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Electrifying Airport Ecosystems

Act Now to Meet a Growing Demand

Significant Power Infrastructure Investments Needed to Meet Growing Electrification Demands Nationwide

Enterprise Mobility™ Xcel Energy® Jacobs

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Enterprise Mobility

Enterprise Mobility is a leading provider of mobility solutions including car rental, fleet management, flexible vehicle hire, carsharing, vanpooling, truck rental, luxury rental, retail car sales and vehicle subscription, as well as other transportation technology services and solutions. Enterprise Mobility manages a diverse fleet of 2.3 million vehicles through nearly 9,500 neighborhood and airport rental locations in more than 90 countries and territories. Privately held by the Taylor family of St. Louis, Enterprise Mobility manages the Enterprise Rent-A-Car, National Car Rental and Alamo brands as well as Enterprise Fleet Management, North America's largest fleet management company.

With its uncompromising commitment to delivering exceptional customer service and experiences, Enterprise Mobility is innovating with intention to meet its customers' ever-changing needs and embracing the thoughtful, strategic transition to electrification. With that, as the fleet includes more electric vehicles ("EV"), consumption of electric power becomes as critical to the organization as liquid fuel. This is one of the reasons why a core pillar of Enterprise Mobility's EV strategy is "expanding power and charging viability to support a positive customer experience."

> *The best path to a more sustainable mobility future is one that maintains a long-term perspective and puts the customer at the center of the transition.*
>
> **Dan Wessel**
> Senior Vice President, Strategic Initiatives, Enterprise Mobility

Enterprise Mobility is focused on the long-term market viability of EVs and is uniquely aligned with electric utilities and airports in its forward-looking planning philosophies. It recognizes the need for cross-industry collaboration to comprehensively assess long-term power needs to enable the development of cost-effective and scalable infrastructure solutions. Importantly, the infrastructure required will likely take many years to develop, necessitating collective action now to help ensure resiliency, sustainability and the long-term viability of the major economic driver of many regions: its airport ecosystem. With this study, Enterprise Mobility aims to bring awareness to this immediate need for collective action and play a leading role in supporting utilities and airports as they prepare for electrification.

Xcel Energy

Xcel Energy is the electric power provider for both Denver International Airport (DEN) and Minneapolis-Saint Paul International Airport (MSP). As a provider of electric infrastructure, the Company engages in long-term planning, reviews technology solutions and considers funding resources.

To accommodate transportation electrification, Xcel Energy recognizes the traditional timing of the load request-based approach to grid planning may result in infrastructure bottlenecks that could inhibit electrification. For example, powering EV adoption requires proactive investment in "no-regrets" grid infrastructure solutions that best enables all customers to electrify at the pace highlighted by this report. A recent white paper from the International Council on Clean Transportation (ICCT) concluded that given the long lead times involved in upgrading electric transmission and distribution infrastructure, capacity building should start as soon as feasible and that investments must be made at scale and at strategic locations suitable for EV adoption.[1]

Enabling proactive "no-regrets" grid infrastructure investment will require new ways of thinking that depart from historic practices. Policies and practices developed under prior market conditions, plus persistent supply chain delays on critical power equipment, contribute to the challenges utilities face when addressing the anticipated demands of electrification.

> *To meet customer needs, support continued economic growth and advance state and federal targets to reduce GHG emissions, utilities must build timely infrastructure that is reliable and affordable. This is one way utilities can enable the electrification transition and deliver cleaner air for all.*
>
> **Stephen Martz**
> Vice President Integrated Planning, Xcel Energy

Jacobs

Jacobs delivers solutions for thriving cities, resilient environments, mission-critical outcomes, operational advancement, scientific discovery and cutting-edge manufacturing, turning abstract ideas into realities that transform the world for good. With approximately $16 billion in annual revenue and a talent force of more than 60,000, Jacobs provides a full spectrum of professional services including consulting, technical, scientific and project delivery for the government and private sector.

> *Airports are critical to mobility and economic activity, but as the scale and pace of electricity demand grows, airport ecosystems are at risk of disruption. This problem requires urgent collective action from stakeholders across mobility, utilities, federal, state and private industry on infrastructure investments needed to keep pace with change.*
>
> **Graeme Cooper**
> Global Vice President, Energy Transition, Jacobs

To capture the approaches to electrification, Jacobs talked with industries across the airport ecosystem and asked them about current and future power needs related to electrification of their specific industries. Data collected were used to develop scenarios and model peak power demand through 2050.

1 Near-Term Infrastructure Deployment (ICCT)

Executive Summary

Airports are major economic drivers, contributing to more than seven percent of the United States' (U.S.) gross domestic product in 2023.[2] Airports and related services are also rapidly electrifying. The growth in electricity demand – and the time required to build power[3] infrastructure to deliver it – means there is significant work to be done now to prepare for the future.

Electrifying Airport Ecosystems aims to raise awareness of the significant power infrastructure investments needed to support electrification in airport ecosystems nationwide.

No one entity can address this challenge alone, and collaboration among airports, industry, technology providers, utilities and regulators will be critical to achieving successful outcomes.

- Timely and strategic electric infrastructure investments are key to support industries that operate in and around airports to avoid disruptions and associated obstacles to economic growth and innovation
- It will require a collective effort to implement essential upgrades to power infrastructure that serves airport ecosystems in a timely and efficient manner
- Planning must begin now to meet increasing electric demands by 2030

No-regrets Investment

This study recommends a near-term focus on no-regrets investments. No-regrets investments refer to decisions and financial commitments that are aligned with long-term needs or strategies which are beneficial under a range of possible future scenarios. They are advantageous because they offer low-risk, high-reward solutions and allow for flexibility during times of change.

