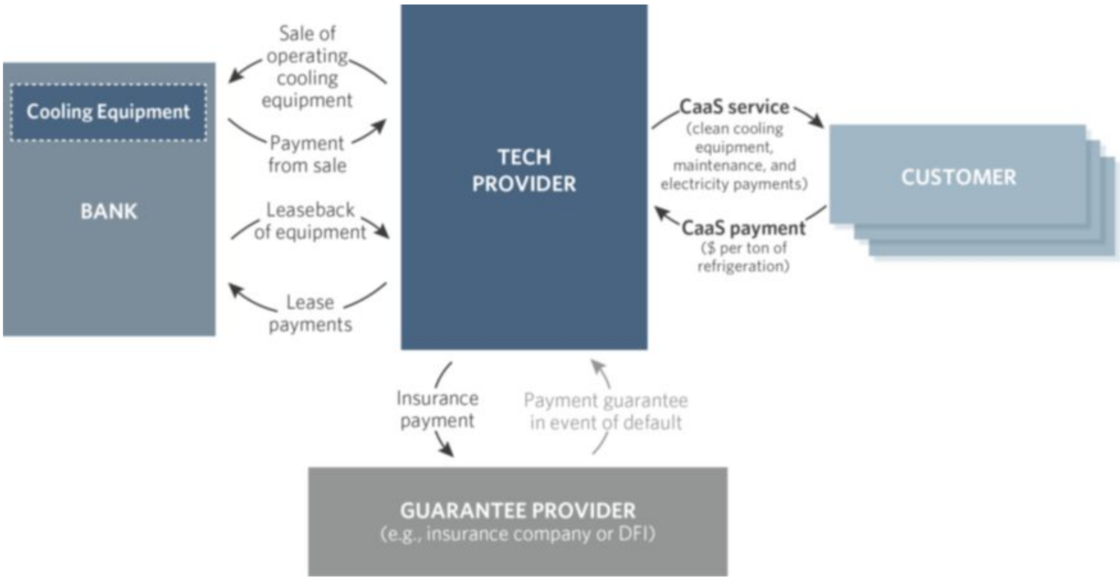
[3] One-ton refrigeration is the amount of heat removed by an air conditioning system that would melt 1 ton (2000 lbs.) of ice in 24 hours.

2.3 PROVIDER RECAPITALIZATION OPTIONS

The cooling technology provider is likely to require recapitalization, especially if the provider scales to multiple CaaS contracts. There are various methods of leveraging external finance and this assessment focuses primarily on an equipment sale-leaseback transaction with a single bank, which is modelled in *Section 5.1*. The team is exploring application of a sale-leaseback recapitalization in several of the initial implementation projects described in further detail in Section 4. The team is also exploring recapitalization via the creation of a special purpose vehicle (SPV) owned by multiple investors, a transaction that is described in further detail in *Annex 8.7*.

In a sale-leaseback approach, a bank or financial institution purchases equipment and then leases it back to the cooling system service provider over a period of time no more than the CaaS contract period. This asset-backed transaction where an operating asset is leased to the technology provider for the duration of the contract is more secure for the finance provider. The contract between the provider and the customer is used as additional collateral. A payment guarantee, from an insurance company or as an investment from a fund, can exist to protect the equipment provider from customer payment default. At the end of the contract, equipment ownership returns to the technology provider.

Figure 1. CaaS mechanics with sale-leaseback recapitalization



2.4 TARGET COUNTRIES AND TECHNOLOGIES

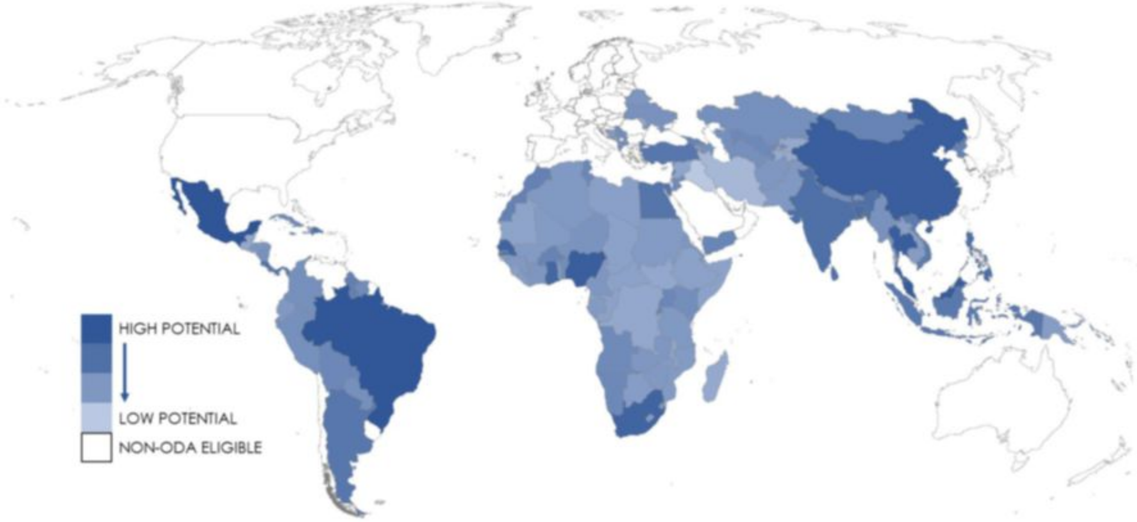
CaaS is flexible and can be implemented in many different regions, particularly as cooling demands increase due to climate change and as imperatives to reduce electricity consumption and fugitive emissions grow. Lab analysis established four categories of market criteria to determine optimal regions for the deployment of the Cooling as a Service model:

- International engagement – Status of country as a signatory to the Kigali Amendment and country selection of Nationally Determined Contribution sub-sectors relevant to clean cooling;
- Domestic planning – Presence of country-led HFC Phase-out Management Plan and National Cooling Plan;
- Price and impact – Average electricity price and grid emissions factor by country;

- Cooling supply and demand – Presence of cooling manufacturers in-country, average cooling degree days, and air conditioning demand.

From these market criteria we developed a ranking of deployment potential for CaaS.[4] This analysis is not determinative, but is instead intended to serve as one input to determination of viable countries for implementation of CaaS. The top 10 countries as assessed by this market criteria analysis, are: Mexico, Brazil, Malaysia, China, Thailand, Nigeria, South Africa, Senegal, Ghana, and Bangladesh.

Figure 2. Country analysis for CaaS deployment



CaaS initially targets the air conditioning and refrigeration segments but aims to expand to cold chains as well. Through refrigeration and cold chain applications CaaS will reduce additional energy consumption and combat food waste and improve health outcomes.

3. INNOVATION

Cooling as a Service supports servitization in emerging markets, aligning incentives for clean cooling technology deployment, efficient maintenance, and optimized consumption.

3.1 BARRIERS ADDRESSED: CAAS REDUCES BARRIERS TO CLEAN COOLING FINANCING AND DEPLOYMENT

The major barriers to financing and deploying clean cooling technologies at scale are the upfront costs of equipment and installation, perceived technology risks associated with new and innovative clean cooling equipment, and poor stakeholder incentives to pursue efficiency. The first two can prevent customers from realizing the operational savings of efficient equipment. The third barrier exists when technology providers are not incentivized to maintain equipment to its most efficient standard and when customers are not incentivized as strongly to consume less electricity.

CaaS presents key solutions to these barriers to deployment and financing of clean cooling:

- Structured payments over a multi-year period eliminate the upfront cost associated with the purchase and installation of clean cooling equipment.

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[4] See *Annex 8.2* for details.

- Technology providers take on performance risks as they own the equipment, pay the electricity bill, are responsible for maintenance, and thus have strong incentives to deploy the most efficient technology and maintain it as effectively as possible.
- Usage payments for the customer send a strong price signal to reduce cooling consumption.

3.2 INNOVATION: UNIQUELY DESIGNED TO COLLECT BEST PRACTICES AND BRING TOGETHER IMPLEMENTATION PARTNERS ACROSS MARKETS AND SECTORS

In our analysis of CaaS's market position, the team explored more than twenty-five comparable instruments, fund structures, and financing mechanisms. We have found that the instrument is uniquely focused on the deployment of clean cooling in both the commercial-industrial sector and the cold chain sector in global emerging economies. The instrument is also uniquely focused on driving the development of standardized tools, demonstrating the model in flagship buildings, and managing an alliance to institutionalize the model.

Similar instruments, including Energy Service Companies (ESCOs), servitization in air conditioning, and district cooling, are all instructive for application of CaaS, but all present marked differences in scope and mechanism involved.