Embracing a no-regrets investment strategy can accelerate traditional development timelines and ensure the electric infrastructure is in place when it is needed. A primary goal of this study is to foster collaboration and partnerships among airports, industry, technology providers, utilities and regulators. *Electrifying Airport Ecosystems* aims to catalyze airport ecosystem stakeholders across the country to perform necessary power needs assessments and to boost understanding that airport ecosystems are "no-regrets" locations for proactive power infrastructure investment.

REGIONAL CASE STUDY, NATIONAL IMPLICATIONS

MSP and DEN international airports were used as examples in this study because of their leading work to assess power demands and their co-location within Xcel Energy's service territory.

The airports provided data ranging from historical energy use to expansion and electrification plans.

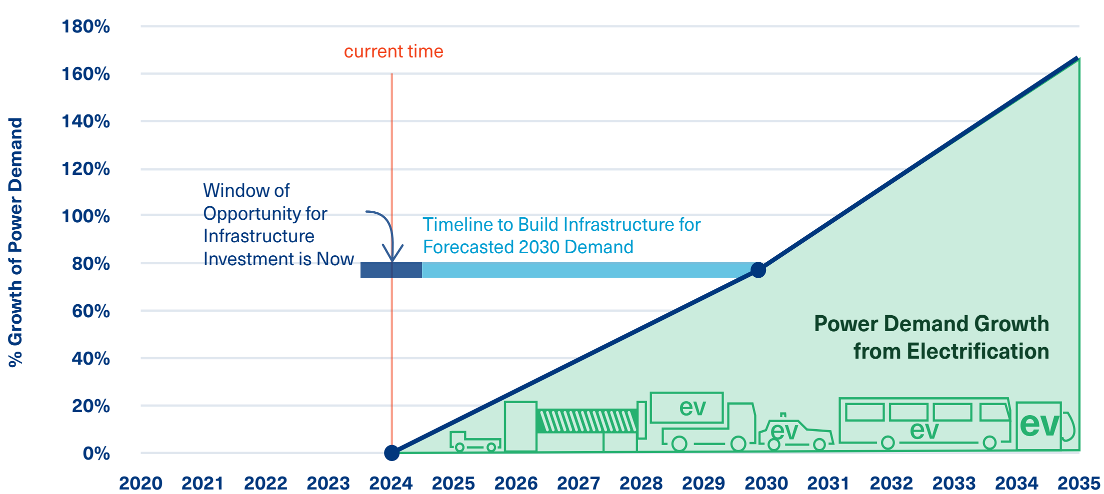
Their leadership has provided a comprehensive view of cross-industry power needs.

Input from more than 50 stakeholders helped create a picture of future power needs.

To achieve the energy transition and decarbonization of transport, detailed power planning is needed at every major airport.

It will take the momentum of a coalition planning and investing to enable, rather than constrain, sustainable electrification.

Invest Now for 2030 Power Needs



2 Airports Council International North America Infrastructure Needs Report
3 In this study, "power" exclusively denotes electric power.

Example Airports

About Denver International Airport

DEN is in the midst of extraordinary growth, guided by its “Vision 100” program to expand DEN facilities to accommodate 100 million passengers before the end of the decade. In the past 2 years, DEN has added 39 new passenger gates to what was already the third busiest airport in the world, with 69.3 million passengers in 2022. By defining “Sustainability and Resiliency” as one of four guiding principles within its Vision 100 Strategic Plan, DEN has developed a framework to consider the impact of all business decisions in a sustainability context and to demonstrate these values to the communities it serves.

In preparation for this growth, DEN has made a commitment to ensure that the airport’s growth is powered by energy that is low-carbon, cost-effective, reliable and resilient. DEN recognizes that in order to support the City of Denver’s 2030 Science-Based Target and 2040 net zero goal, significant infrastructure investments will be necessary to enable the electrification of facilities, vehicles and other equipment, and the airport appreciates the partnership with Xcel Energy and other DEN business partners for their proactive work to prepare for this transition in the unique airport context.

About Minneapolis-Saint Paul International Airport and the Metropolitan Airports Commission

Based on Airport Council International’s 2022 North American Airport Traffic Summary, the MSP ranked as the 19th-largest airport in North America in terms of total passenger volume, with more than 31 million passengers in 2022. MSP is home to a large Delta Air Lines hub, and it is also the headquarters of ultra low-cost carrier Sun Country Airlines. In addition to passenger air service, MSP also accommodates operations for air cargo, a U.S. Air Force Reserve Command Unit and a Minnesota Air National Guard Unit.

MSP is owned and operated by the Metropolitan Airports Commission (MAC), which also owns and operates six reliever airports. Together, these seven airports comprise one of the largest airport systems in the nation. The MAC is governed by a board of 15 commissioners, who report to the Minnesota Legislature.

The MAC’s purpose is to provide exceptional airport experiences so Minnesota thrives. The MAC’s airports connect the region to the world and showcase Minnesota’s extraordinary culture to millions of passengers from around the globe who arrive or depart through its seven airports each year. Though a public corporation of the state of Minnesota, the organization is not funded by income or property taxes. Instead, the MAC’s operations are funded by rents and fees generated by users of its airports.

The MAC has a long history of and commitment to sustainability. In February 2020, the MAC formally adopted a comprehensive set of sustainability goals to reach by 2030:

- Reduce MSP total emissions by 80% from a 2014-15 baseline
- Reduce MSP water use per passenger by 15% from a 2015 baseline
- Divert 75% of material from our waste stream either by consuming less or reusing, recycling or composting what is used
- Increase MAC employee engagement with and understanding of sustainability as measured through regular surveys and achieve a score of 85 from a baseline score of 52

In November 2022, the MAC board approved the 2023-2027 Enterprise Strategic Plan.[4] Sustainability is a prominent element of the strategic plan and demonstrates the MAC’s commitment to a sustainable future. One of the plan’s five focus areas is to “actively manage sustainability and stakeholder and community relations.”

4 2023-2027 Enterprise Strategic Plan

Highlighting the Challenge

As the U.S. undergoes a monumental energy transition, the electric grid will need to keep pace.[5] Shifting to cleaner electric energy sources while electrifying transportation is an opportunity to upgrade our nation's electric grid and avoid negative impacts to the market.

Industries aiming to electrify their facilities, operations and fleets highlight a growing need for power[6] that will exceed existing system capacity and could outpace the speed of infrastructure expansion. The window of opportunity to build efficient infrastructure necessary for early electrification targets is narrowing and the operations of industries across the country are at risk unless collective action is taken now.

Ease of mobility and connectivity are critical markers in a mature, progressive economy and key aspects of modern life. Transportation fleets are converting to electric vehicles concurrently with building systems being replaced with lower-emission fuels, adding power demands to infrastructure at rates not previously seen in history.[7] Electric utilities, tasked with building and maintaining new power infrastructure to support electrification, have historically responded to customers with load request-based investment in mature and stable markets. However, rapid electrification across industries calls for an evolving response to accelerating needs, with new power demands now capable of outpacing the speed at which new infrastructure can be built. To ensure new infrastructure arrives with new power demand, innovative ways of planning infrastructure are required.

Shared Understanding Catalyzes Shared Action

The purpose of this study is to foster a shared understanding of the scale of power demands within airport ecosystems to catalyze shared action. Shared understanding helps ensure infrastructure lead times are considered, preserving all viable options and enabling the pursuit of optimal solutions throughout the trajectory of electrification. Understanding the scale of power demands also reveals the opportunity for no-regrets investments now that can be aligned with long-term needs and will be beneficial under a range of possible future scenarios, even during times of uncertainty.

However, to achieve no-regrets infrastructure investment, utilities, airports, industry, utility commissions and policy leaders must take shared action now. Collectively, these actions can contribute to a future where power access becomes the enabler for electrification, rather than a barrier.

Enabling "no-regrets" power investments requires a shared understanding that:

- Electrification will drive dramatic increases in power demand across the airport ecosystem as demonstrated by the results of this study
- Large-scale power infrastructure takes a long time to build[8]
- Large-scale power infrastructure has a long useful life (30+ years)[9]
- Visibility into long-term power needs enables the cost-effective "future-proofing" of solutions pursued today
- No one entity can "fix" this alone

While there is wide recognition that all airports are unique, the challenges of power demands they face can be similar. The *Electrifying Airport Ecosystems* study aims to encourage sharing of best practices, knowledge and resources among airports, industry, technology providers, utilities and regulatory governmental bodies to enable shared action. This collaborative approach can help enable a smooth and coordinated transition toward meeting electrification necessary to achieve industry objectives and city, state and federal greenhouse gas (GHG) reduction targets.

> *The purpose of this report has always been a call to action. We have a large job ahead of us to electrify at the pace needed to support the sustainability goals of DEN, Xcel Energy and the rental car industry. It is important that we work proactively to identify our future electric demand, because the benefits will be significant and we don't have time to waste.*
>
> **Scott Morrissey**
> Senior Vice President, Sustainability,
> Denver International Airport