Instrument	Description	Differentiation from CaaS
Energy Service Company (ESCO)	A mechanism to improve building cooling efficiency through an array of energy-saving solutions including retrofitting, energy conservation, power generation, and risk management.	ESCO payments are dependent on energy savings while a CaaS payment is agreed in advance as a function of actual usage.
Air conditioning as a service	A model offered by Kaer Air, based in Singapore. Under this model, the building owner specifies a required temperature for indoor environment and all aspects of design, installation, and maintenance are delegated to a provider of service.	Air conditioning as a service is provider-specific to one company and focused exclusively on developed markets in Southeast Asia, without the use of recapitalization including sale-leaseback or establishment of an SPV and is not applied to other cooling sectors such as refrigeration.
District cooling	An urban utility service where a centralized production of chilled water is piped to commercial buildings for air-conditioning.	District cooling is focused on the aggregation of demand in large-scale systems while CaaS can be applied without aggregation to a single customer and the payment is structured as a usage fee per ton of refrigeration.

A full table of the most relevant comparable instruments examined in this analysis is in *Annex 8.1*.

3.3 CHALLENGES TO INSTRUMENT SUCCESS

There are several challenges facing CaaS, however, they are mitigated and managed through a number of design and implementation approaches.

Potential Challenge	Management Strategy
Sourcing capable implementation partners	CaaS Initiative[5] will provide presentation materials explaining benefits of the business model for customers, technology providers, and finance providers. It will grow a network of capable CaaS implementation partners in different markets over time.
Changes to traditional cooling business operations	CaaS Initiative will provide resources to aid implementation partners in the setup of new operations including, standardized financial models, structuring guidance, template contracts, and an ongoing knowledge management platform supporting implementation.
Markets with difficult enabling environments (e.g., low capital availability, high customer default rates)	Guarantee funds insuring technology provider repayment will be used in certain markets for early implementation, to demonstrate the efficacy and reliability of the business model.

Proponents require capable implementation partners to implement the business model, which will involve the sustained engagement of a variety of stakeholders including technology providers, cooling customers, and financiers. Commitment by governments and policymakers to support the business model can also help it to scale. Innovative business models also require changes in traditional business operations including how owners think about cashflows and payment structures. To facilitate the introduction and mainstreaming of this business model, the implementation of demonstration projects in a variety of environments will be critical to success.

MARKET TEST AND BEYOND

Proponents have advanced implementation of the Cooling as a Service model in various geographies. Initial operation is being explored in the Dominican Republic, Jamaica, India, South Africa, and Mexico.

4. IMPLEMENTATION PATHWAY AND REPLICATION

CaaS proponents, BASE and K-CEP, have made significant progress towards initial implementation of Cooling as a Service in two countries: the Dominican Republic and Jamaica. The proponents are also pursuing larger flagship projects in South Africa, India, and Mexico. Proponents expect to seek US$ 10 million of investment and guarantees covering up to 50% of the invested amount or US$ 5 million to support the flagship implementation. Once implemented in flagship countries, the pathway will be smoother for further implementation with lower risks.

In both initial and flagship implementations, the CaaS Initiative will provide technical assistance resources for promoting the model to providers and customers, and will support implementation by providing standardized contracts, financial analysis tools, suggested financial structures, and other resources. CaaS proponents are currently laying the groundwork for potential implementation in a number of geographies.

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[5] See *Section 4* and *Annex 8.11* for details.

- Dominican Republic – Proponents are working with a global technology provider, have developed a CaaS contract to fit the country requirements, and have been engaging potential customers in the hospitality industry there.
- India – CaaS holds promise both in the industrial and commercial building cooling sector, and in other cooling-reliant sectors, including stationary refrigeration and mobile cold-chain technology for agriculture. In India, the proponents are providing technical support to an energy service company (ESCO) to offer and close a CaaS deal with a private hospital in Delhi.
- Jamaica – The team is working with an investment fund interested in structuring an SPV to recapitalize potential CaaS contracts. The team is also engaging local technology providers who would serve as implementing partners.
- Mexico – The team is working with a global technology provider and a global real estate manager to investigate possible implementation of Cooling as a Service in a major building. These engagements hold potential as flagship early implementation projects to test and promote CaaS in several large implementations spread over discrete markets around the world.
- South Africa – The team is working with a refrigeration company focused on low-global warming potential trans-critical CO_2 refrigeration and is in discussion with investors towards payment guarantees and potential co-investment.

CaaS implementation will require coordinated action on the part of the cooling user, the technology provider, and the finance provider in all stages of the transaction: preparation, financing, transaction contracting, and operation and close. The proponents aim to pilot three projects by the end of 2020 – a two-year implementation period from initiation to beginning of CaaS transaction. As CaaS transactions become widespread and standardized, the expectation is that this implementation timeframe from selection of a provider and customer to finalization of a term sheet, sale agreement, and installation and operation of equipment will decline.

Key milestones include the selection of a provider and customer to engage in a Cooling as a Service contract, development and tailoring of tools and service pricing to support the transaction, development of a term sheet and sale agreement, installation and operationalization of the equipment, and end of contract returns of ownership to the technology provider. A diagram outlining the high-level stages of the Cooling as a Service transaction, key steps and milestones for each actor in the transaction (technology provider, cooling customer, finance provider, and CaaS Initiative actors), and a list of toolkits needed at various points in the transaction is included in *Annex 8.11*.

5. IMPACT

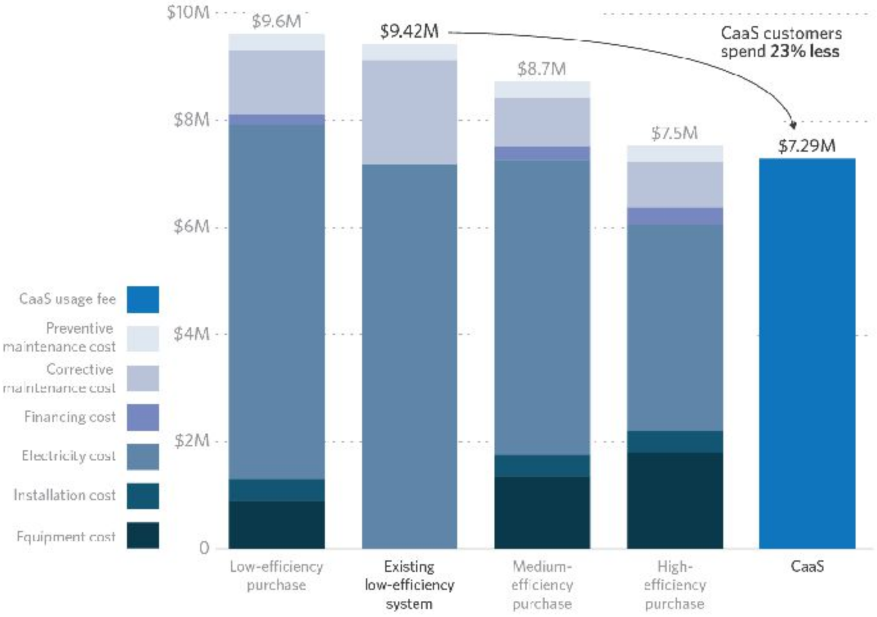
CaaS saves up to 23% of cooling costs for customers and reduces emissions from electricity use and coolant leakage by up to 49%, while providing significant profits for both technology and finance providers. It can also reduce food waste and increase resilience of agricultural value-chains when applied to refrigeration and cold chains.

5.1 QUANTITATIVE MODELING

Lab Secretariat modeling has compared implementation of clean cooling systems via CaaS against low-, medium-, and high- efficiency systems in several countries.[6] The model considers five possible scenarios[7] for purchase of a chiller system in a commercial or industrial space. The results presented in this section reflect outputs from Mexico because it is a target country for flagship implementation of CaaS and because its electricity prices and grid emissions factor are relatively representative of target countries evaluated.

CaaS saves 16-23% for cooling customers in Mexico[8] over the course of the contract, compared to operation of a low-efficiency legacy system and purchase of a medium-efficiency system. CaaS would be US$ 1.4 million (16%) cheaper in discounted lifetime costs than purchasing a medium-efficiency system and US$ 2.1 million (23%) cheaper in discounted lifetime costs than operating a 10-year old low-efficiency system, in spite of the existing system having no equipment cost. CaaS saves money in part because electricity use is the majority of total cost in all scenarios, and thus energy efficiency gains contribute to significant savings. Lower lifetime operating costs from regular preventative and corrective maintenance and higher-quality equipment also contribute to lowering total cost.

Figure 3. Cumulative discounted customer spending for a 1200 TR chiller system



CaaS expands the clean cooling market and revenue stream for technology providers and **produces 18-28% more profit** than provision of maintenance to a low-efficiency legacy system or upfront sale of a medium-efficiency system. CaaS provides US$ 99k (18%) more cumulative discounted profit than the purchase of a medium-efficiency system and US$ 142k (28%) more cumulative discounted profit than the provision of maintenance for a legacy low-efficiency system. CaaS also locks a stream of maintenance revenue that might otherwise be uncertain or flow to a third-party provider, while expanding the market for high-efficiency cooling equipment that might otherwise by cost-prohibitive.