Airport Ecosystems

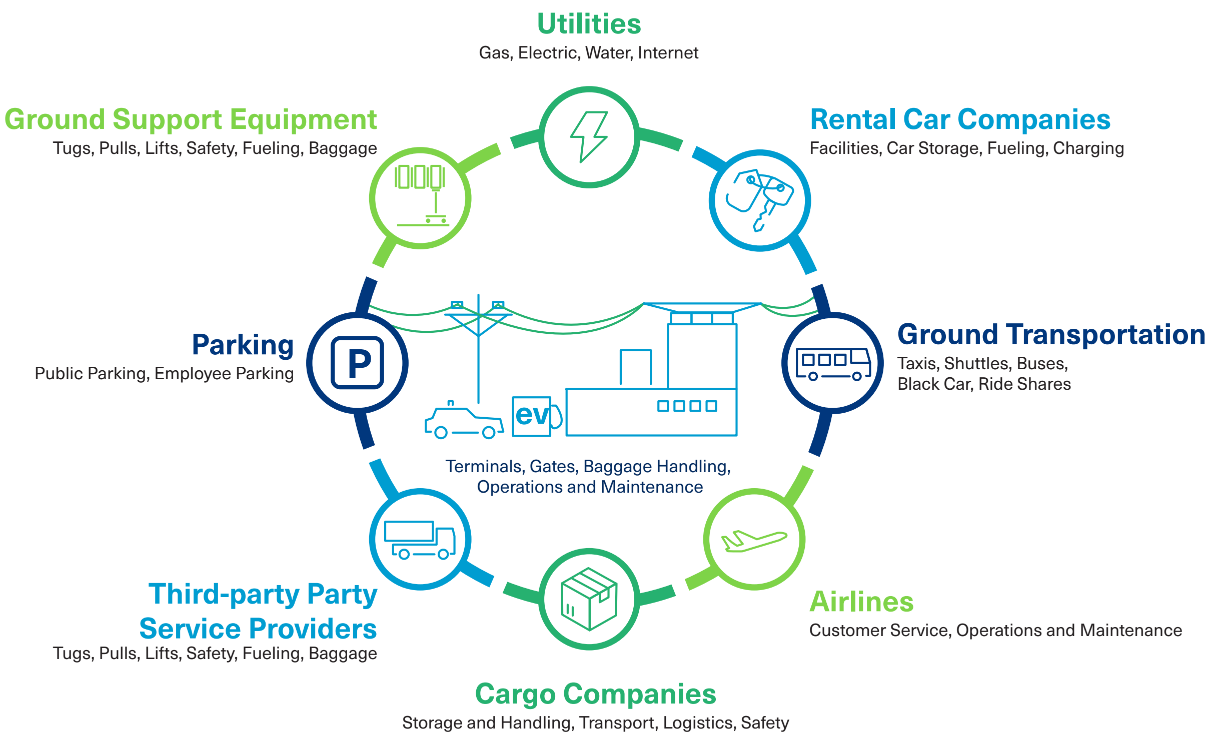
Airports and their associated ecosystems are critical transportation nodes that highlight the challenge of meeting electric power demands. The two case study airports in *Electrifying Airport Ecosystems*, DEN and MSP, are representative of the broader airport industry as they anticipate future electrification and power demands.

"Airport ecosystems" include all industries that operate and draw power on airport campuses including airlines, rental car companies, ground support equipment (GSE), cargo companies, ground transportation, ride share companies and third-party contractors. Due to the breadth and interconnectedness of industries and businesses within

5 Electricity Grids and Secure Energy Transitions – Analysis - IEA
6 In this study, "power" exclusively denotes electric power.
7 Pace of Progress — Rewiring America
8 EPRI's EVs2Scale
9 Electricity Grids and Secure Energy Transitions – Analysis - IEA

airport ecosystems, *Electrifying Airport Ecosystems* is a stakeholder-informed assessment, propelled by data from more than 50 companies to quantify power demands at two example airports that are facing challenges similar to airports nationwide. By leveraging the strength of stakeholder inputs, this report provides a unique perspective into the scale and magnitude of power demands at airport ecosystems over time to support commerce, mobility and business operations.

Airport Ecosystem Stakeholders



Driving the Economy

Airport ecosystems are significant regional economic drivers, and many businesses across industries rely on a vibrant airport economy to thrive. Airports Council International's (ACI) latest study finds that the commercial airports in the U.S. have a collective annual economic output of $1.7 trillion. That equates to more than 7% of the U.S. gross domestic product.[10] Airports support a total of 11.5 million jobs and create a total payroll of $525 billion. For the example airports in *Electrifying Airport Ecosystems*, DEN is the state of Colorado's primary economic engine and generates more than $36 billion in annual economic impact.[11] Similarly, MSP generates $15.9 billion in business revenue.[12] Both airports are regional transportation and cargo hubs and support tens of thousands of jobs.

Airport ecosystems that collaborate to make needed infrastructure investments now will have planning advantages over those that do not and avoid potential limits on their economic impact.

Economic Impact

Economic Impact	Denver International Airport	Minneapolis – Saint Paul International Airport
Number of Gates	179	131
Total Land Areas (sq. mi.)	53	4.6
Annual Economic Impact to State	$36.4B	$15.9B
Jobs Supported	220,000	86,900
Annual Numbers of Originating and Destination Passengers	49M	24.5M
Annual Cargo (lbs.)	72M	521M

10 Airports Council International North America Infrastructure Needs Report
11 Regional Benefits | Denver International Airport (flydenver.com)
12 Minneapolis-St. Paul International Airport, the Economic Impact of Operations 2016

Advantages to Electrification

Energy efficiency increases cost savings and lowers energy consumption

Reduces volatility in supply chains and pricing of fossil fuels dependence

Lower operation costs with fewer moving parts

Reduced GHG emissions and improved air quality

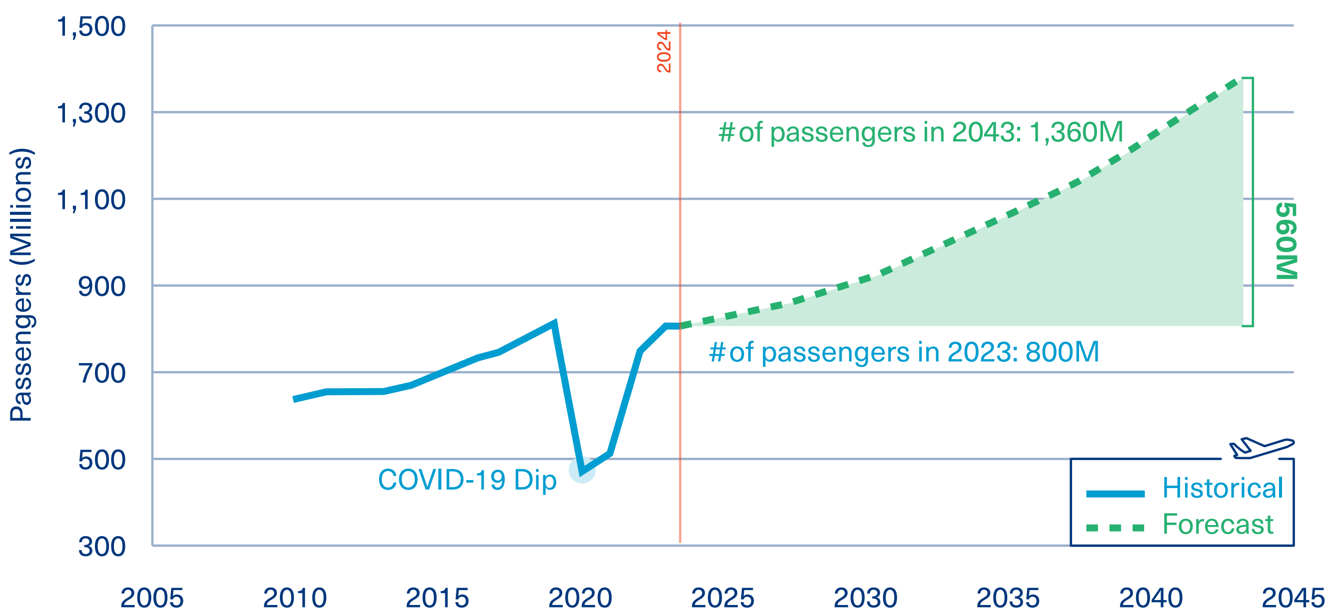
Promotes innovations in technologies

Supports customer demands and global trends

Aligns with city, state and federal targets

Airports will continue to be economic growth engines as air travel is expected to grow significantly during the next two decades. The FAA (Federal Aviation Association) Aerospace Forecast Report (2023-2043) expects to add 560 million passengers to reach nearly 1.4 billion enplanements at U.S. airports during the next 20 years.[13]

U.S. Commercial Carrier Domestic Passenger Traffic



Electrification to support this anticipated passenger growth will require new investments in power infrastructure in and around airport facilities.

13 FAA Forecasts

Sustainability Goals Are a Catalyst for Change

Both DEN and MSP have aggressive GHG emissions goals that align with their cities and states. The City and County of Denver plans to reduce GHG emissions 80% by 2050, further electrify its transportation system to reduce the impact of cars on climate change, and transition the city to 100% renewable electricity by 2030 including all city government buildings and facilities by 2025. The city of Minneapolis has a Race to Zero campaign that includes reaching net-zero GHG emissions by 2050. This plan updates an earlier goal and includes reducing GHG emissions by 80% by 2030.

MSP has its own sustainability goals that include reducing GHG emissions by 80% compared to a 2014 baseline by 2030.[14] The MAC voluntarily publishes a Greenhouse Gas Emissions Report, which reports the GHG emissions footprint for MSP as a whole. MAC-owned and -controlled sources contribute 12% to the total MSP carbon footprint.[15] Further, the state of Minnesota has GHG emissions reductions goals.[16]

> **The FAA Is on Board**
> The FAA has established an Airport Climate Challenge with a net-zero emissions goal for U.S. airports by the year 2050.[17]

The Scale and Pace Needed for Building Infrastructure Is No Simple Task

The transportation and energy sectors are deeply linked, and enabling future growth requires that airport ecosystems prepare by proactively planning for power demands including infrastructure lead-times.

A recent study by the electric utility National Grid and Hitachi Energy assessed the timeframes for grid infrastructure to meet electrification needs and found the lead times for distribution were from one to four years and the lead times for substations and transmission were from four to eight years.[18]

Public utility commissions (PUCs) and state legislatures play a critical role in overseeing and regulating utility services. PUCs review and approve rates that utilities can charge, establish and enforce standards and review and approve capital investment plans submitted by utilities. State legislatures create the legal and regulatory frameworks within which utility companies operate, shape utility policies, allocate budgets and provide oversight of the PUC.

PUCs have historically been asked to approve utility investments based on forecasts made in a relatively steady state market. While infrastructure planning models can now be done on a more granular level, if the nation waits for "perfect" forecasts for capital investment, it will be too late to build infrastructure that meets power demands. Due to the scale and pace of change in the energy transition, the utility industry must move toward "no-regrets" investment to meet growing needs.

In addition to the long lead times that accompany the processes of infrastructure planning, design, procurement and construction, permitting can take multiple years because airports and the electric grids that power them are under the jurisdiction of multiple state and local entities and/or utility commissions.[19] Individually, industries that make up an airport ecosystem are likely to make isolated changes based on each company's needs and time frames.

Securing investments needed to support electrification at airports and other transportation hubs will require innovative strategies and collaboration among federal, state and municipal entities, as well as the utilities, airports, public and businesses they serve.