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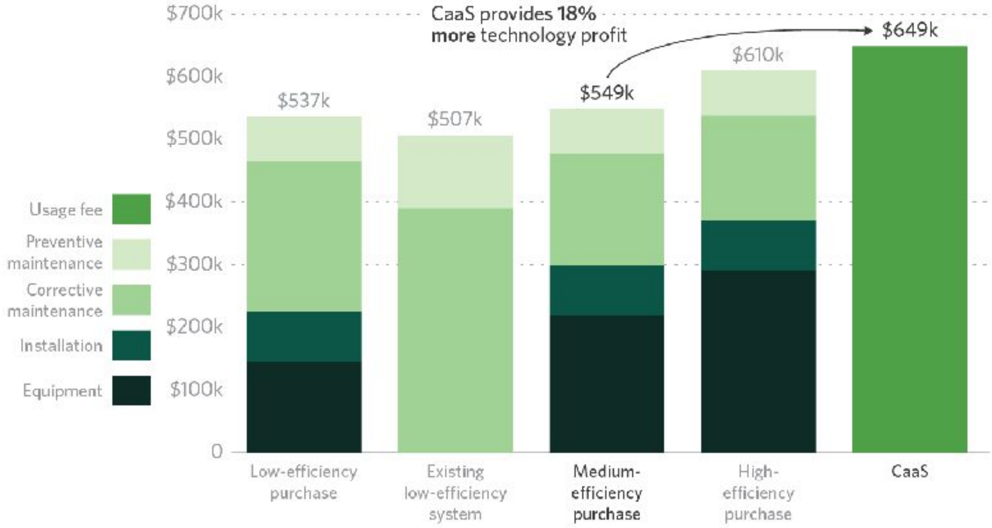
[6] See Annex 8.9 for complete results.

[7] See Annex 8.4 for additional details.

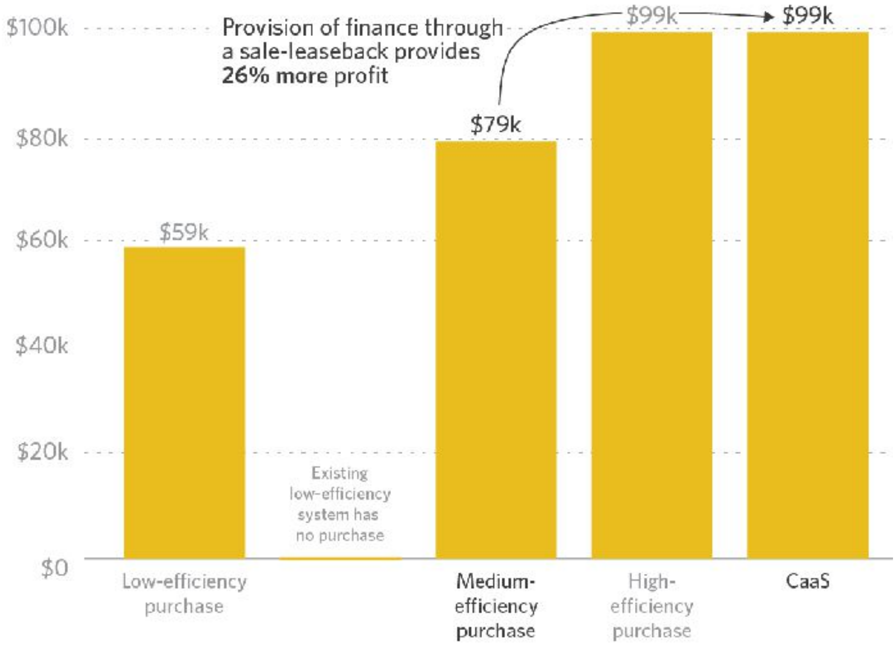
[8] Using an electricity price of US$ 0.1533/kWh. See *Annex 8.8.4* for additional detailed model inputs.

Figure 4. Cumulative discounted profit for technology providers for a 1200 TR chiller system in Mexico



For finance partners, CaaS provides stable profit streams backed by the long-term service contract between the technology provider and the customer. A sale-leaseback deal under a CaaS instrument provides US$ 20k (26%) more cumulative discounted profit than traditional loan financing for a customer paying upfront for a medium-efficiency cooling system. Under the operation of an existing legacy low-efficiency cooling system, the customer does not require any financing, so scenario 2 illustrates a lack of finance provider involvement in this instance.

Figure 5. Cumulative discounted finance provider profit from 1200 TR chiller system in Mexico in loan and sale-leaseback scenarios

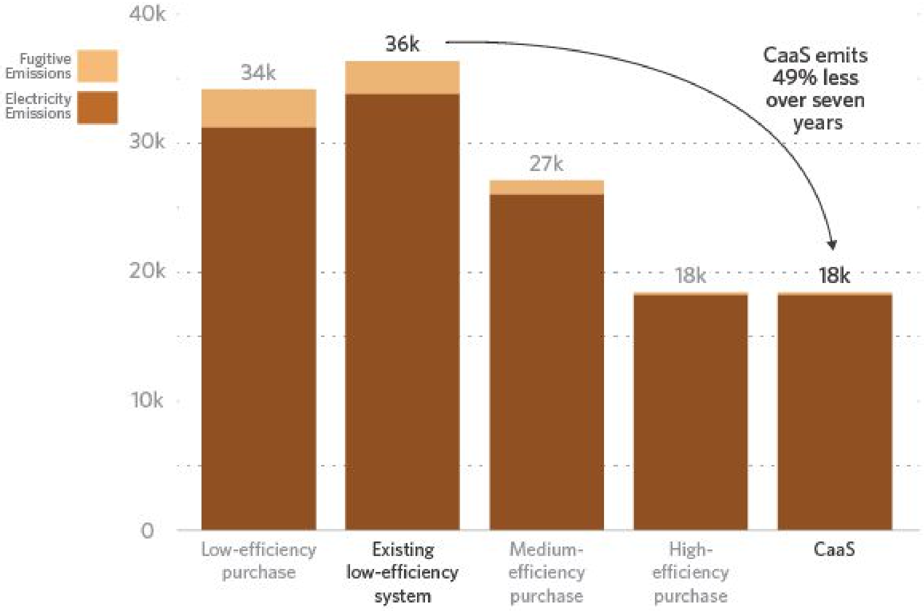


5.2 ENVIRONMENTAL AND SOCIAL IMPACT

CaaS mobilizes capital for investment in high-efficiency cooling systems, incentivizes quality preventive maintenance to reduce future corrective maintenance costs and ensure high efficiency energy consumption, and leads to selection of low-GWP coolant use systems. In

Mexico, installation and operation for seven years of a single high-efficiency chiller through CaaS yields an 8,663 tCO_2e reduction from upfront purchase and operation of a medium-efficiency unit and a 17,909 tCO_2e reduction from operation of a legacy low-efficiency unit over the same period. The reduction in tCO_2e attributable to a shift from scenario 2 to CaaS is equivalent to 1,945 homes' energy use for one year.

Figure 6. Cumulative emissions from 7-year operation of 1200 TR chiller system in Mexico (tCO_2e)



Application of the CaaS model presents significant opportunities for benefits in climate adaptation to increasing global average temperatures. The IPCC cites an estimate that suggests that global labor productivity will be reduced during the hottest months to 60% of present productivity by 2100 under the business-as-usual RCP 8.5 scenario (IPCC, 2018). CaaS aims to support adaptation to extreme heat in commercial buildings by financing high-efficiency cooling, which in turn has less effect on continued emissions that lead to additional temperature increase.

The CaaS model is also applicable in the refrigeration and cold-chain sector particularly in developing countries where food waste due to insufficient cold storage is common. The FAO estimates that approximately 25% of total food waste in developing countries could be eliminated by adopting the same level of refrigeration equipment available in developed economies (FAO, 2016). Increased temperatures associated with climate change will also affect food storage capacity and will lead to increased harvest losses, increased food waste, and adverse health outcomes. A financing mechanism to reduce upfront cost barriers to cooling for the agriculture sector could have enormous adaptation benefits for smallholder farmers and the agriculture value-chain.[9]

5.3 PRIVATE FINANCE MOBILIZATION AND REPLICATION POTENTIAL

Mexico is one of many markets around the world poised for growth in cooling demand. The total space cooling capacity of air conditioning equipment in the commercial sector in Mexico is approximately 79 GW in 2019 and is projected to grow more than 100% by 2030 and 268% by 2050 (IEA, 2018).

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[9] Global technology provider interview.

Implementation of CaaS for a flagship system would require roughly US$ 2.2 million of initial bank investment to cover equipment and installation costs.[10] Given significant improvements in financial outcomes under CaaS for customers, technology providers, and finance providers, the move towards servitization could happen very quickly. One technology provider interviewed, suggested that up to 30% of future installations in Mexico could be driven by servitization solutions.