Addressing the challenge of insufficient infrastructure begins with three things:

1. Assess the future electric power demand growth of airport ecosystem industries to understand short-, medium- and long-term infrastructure needs
2. Evaluate the infrastructure investments needed and the timelines necessary to enable the development of efficient and scalable infrastructure
3. Promote open communication, partnerships and trust among stakeholders across industries

City and State Emissions Targets

2005
Baseline
Minnesota
Colorado

2006
Baseline
Minneapolis

2019
Baseline
Denver

2030
Colorado
- GHG Emissions Reduction Roadmap Is to Be 50% Below 2005 Levels
- EVs Accounting for 70% of New Light Duty Vehicle Sales

Denver
- 100% Renewable Energy

2040
Minnesota
- 55% Renewable Electricity
- 100% Carbon-free Electricity

Denver
- Elimination of 100% of GHG Emissions

2050
Colorado
- 100% Renewable Electricity
- GHG Emissions Reduction Roadmap Is to Be 100% below 2005 Levels
- 100% Light Duty Electric Vehicles

Minnesota
- GHG Emissions Reduction Roadmap Is to Be 80% below 2005 Level
- 80% Reduction In Transportation Emissions

Minneapolis
- Net-zero GHG Emissions by 2050

14 Sustainability Goals - Explainer (metroairports.org)
15 Environmental Sustainability | MSP Airport
16 See Appendix A: Additional Details on the Analysis p.23
17 FAA Airport Climate Challenge
18 The Road to Transportation Decarbonization: Readying the Grid for Electric Fleets
19 EPRI's EVs2Scale

Case Study Methodology

Electrifying Airport Ecosystems is an analysis of the electrification plans and efforts to forecast airport ecosystem power needs using DEN and MSP airports as example locations, plus data from more than 50 companies. The following list was not in the study's scope and was omitted from the analysis:

- Electrification of aircraft
- Electric vertical take-off and landing (eVTOL)
- Current and future power demands associated with the greater DEN-owned land mass
- Current and future power demands associated with the MAC's six reliever airports
- Airport or industry electrification or expansion plans announced after the data collection period (summer of 2023)

This study is a snapshot in time. Airports are dynamic hubs, and their plans change frequently based on the needs of the customers they serve.

Electrifying Airport Ecosystems did not evaluate solutions for increased power generation or mitigation measures. Rather, it is meant to recognize the magnitude of electric power demands that result from electrification and the timelines to build infrastructure essential for continued economic growth and mobility at airports. Additional details on the methodology may be found in the Appendices.

> Power demand for aviation fuel transition and the potential of future electric vertical take-off and landing (eVTOL) operations were not included, suggesting that the power demands identified are conservative.

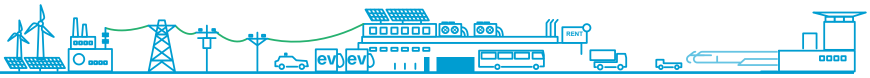
Stakeholder Approach and Data Gathering

Stakeholder Engagement

Jacobs approached industries across the airport ecosystem and asked them about current and future power needs related to electrification of their specific industries. The engagement revealed that city and state governments, airport authorities and private businesses approach electrification with their own goals – from a handful of companies with "wait and see" tactics to very aggressive and proactive targets to reduce emissions and electrify assets. Many stakeholders in this study are in highly competitive industries, which made Jacobs' role as a confidential third-party data collector and aggregator critical. Any individual company's participation has been kept strictly confidential and their data sufficiently aggregated by Jacobs to maintain anonymity from all other entities, including *Electrifying Airport Ecosystems* sponsors. Jacobs engaged with stakeholders representing the following entities: airport authorities, rental car companies, airlines, cargo companies, ground transportation companies, transportation network companies and third-party service providers to acquire the data for the analysis presented in this report.

Data Collection

Jacobs obtained historic gas and electric utility data, airport current state information (footprint, heating, ventilation and air conditioning, EV chargers, parking, operations and maintenance, facilities, etc.), future airport plans (capital expansion, energy, sustainability), industry current state (resources, fleets, footprint, operations) and industry future energy plans and sustainability targets and state and city air quality and emissions target data. For passenger growth projections at both airports, Jacobs obtained FAA data from December 2022. While Jacobs aimed to acquire data from a wide range of stakeholders at both DEN and MSP airports, this study did not capture the electrification plans from all airport stakeholders, and therefore, the numbers are likely underestimated.



Electrifying Airport Ecosystems Scenarios

Current Power Demand

This study began with an assessment of the current gas and electric power demand based on historical monthly consumption data for DEN and MSP. This data was used as the current baseline to develop the forecasts of power demands in 2030, 2040 and 2050 for two scenarios using FAA data for passenger growth projections.

Industry Scenario

The industry scenario envisions the power demands based on each entity's stated future plans reflected in the data provided by the 50+ companies and the airports themselves. Examples of stated plans include MSP's announcement that the airport will be replacing the existing heating and cooling equipment within the Central Plant by 2030 and DEN's announcement of contracting with energy efficiency providers to reduce terminal/concourse energy use by 20% in the near future.[20, 21]

Policy Scenario

The policy scenario envisions a more aggressive pathway to electrification to meet city and state decarbonization targets – implying that the forecasted power demands for both airports are considerably higher and will be felt sooner than those envisioned in the industry scenario. The higher power demand is attributable to two factors – a higher level of EV adoption (that is, increased numbers of internal combustion engine cars, trucks, GSE and buses are replaced by battery-electric counterparts) and more powerful charging infrastructure that allows for automotive/heavy equipment batteries to charge faster.