In a more conservative estimate of CaaS operating in 10% of the total commercial space cooling capacity in Mexico by 2030, it would represent **more than US$ 14 billion in assets being financed and operated through CaaS** and could conservatively represent a more than 49% GHG emissions savings versus existing low-efficiency cooling and more than 31% GHGs savings versus medium-efficiency cooling.[11]

In other emerging economies, the commercial cooling market is also expected to grow very rapidly. Commercial space cooling capacity outside the US and EU will grow more than 55% between 2019 and 2030, and more than 150% by 2050. If the benefits of CaaS implementation in Mexico and elsewhere are communicated effectively and the tools for its implementation are disseminated widely to partners, the CaaS business model could grow to capture a meaningful fraction of the global commercial cooling market in developing and developed countries alike.

As a point of reference, CaaS financing and operating 2% of the total non-US/EU commercial cooling capacity by 2030, would represent more than **US$ 88 billion** in total low-efficiency cooling assets displaced. More broadly, the global air conditioning market as a whole is poised to grow to $230 billion every year between now and 2050.

When scaled beyond strictly commercial air conditioning technology to refrigeration and cold chains, CaaS has the potential for far greater scale. In both air conditioning and other technology sectors, CaaS overcomes the most important barriers to investment in clean and efficient cooling, namely the upfront cost and performance risk for the client. It provides opportunities for businesses to demonstrate their increased focus on environmental and sustainability concerns and the promotion of the circular economy. And CaaS is based on a partnership approach in which different entities collaborate in the long-term to improve competitiveness, efficiency, and sustainability.

6. KEY LAB TAKEAWAYS

6.1 2019 LAB FOCUS SECTOR: SUSTAINABLE CITIES

The Sustainable Cities stream of the Lab's 2019 program strives to mobilize private capital at scale for climate solutions in cities. Cooling is a critical component of cities and a significant source of energy consumption and emissions. Demand for cooling will continue to grow as climate change persists. CaaS can be a critical strategy for mobilizing private finance for clean cooling in cities. Though pilots may include rural and peri-urban customers, particularly for refrigeration, growth in the addressable global commercial cooling market will be

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[10] Based on 1200 TR system. See model details in *Annex 8.8.4*.

[11] This is true even assuming no further technology advances for efficient cooling equipment, and without considering greater rates of fugitive refrigerant emissions at end-of-life from non-CaaS equipment.

disproportionately in cities, and the CaaS business model will be important to meeting this need.

The CaaS model can be scaled to other sub-sectors like refrigeration which will be critical to reducing energy consumption in future cities and to improving food access, waste reduction, and water conservation which are particularly critical to sustainable cities. In the agricultural sector, CaaS has significant potential to support the climate adaptation efforts of smallholder farmers and the agriculture value-chain at large when applied to cooling harvested and transported food. CaaS can support achievement of Sustainable Development Goal (SDG) 11 (sustainable cities and communities) and can also contribute to SDGs 2 (zero hunger), 12 (responsible consumption and production), and 13 (climate action).

6.2 LAB ENDORSEMENT CRITERIA

Cooling as a Service meets the Lab criteria in the following ways.

Innovation: Cooling as a Service is an innovative approach to financing and deploying energy-efficient and low-GWP clean cooling technology at scale in emerging economies. Structured CaaS usage payments over a multi-year period eliminate the upfront cost associated with high-efficiency equipment and the servitization model where the technology provider maintains ownership[12] of the equipment incentivizes quality maintenances and installation of the most efficient equipment to reduce operational costs.

Financial sustainability: CaaS is designed to be a financially sustainable fully-commercial solution via cost savings from installation and operation of highly efficient cooling equipment. It has relatively low reliance on concessional capital as some cooling servitization models are commercially viable today in developed markets. Where concessional capital is needed to support expansion to countries with less stable and established capital markets and emerging technology providers, the CaaS Initiative will support the establishment of payment guarantees for CaaS transactions.

Actionability: CaaS is actionable today. Proponents have efforts underway in Jamaica, the Dominican Republic, Mexico, South Africa, and India to implement CaaS in various sectors. Jamaica and the Dominican Republic will be smaller-scale efforts to implement the CaaS model, while in Mexico, South Africa, and India, the CaaS Initiative will aim to establish flagship projects to demonstrate the CaaS model at scale in diverse geographies and sectors.

Catalytic potential: CaaS has significant catalytic potential. Even capturing a fraction of the commercial space cooling capacity in emerging economies by 2030, it could transition more than US$ 88 billion of assets and reduce their emissions by more than 49% versus low-efficiency cooling.

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[12] The technology provider may instead maintain responsibility for the equipment in the case of financier ownership.

7. REFERENCES

Food and Agriculture Organization of the United Nations (FAO). 2016. “How Access to Energy Can Influence Food Losses.” Available at: http://www.fao.org/3/a-i6626e.pdf

Intergovernmental Panel on Climate Change (IPCC). 2018. “Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.” Available at: https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-Chap11_FINAL.pdf

International Energy Agency (IEA). 2018. “Future of Cooling.” Available at: https://webstore.iea.org/the-future-of-cooling

Kigali Cooling Efficiency Program (K-CEP). 2018. “Optimization, monitoring, and maintenance of cooling technology.” Available at: http://k-cep.org/wp-content/uploads/2018/03/Optimization-Monitoring-Maintenance-of-Cooling-Technology-v2-subhead....pdf

Kigali Cooling Efficiency Program (K-CEP). 2019. “Homepage.” Available at: https://www.k-cep.org/

United Nations. 1987. “2. A Montreal Protocol on Substances that Deplete the Ozone Layer.” Available at: https://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-2-a&chapter=27&lang=en

United Nations Environment Programme (UNEP). 2016. “The Kigali Amendment to the Montreal Protocol: HFC Phase-down.” Available at: https://multimedia.3m.com/mws/media/1365924O/unep-fact-sheet-kigali-amendment-to-mp.pdf

United Nations Environment Programme (UNEP). 2019. “Manual of Financing Mechanisms and Business Models for Energy Efficiency.” Basel Agency for Sustainable Energy for UN Environment. March 2019. Available at: http://energy-base.org/wp-content/uploads/2013/11/Manual-of-Financing-Mechanisms-and-Business-Models-for-Energy-Efficiency2.pdf

United Nations News (UN News). 2019. “Keeping cool in the face of climate change.” Available at: https://news.un.org/en/story/2019/06/1041201

8. ANNEX

8.1 COMPARABLE INSTRUMENTS

Name of instrument, initiative, or concept	Sector	Differentiation from CaaS	Financing type
Energy Service Company (ESCO) [1A]	Energy Efficiency	ESCO payments are dependent on energy savings while a CaaS payment is agreed in advance as a function of actual usage.	Standardized energy performance contracts
Energy Savings Insurance [2A]	Energy Efficiency	The ESI instrument insures the financial performance of energy efficiency savings of a project.	Standardized energy performance contracts
Energy Efficiency Revolving Fund [2A]	Energy Efficiency	Provides low-interest loans to bank which finance energy efficiency projects.	Low-interest loans
EESL Super-Efficient Air Conditioning Programme [2A]	Energy Efficiency	Bulk buying and streamlining distribution & installation of high-efficiency RACs with low-GWP coolant.	Competitive bulk procurement
Commercialising Sustainable Energy Finance [2A]	Energy Efficiency	Provision of credit lines and technical assistance for energy efficiency investments to leasing companies.	Energy efficient technology leasing
Programa Nacional de Sustitución de Equipos Electrodomésticos [2A]	Energy Efficiency	Appliance rebates for end-use consumers dependent upon monthly energy consumption.	On bill financing
Power-By-The-Hour [2A]	Transport	Servitization approach applied by Rolls Royce to engine maintenance through a PAYG model.	Servitization
Light as a Service [2A]	Energy Efficiency	Servitization approach applied to LED lighting to replace incandescent light bulbs.	Servitization
Mobility-as-a-Service [3A]	Transport	Rental of vehicles charged per minute where equipment, parking, fuel, and insurance are included in price.	Servitization
District cooling [4A]	Energy Efficiency	Focuses on aggregation of demand in a large-scale system and there are a variety of payment options available.	Servitization
ColdHubs Pay-as-you-Store [5A]	Renewable Cooling	Plug and play modular walk-in cold room for off-grid storage of perishable foods, prices as a short-term rental.	Subscription
Air conditioning as a service [6A]	Cooling	Focused exclusively on developed markets in South East Asia, without use of recapitalization including sale-leaseback or establishment of an SPV.	Servitization
Air as a Service [7A]	Cooling	A company owns and installs air-conditioning in building on behalf of building owners and offers a subscription service to manage cooling operations.	Subscription

8.2 TARGET MARKETS METHODOLOGY

The table below indicates the criteria and points allocation used for a viability analysis of Cooling as a Service by country around the world. This analysis focused on country economic status, stated commitment to clean cooling, energy-related economic and environmental factors, and supply and demand potential for clean cooling. This analysis is not intended to be determinative but is instead one source of information in informing country context analysis.

Focus	Criteria	Point Allocation
ODA [1B]	Not ODA	Not included
	Least Developed	Included
	Lower Middle Income	Included
	Other Low Income	Included
	Upper Middle Income	Included
OECD [2B]	OECD	Not included
	Non-OECD	Included
UNFCCC [3B]	Not Annex I	Not included
	Annex I	Included
Montreal Amendment Group	Group 1	20 points
	Group 2	5 points
	No ratification	0 points
Kigali Amendment Ratification [4B]	Group 1	5 points
	Group 2	0 points
	No ratification	0 points
HCFC Phase-out Management Plan [5B]	Approved	10 points
	No plan	0 points
National Cooling Plan Status [6B]	In place/progress	10 points
	No plan	0 points
NDC Relevant Sub-Sectors (# of relevant) [7B]	5 sub-sectors	10 points
	4 sub-sectors	9 points
	3 sub-sectors	8 points
	2 sub-sectors	7 points
	1 sub-sectors	6 points
	0 sub-sectors	0 points

Electricity prices - USD/MWh (percentile) [8B]	81-100%	10 points
	61-80%	7 points
	No data	4 points
	41-60%	3 points
	21-40%	2 points
	0-20%	1 point
Emissions factor (percentile) [9B]	81-100%	10 points
	61-80%	7 points
	No data	4 points
	41-60%	3 points
	21-40%	2 points
	0-20%	1 point
Presence of Cooling Manufacturer	Presence of cooling manufacturer	10 points
	Lack of manufacturer	0 points
Number of enterprises * cooling degree days (percentile) [10B] [11B]	81-100%	10 points
	61-80%	7 points
	No data	4 points
	41-60%	3 points
	21-40%	2 points
	0-20%	1 point
AC demand (percentile) [12B]	81-100%	10 points
	61-80%	7 points
	No data	4 points
	41-60%	3 points
	21-40%	2 points
	0-20%	1 point

8.3 ADDITIONAL RISKS RELEVANT TO IMPLEMENTING CAAS

The team identified 10 core risks relevant to implementation of Cooling as a Service and evaluated the implications of implementation on each party in a cooling transaction. The analysis noted the parties currently bearing the risk under a business-as-usual clean cooling transaction, the amount of risk borne by each party under a Cooling as a Service transaction, and the party best-positioned to bear the risk.

Risk	Description of risk	Party bearing risk under a BAU	Party best-positioned to bear the risk	Parties in transaction	Amount of risk borne by party in CaaS
Cooling equipment technology performance risk	Risk that the cooling equipment underperforms projected specifications over the expected lifetime.	Customer	Cooling Tech Provider	Customer	
				Finance Provider	
				Cooling Tech	Full
				Guarantee Provider	
Cooling technology provider existential risk	Risk that the technology manufacturer will no longer be solvent or able to meet the terms of the warranty or provide replacement parts/materials support.	Customer	Cooling Tech Provider or Guarantee Provider	Customer	Minority
				Finance Provider	Majority
				Cooling Tech Provider	
				Guarantee Provider	
Foreign exchange risk	Risk of potential foreign exchange losses, when capital is borrowed in foreign currency and revenue is gathered in domestic currency.	Capital Provider or Customer	Guarantee Provider	Customer	Partial
				Finance Provider	Partial
				Cooling Tech Provider	Partial
				Guarantee Provider	
Counterparty risk	Risk that customer will default on loan/cooling usage fee payments.	Cooling Tech Provider or Capital Provider	Customer	Customer	
				Finance Provider	
				Cooling Tech Provider	Minority
				Guarantee Provider	Majority
Electricity price risk	Downstream risk of higher electricity prices due to greater generation/distribution/transmission costs and/or greater utility market power.	Customer	Customer	Customer	Full
				Finance Provider	
				Cooling Tech Provider	
				Guarantee Provider	
Policy, regulatory, and accounting standards risk	Risk of policy or regulatory changes that affect recapitalization options and risk of changes in accounting standards.	Cooling Tech Provider	Guarantee Provider	Customer	
				Finance Provider	Partial
				Cooling Tech Provider	Partial
				Guarantee Provider	
Procurement risk / tariff risk	Risk of delays in procurement processes due to bureaucratic			Customer	
				Finance Provider	Minority

	delays or changes to the tariff environment as a transaction is ongoing.	Cooling Tech Provider	Cooling Tech Provider	Cooling Tech Provider	Majority
				Guarantee Provider	
Unanticipated extreme heat	Risk of much greater cooling demand than anticipated.	Customer	Customer	Customer	
				Finance Provider	
				Cooling Tech Provider	Full
				Guarantee Provider	
Service continuity risk	Risk that cooling equipment cannot be operated due to power outage or that equipment is inoperable due other business interruptions.	Customer	Customer	Customer	Partial
				Finance Provider	
				Cooling Tech	Partial
				Guarantee Provider	
Extreme weather damage risk	Risk that cooling equipment is damaged and requires additional corrective maintenance due to storms/flooding/other extreme weather.	Customer	Cooling Tech Provider	Customer	Minority
				Finance Provider	Majority
				Cooling Tech Provider	Minority
				Guarantee Provider	

8.4 MODEL SCENARIOS

The five model scenarios selected for this analysis are intended to represent the array of cooling transactions in the market today. Although cooling-efficiency exists on a spectrum rather than three-tiers of low-, medium-, and high-efficiency systems, for the sake of simplicity, we have elected to assess the cooling transaction across those three tiers. A description of each scenario is below and the key inputs that inform the modelling of each scenario are outlined in *Section 8.8.4*.

Scenario 1 – Upfront purchase of a low-efficiency system with customer loan financing. This scenario is representative of a common transaction approximately a decade ago, when many commercial buildings purchased relatively low-priced low-efficiency cooling systems with high-GWP coolants. As the cooling market has developed and production of this level of low-efficiency cooling system has declined, this scenario has become less common. This scenario is thus not a focus of the modelling comparisons highlighted in the team's analysis, but it does still occur in less developed cooling markets where customers have limited capital.

Scenario 2 – Legacy use of a low-efficiency system. This scenario is a remnant of the scenario 1 purchases made about a decade ago and is intended to represent the commercial buildings that operate old low-efficiency equipment – in this analysis 10 years old – to avoid the upfront costs associated with purchase and installation of a new system. We assume that maintenance and electricity costs are very high in this scenario due to the deterioration of an already low-efficiency system.

Scenario 3 – Upfront purchase of a medium-efficiency system with customer loan financing. This scenario is representative of a common transaction in the market today and is illustrative of the change in the market from the period in which scenario 1 would have been most common. Equipment purchased in this scenario is significantly improved from scenario 1 in both energy efficiency and GWP of coolant but is not cutting edge as compared to the best systems available.

Scenario 4 – Upfront purchase of a high-efficiency system with customer loan financing. In conversations with cooling experts, this scenario is the least likely to occur in practice because of the – in many cases prohibitively – high upfront costs associated with high-efficiency, cutting edge equipment. Indeed, the premise of the CaaS transaction is that it serves as a solution to the challenges associated with implementing scenario 4 in the market. This scenario is therefore intended as a point of comparison to the other scenarios rather than a likely transaction.

Scenario 5 – CaaS transaction of a high-efficiency system with sale-leaseback. This scenario represents the cooling transaction that would occur under the proposed CaaS instrument. All other scenarios are thus compared against Scenario 5 to understand how implementation of CaaS would affect customer spending, technology provider profit, finance provider profit, and emissions.

8.5 MODEL AND DUE DILIGENCE CONSIDERATIONS

The CaaS model as created has been focused on illustrating the impacts of a CaaS transaction versus a number of alternatives as simply as possible. It is designed to demonstrate the places where CaaS adds potential value for key stakeholders in the transaction. However, there are many enhancements and future functionalities that could make it even more useful for certain audiences considering implementation. These considerations include:

- **Multiple installations:** The ability to account for more than one system installed and operated by the technology provider for a given customer.
- **Depreciation:** Comparison of the depreciation benefits across scenarios for customers and finance providers. This functionality would allow us to understand a key input to the total cost/value of the project from customers' perspectives.
- **End of contract:** Treatment at end of contract period (renewal of contracts, residual value of equipment, etc.).
- **Accounting treatment:** Differences in accounting for CaaS transaction stakeholders under a variety of leasing and services contract conditions.
- **Behavior change:** Customer behavior/consumption change due to cost per unit volume of cooling which would allow us to estimate customer savings, GHG savings, etc.
- **Minimum fee threshold:** Addition of a lower-bound for payment to the technology provider to ensure they are made whole in a scenario where customer dramatically curtails use.
- **Demand-side management:** Tech provider's ability to take advantage of preferential pricing/ToU, etc. to optimize energy savings while meeting customers' needs.
- **Reuse of waste heat and thermal storage:** Incorporating the sale and emissions reduction from the reuse of waste heat that is removed through the cooling process
- **Guarantee fund:** Consideration of the additional risk management value and costs of a customer payment guarantee fund.
- **Leakage end of equipment life:** Comparison of the likelihood of refrigerant leakage under different end-of-life scenarios.