Emissions Reduction

Sustainability objectives were identified as a significant driver for electrification plans within airport ecosystems, and *Electrifying Airport Ecosystems* conducted a targeted analysis of carbon dioxide (CO_2) and nitrogen oxides (NO_x) emission reductions that could be achieved from the studied buildings and transportation electrification. This analysis is not intended to be comprehensive but provides perspective into the sustainability benefits that could be realized. The emissions data was sourced from Public Service Company of Colorado's electric resource plan and Xcel Energy's 2020-2032 integrated resource plan.[22, 23] The emission reductions were calculated based upon the substitution of electricity for gasoline/diesel in transportation and electricity for natural gas in space and water heating as well as cooling for the two scenarios across airport ecosystems.

20 Metropolitan Airports Commission Terminal 1 EMC Boiler and Chiller Study (Kimley Horn, 2023)
21 Denver International Airport's 2021 Annual Environmental Report
22 PUBLIC SERVICE COMPANY OF COLORADO Our Energy Future: Destination 2030 2021 Electric Resource Plan and Clean Energy Plan, 120-Day Report, Public Version, Proceeding No. 21A-0141E
23 Xcel's Approved 2020-2034 Integrated Resource Plan

Electrifying Airport Ecosystems Results

The industry and policy scenarios were developed as they represent approximate low and high bookends for the pace of electrification. However, the study found that regardless of scenario, in a decarbonized world, power demand is anticipated to grow to levels dramatically higher than experienced at these two airports today.

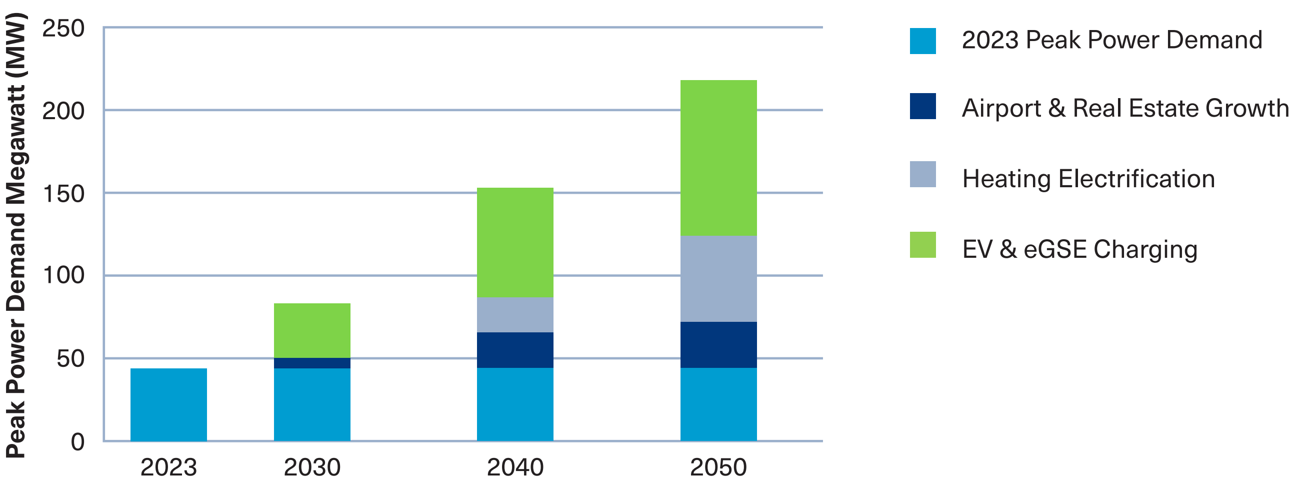
Numbers presented in this section without citation are derived from Jacobs' analysis. Results are from aggregated data from all stakeholders involved.

Electrifying Airport Ecosystems found that by 2030, under the industry scenario, the power demands at both airports will nearly double their current levels. By 2040, the power demand continues to grow aggressively to more than 3.4 times current levels.[24] In 2050, DEN will require 4.9 times more power demand, and MSP will require 4.3 times more power demand than current levels. This power demand grows even larger to 5 times and 4.6 times respectively to meet city and state sustainability goals under the policy scenario.

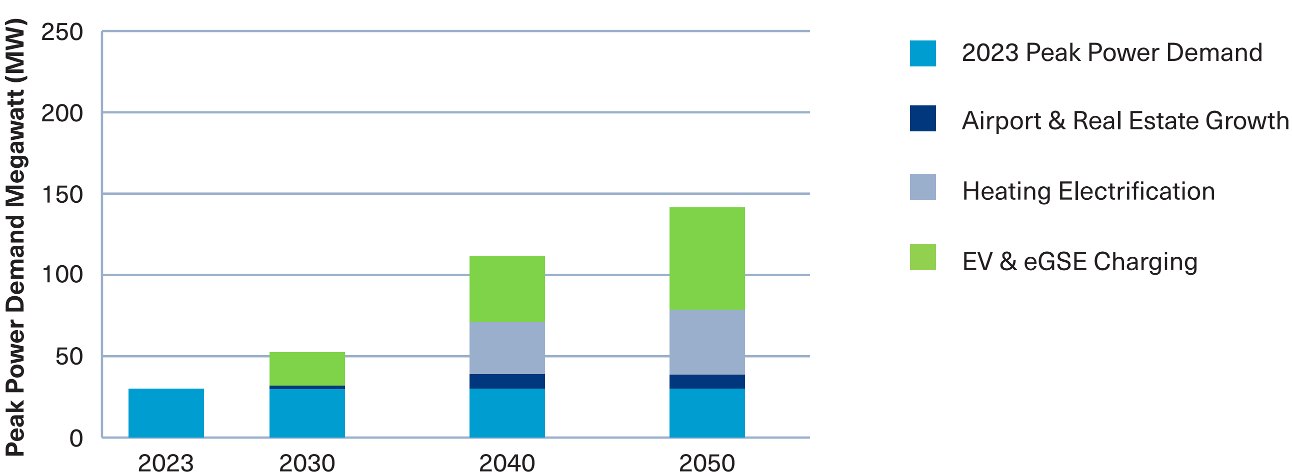
The near-term growth in power demand from now through 2030 at both airports is primarily driven by EV charging due to electrification loads from rental vehicles, passenger and employee parking and GSE as shown on the following graphs.