8.6 ACCOUNTING TREATMENT

The accounting characterization of a CaaS transaction under the standards set by the International Accounting Standards Board and the Financial Accounting Standards Board will be critical to consider in structuring of the transaction. In order for the transaction to remain off of the balance sheet of the customer (avoiding limitations to the customer's credit capacity) the transaction must be characterized as a service arrangement as opposed to an embedded lease and the equipment supplier must be able to achieve sales treatment for the equipment (i.e., ownership transfers to the financier). CaaS transactions are still possible on-balance sheet, but would face challenges associated with competitiveness in the market due to constraints to customers' credit capacity. There are variety of approaches to ensure an off balance sheet characterization:

1. Multiple off-taker model – Equipment installed provides cooling to multiple off-takers through multiple CaaS contracts. Under this approach, there is no embedded lease and the approach can potentially be expanded in single building situations by contracting directly with building tenants as opposed to the building owner.
2. Non-amortization of equipment – A model to ensure that the term of the CaaS transaction is not sufficient to fully amortize the equipment delivering the service and there is no end of agreement transfer of ownership. This approach incentivizes

modular equipment solutions that allow for redeployment in case of agreement non-renewal.

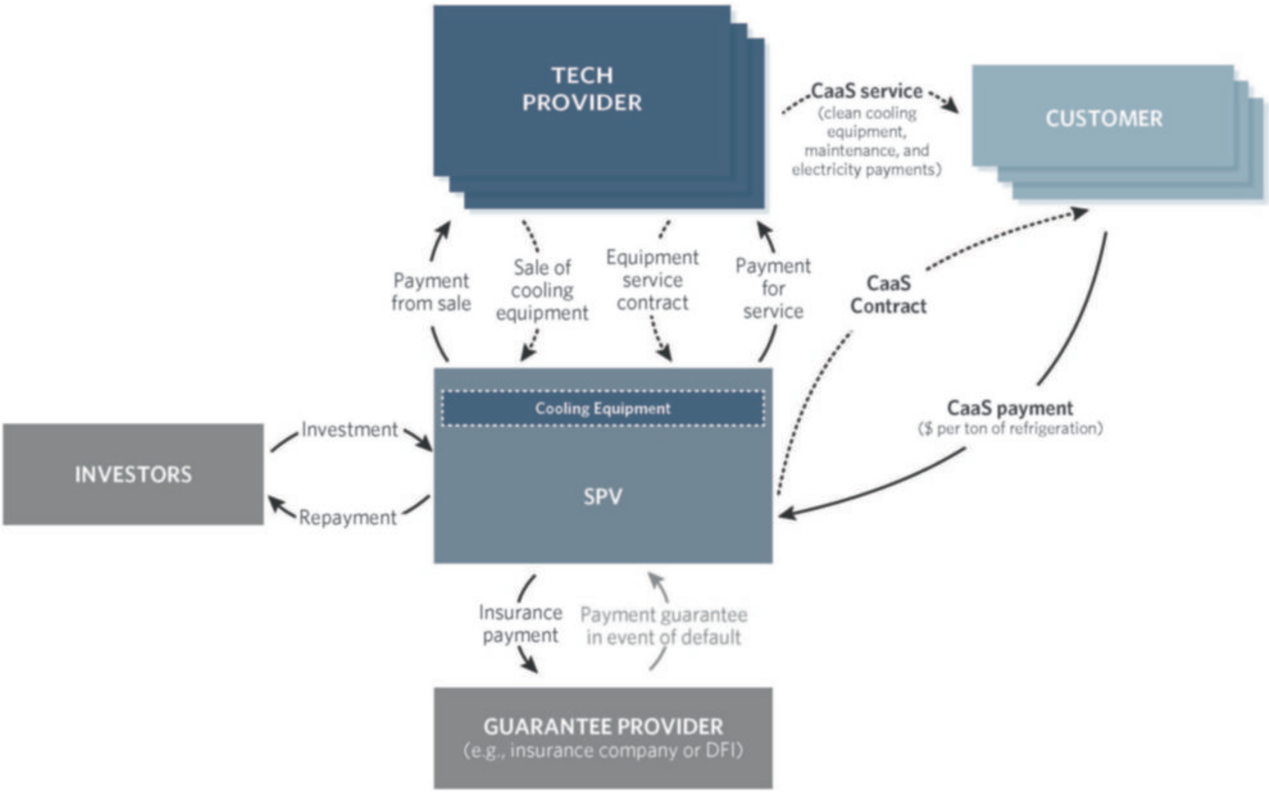
3. Asset identification and control – The cooling equipment would not be identified with a serial number and would be characterized as a component among others in generation of a cooling output. The end customer does not have access to or control of the equipment, ensuring that the technology provider is in control of the equipment maintenance and operation.

8.7 OTHER RECAPITALIZATION STRUCTURES

Although this analysis has centered on recapitalization via a sale-leaseback mechanism, other transactions are possible in order to recapitalize the technology provider. In a transaction in which investors set up a special purpose vehicle (SPV), the SPV buys the equipment from the technology provider and signs CaaS contracts with clients. Under an agreement between the SPV and the technology provider, the provider is responsible for the maintenance and operation of the equipment (including the payment of utilities) but does not own the equipment. As under a standard sale-leaseback, a payment guarantee protects the SPV from some of the risks of a customer default or technology provider non-performance. The SPV engages with an insurance provider or a fund to establish a payment guarantee linked to the value of the cooling equipment. The team is exploring application of this model with interested parties in several markets and it will likely be applied in at least one early implementation of Cooling as a Service.

The following graphic illustrates the recapitalization of the technology provider through establishment of an SPV:

Figure 7. CaaS mechanics with SPV recapitalization



8.8 MODEL APPROACH AND METHODOLOGY

8.8.1 SERVITIZATION PAYMENT CALCULATION

The Cooling as a Service Usage fee is calculated as a function of the total operational costs associated with installation, operation, provision of maintenance, and financing of a high-efficiency cooling system. The usage fee is determined by a monthly cut of total revenue from cost of the equipment to produce, maintenance costs, electricity costs, leasing payments, and bank sale for the lease. A surcharge is associated with all costs but electricity, while electricity is included in the usage fee without surcharge to ensure the technology provider is not profiting from energy bills paid.

8.8.2 SALE-LEASEBACK PAYMENT CALCULATION

$$\text{LEASE PAYMENT} = \frac{\text{TOTAL LEASE AMOUNT} - \dfrac{\text{RESIDUAL VALUE}}{(1 + \text{INTEREST RATE})^{\#\text{ OF PERIODS}}}}{\left(\dfrac{1 - \dfrac{1}{(1 + \text{INTEREST RATE})^{\#\text{ OF PERIODS}}}}{\text{INTEREST RATE}}\right)}$$

Calculation of leasing payment from the technology provider to the finance provider in a sale-leaseback transaction is completed via this formula:

8.8.3 EMISSIONS

Total emissions is calculated in each scenario through a sum of electricity emissions (total consumption multiplied by an emissions factor) and fugitive emissions (including the emissions from installation, operation, and end-of-use). The GWP of the coolant and leakage rate varies by scenario: low-efficiency cooling has the highest-GWP coolant and highest leakage rate while CaaS has the lowest-GWP coolant and lowest leakage rate due to quality maintenance. There are variables that would be relevant in analysis of a specific implementation that aren’t included in this analysis because of dependency on the source of those variables. These variables include the energy mix, efficiency of established cooling systems, and economic and policy conditions within a country. Additional details on inputs is available in the section below.

8.8.4 KEY INPUTS AND SOURCES

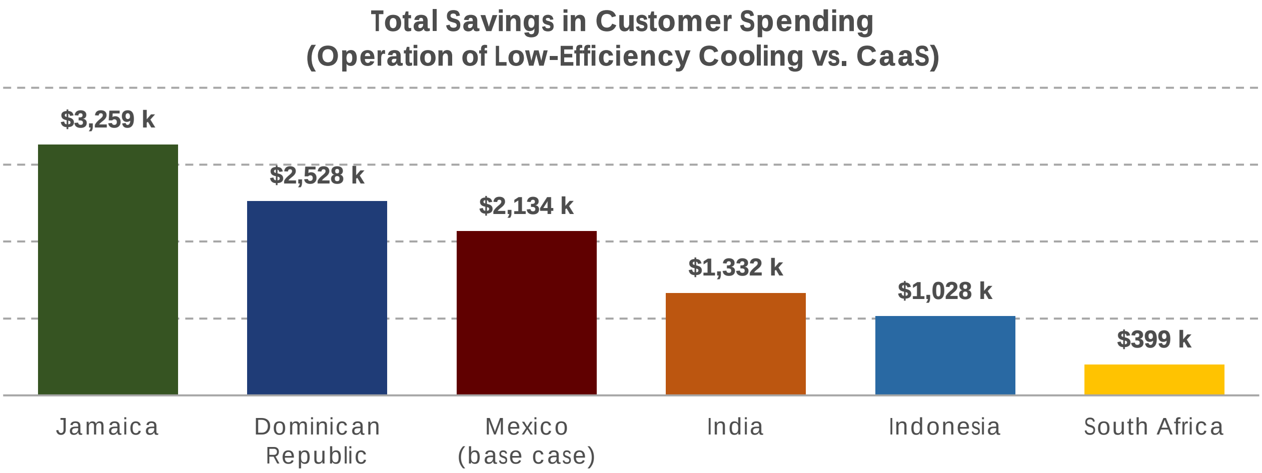
INPUT		CONSTANT	UNIT	SOURCES
TECHNICAL				
SYSTEM	Capacity	1200	TR	[1C]
	Scenario 1: Efficiency	1.2	kW/TR	[1C]
	Scenario 2: Efficiency	1.3	kW/TR	[1C]
	Price of electricity	0.1533	$/kWh	[2C]
COSTS	Cooling equipment MSRP	900k-1.8mn	$	[1C]

	Installation cost MSRP	400,000	$	[1C]
	Corrective maintenance cost	200,000	$/year	[1C]
	Preventive maintenance cost	60,000	$/year	[1C]
	Depreciation rate	99	%	[3C]
FINANCING and FISCAL				
TECHNOLOGY PROVIDER	Annual discount rate (standard)	10	%	[1C]
	Annual discount rate (CaaS)	12	%	[4C]
	Residual equipment value	10	%	[4C]
	Taxation rate	30	%	[5C]
CUSTOMER	Annual discount rate	10	%	[1C]
	Annual nominal interest rate	15	%/year	[4C]
	Tenor of loan	7.0	years	[1C]
FINANCING PROVIDER	Annual discount rate	10	%	[1C]
	Annual interest rate – sale-leaseback	15	%	[4C]
	Tenor of sale-leaseback	7.0	years	[1C]
SOCIAL AND ENVIRONMENTAL IMPACT				
SCENARIO #1: Low-Efficiency Purchase & SCENARIO #2: Existing Low-Efficiency	Grid-intensity of region deployed	0.5	tCO_2/MWh	[6C]
	Scenario 1: Type of coolant	R-410a		[1C]
	Scenario 1: GWP of coolant	2088	GWP	[7C]
	Scenario 2: Type of coolant	R-22		[1C]
	Scenario 2: GWP of coolant	1810	GWP	[7C]
	Full operation cooling capacity	1008	kg coolant	[8C]
	Coolant installation emissions factor	1	% of capacity	[8C]
	Coolant annual operation emissions leakage	20	% of capacity	[1C]
	Cooling remaining at disposal	100	% of capacity	[8C]
	Coolant recovery efficiency	95	% of remaining	[8C]
SCENARIO #3: Medium-Efficiency Upfront Purchase	Scenario 3: Type of coolant	R-134a		[1C]
	Scenario 3: GWP of coolant	1430	GWP	[7C]
	Full operation cooling capacity	804	kg coolant	[8C]
	Annual coolant operating emissions leakage	15	%	[1C]
SCENARIO #4: High-Efficiency Upfront Purchase & SCENARIO #5: CaaS	Scenario 4 & 5: Type of coolant	R-32		[1C]
	Scenario 4 & 5: GWP of coolant	675	GWP	[7C]
	Full operation cooling capacity	1008	kg coolant	[8C]
	Coolant annual operating emissions leakage	5	% of capacity	[1C]

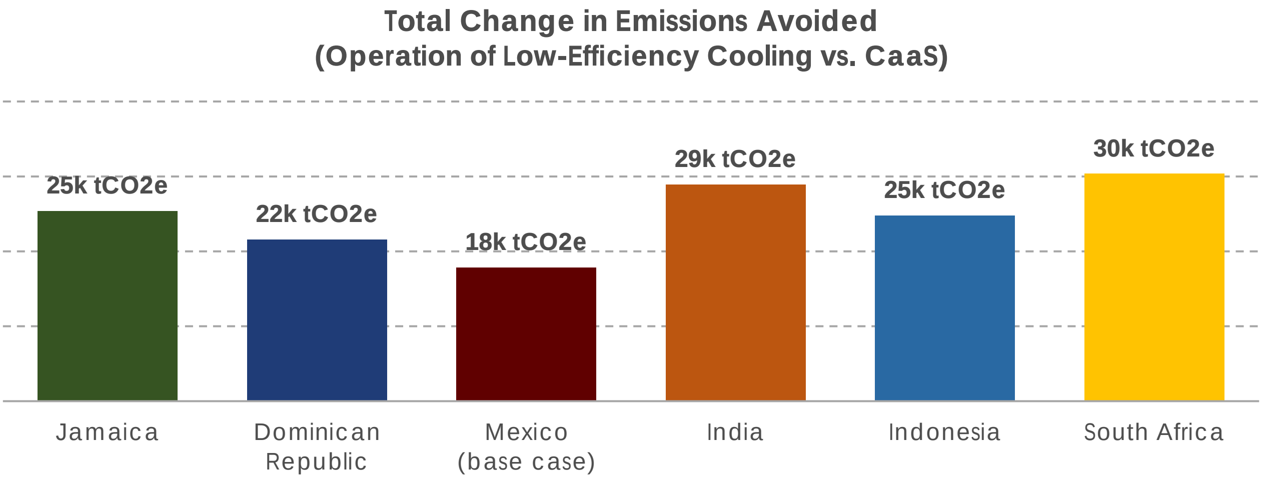
8.9 MODEL RESULTS FOR CAAS IN SIX TARGET COUNTRIES

While the paper highlights CaaS results that are specific to Mexico, the team has assessed how a Cooling as a Service transaction would compare to operation of a low-efficiency cooling system over a seven-year time frame for six target countries – concentrating exclusively on the important roles changing electricity prices and emissions factors in driving cost and emissions outcomes, with all other variables held constant.

Country	**Electricity price ($/kWh)** [1D]	**Emissions factor (tCO$_2$/MWh)** [2D]
Jamaica	0.21	0.78
Dominican Republic	0.17	0.65
Mexico (base case)	0.15	0.53
India	0.12	0.90
Indonesia	0.10	0.76
South Africa	0.07	0.95



Total savings in customer spending is positive in all countries – meaning that Cooling as a Service saves customers compared to operation of a low-efficiency cooling system under all scenarios. Customer spending savings are driven by electricity prices and are highest when electricity prices are highest (in Jamaica) and lowest in South Africa where they are lowest (0.07 $/kWh).



Implementation of Cooling as a Service yields greatest increase in emissions avoided in countries with grids reliant on coal and natural gas. South Africa, the country with the highest emissions factor among those assessed yields the highest total change in emissions avoided.

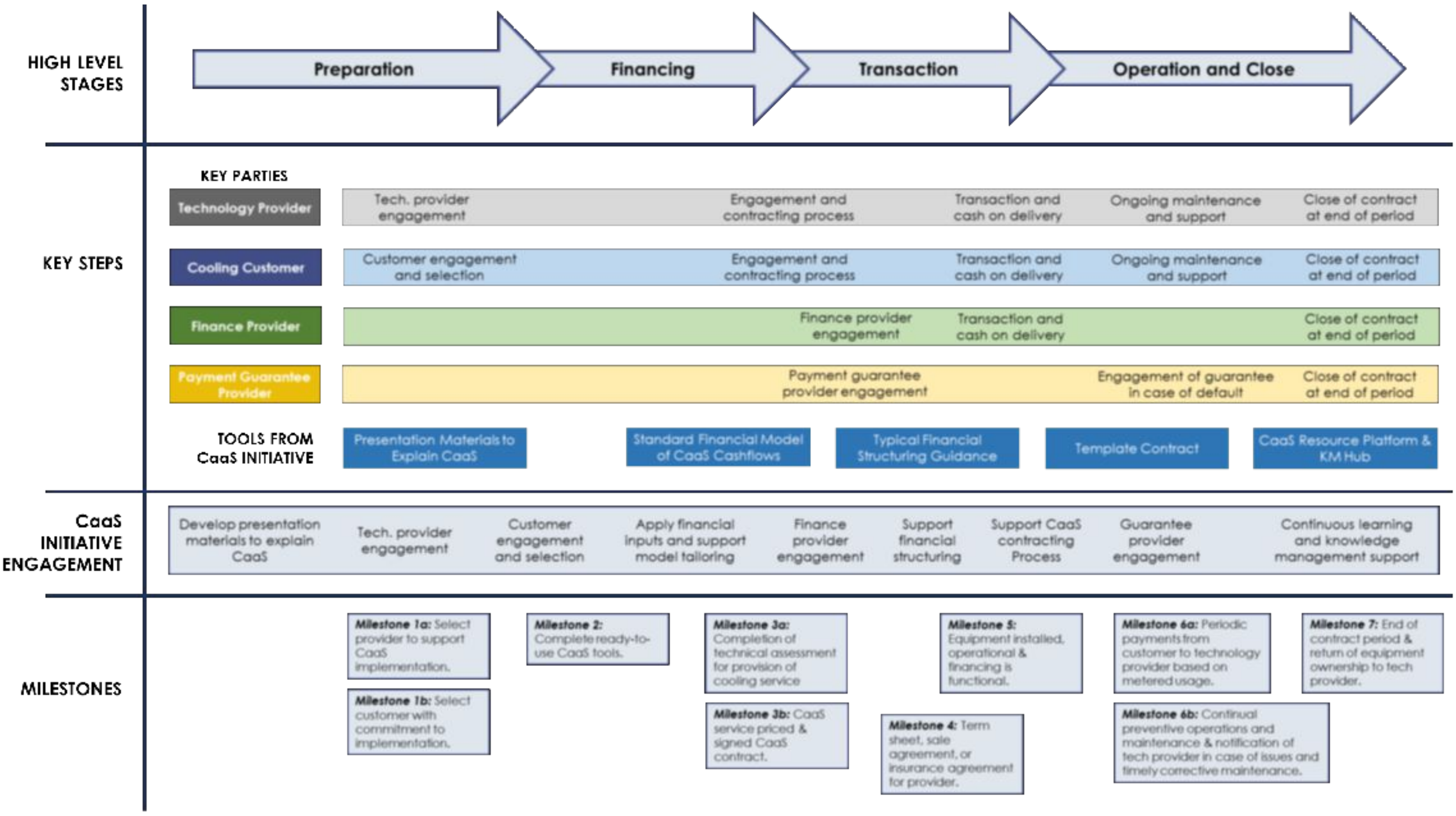
8.10 ADDRESSABLE MARKET CALCULATIONS

Addressable market calculations are an extrapolation from IEA (2018) data from Figure 3.3 “Commercial AC cooling capacity in the Baseline Scenario by country/region.” IEA data are converted from GW installed to value in US dollars, using assumptions from scenario 1 in *Annex 8.8.4 Key inputs and sources* including, chiller cost (US$1.3M), size of system (1200 TR), efficiency of system (1.2 kW/TR), and peak system power (1440 kW).

These inputs are not necessarily indicative of future market conditions through 2030 and 2050 but are employed for consistency with elements used in the CaaS financial model, in order to provide rough estimates for total asset value of commercial space cooling capacity both in Mexico specifically, and in broader contexts around the world.

Due to lack of data granularity on emerging market commercial space cooling capacity, global capacity with United States and European Union capacity subtracted, is used as a proxy for the Lab’s global addressable market scope.

8.11 IMPLEMENTATION PATH DIAGRAM



Milestone 1a: Select provider to support CaaS implementation.

Milestone 1b: Select customer with commitment to implementation.

Milestone 2: Complete ready-to-use CaaS tools.

Milestone 3a: Completion of technical assessment for provision of cooling service

Milestone 3b: CaaS service priced & signed CaaS contract.

Milestone 4: Term sheet, sale agreement, or insurance agreement for provider.

Milestone 5: Equipment installed, operational & financing is functional.

Milestone 6a: Periodic payments from customer to technology provider based on metered usage.

Milestone 6b: Continual preventive operations and maintenance & notification of tech provider in case of issues and timely corrective maintenance.

Milestone 7: End of contract period & return of equipment ownership to tech provider.

9. ANNEX REFERENCES

8.1 Comparable Instrument Sources

[1A] IEA. 2019. “Energy Service Companies.” https://www.iea.org/topics/energyefficiency/escos/

[2A] Kigali Cooling Efficiency Program. 2018. “Cooling efficiency finance case studies.” https://www.k-cep.org/wp-content/uploads/2018/04/Cooling-efficiency-financing-case-studies_final-edited03.pdf

[3A] Daimler. 2019. “Car2Go.” https://www.daimler.com/sustainability/mobility-services/car2go-registration.html

[4A] SPgroup. “Cooling & Heating.” https://www.spgroup.com.sg/what-we-do/cooling-and-heating

[5A] ColdHubs. “Solar Powered Cold Storage for Developing Countries.” http://www.coldhubs.com/

[6A] Ellen Macarthur Foundation. 2017. “Air conditioning as a service reduces building carbon emissions.” https://www.ellenmacarthurfoundation.org/case-studies/air-conditioning-as-a-service-reduces-building-carbon-emissions

[7A] Mitsui & Co. 2018. “Establishment of Air as a Service, the first*1 in the industry to provide comfortable air-conditioned space for buildings at a fixed monthly fee.” https://www.mitsui.com/jp/en/topics/2018/1225589_11241.html

8.2 Target Markets Sources

[1B] OECD. 2018. “DAC List of ODA Recipients.” http://www.oecd.org/dac/financing-sustainable-development/development-finance-standards/daclist.htm

[2B] OECD. 2019. “Where: Global reach.” https://www.oecd.org/about/members-and-partners/

[3B] UNFCCC. 2018. “Type of Party to the Convention.” https://unfccc.int/process/parties-non-party-stakeholders/parties-convention-and-observer-states

[4B] Open Climate Data. 2019. “Kigali Amendment.” https://kigali-amendment.openclimatedata.net/

[5B] UNEP. 2018. “Desk Study for the Evaluation of HCFC Phase-out Management Plan Preparation Activities to Assist with the Implementation of the Kigali Amendment.” http://www.multilateralfund.org/82/English/1/8212.docx

[6B] Kigali Cooling Efficiency Program. 2019. “Year 2 Annual Report.” https://www.k-cep.org/year-two-report/

[7B] World Bank. 2019. “Intended Nationally Determined Contributions (INDCs).” http://spappssecext.worldbank.org/sites/indc/Pages/INDCHome.aspx

[8B] BloombergNEF. 2018. “CLIIMATESCOPE 2018.” http://global-climatescope.org/

[9B] Institute for Global Environmental Strategies (IGES). 2019. “IGES List of Grid Emission Factors.” https://pub.iges.or.jp/pub/iges-list-grid-emission-factors

[10B] Chartsbin. 2011. “Worldwide Cooling Needs.” http://chartsbin.com/view/1030

[11B] OECD. 2017. “Enterprises by business size.” https://data.oecd.org/entrepreneur/enterprises-by-business-size.htm

[12B] Japan Refrigeration and Air Conditioning Industry Association. 2018. “World Air Conditioner Demand by Region.” https://www.jraia.or.jp/english/World_AC_Demand.pdf

8.8.4 Key Model Input Sources

[1C] Global Technology Provider. (2019, July 19). Phone interview.

[2C] BloombergNEF. 2018. “CLIIMATESCOPE 2018.” http://global-climatescope.org/

[3C] www.PWC.com – BASE, can you indicate where this is from? From the BASE model: “Comes from DR - Air Conditioning -- 15% per year --> www.PWC.com”

[4C] Basel Agency for Sustainable Energy. (2019, August). Phone interview.

[5C] Trading Economics. 2019. “List of Countries by Corporate Tax Rate.” https://tradingeconomics.com/country-list/corporate-tax-rate

[6C] Institute for Global Environmental Strategies (IGES). 2019. “IGES List of Grid Emission Factors.” https://pub.iges.or.jp/pub/iges-list-grid-emission-factors

[7C] The Linde Group. “Refrigerants Environmental Data. Ozone Depletion and Global Warming Potential.” https://www.linde-gas.com/en/legacy/attachment?files=tcm:Ps17-111483,tcm:s17-111483,tcm:17-111483

[8C] EPA. 2014. “Direct Fugitive Emissions from Refrigeration, Air Conditioning, Fire Suppression, and Industrial Gases.” https://www.epa.gov/sites/production/files/2015-07/documents/fugitiveemissions.pdf

8.9 Model Results by Country

[1D] BloombergNEF. 2018. “CLIIMATESCOPE 2018.” http://global-climatescope.org/

[2D] Institute for Global Environmental Strategies (IGES). 2019. “IGES List of Grid Emission Factors.” https://pub.iges.or.jp/pub/iges-list-grid-emission-factors