Air quality improvements and GHG emission reductions were found to be significant with the near-complete electrification of operations at both airports. This is due to reduction of natural gas operations as well as the overhaul of the electric utilities' power generation fleets to meet both internal utility as well as city, state and airport emissions reductions targets.

DEN Peak Power Demand Forecast by Category (Industry Case)



MSP Peak Power Demand Forecast by Category (Industry Case)



24 In this study, forecasted growth in power demands refers to growth in peak electric power demands.

DEN Case Study

DEN was selected as one of the case study airports because of the leading work it has already initiated to assess the power demands of their ecosystem. DEN has also undertaken a suite of energy conservation upgrades including improvements to heating and cooling systems, installation of solar arrays and light-emitting diode (LED) and streamlined energy management controls.

DEN is working closely with Xcel Energy to forecast the growth of its own power demand and industry needs within their ecosystem, as well as future planned growth for the greater land area owned by the airport. DEN's close relationship with Xcel Energy has been critical in assisting both entities move toward shared goals.

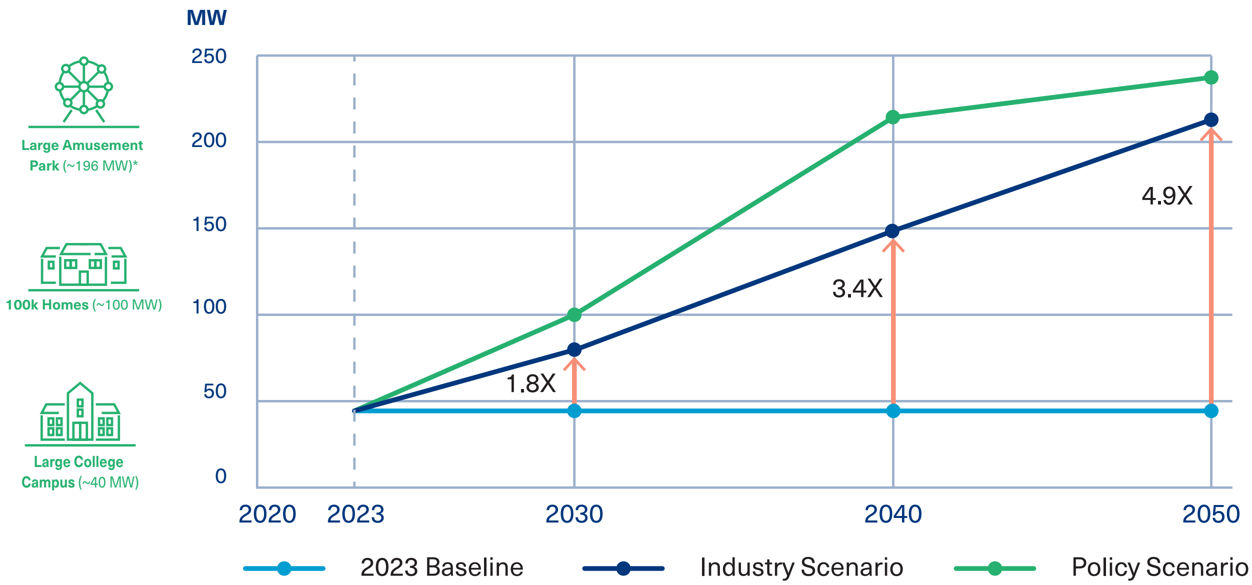
DEN's current power demand is 44 MW, which serves as the baseline for *Electrifying Airport Ecosystems.*

DEN Industry Scenario

Within both the industry and policy scenarios, EV charging and electrification of airline GSE are the electrification elements that are projected to grow the most rapidly between now and 2030, rising from a negligible level currently to 33 MW by 2030 and ultimately to 94 MW by 2050.

Some firms in the rental car industry have announced aggressive electrification targets and have already begun converting their fleets from internal combustion engine technology to electric; hence, rental cars are driving significant demand for electric vehicle chargers. In addition, airlines are already converting GSE from fossil fuels to electric power, and this trend is expected to continue.

DEN Power Demand Forecast



*Amusement park load is based on Disney World®.
https://www.oversightdistrict.org/doing-business/utilities/systems-services/

> *GSE can be particularly well-suited for electrification because it benefits from low-end torque and has frequent start/stops, idle time and short required ranges.*[25]
>
> U.S. Department of Energy Study on eGSE

By 2040, *Electrifying Airport Ecosystems* projects that the bulk of tugs, trucks, cargo and baggage handling equipment, and more, will all be electrified. By 2050 vehicle charging needs will account for ~44% of the increase in DEN's power demand.

In the industry scenario, expansion of existing facilities (for example, construction of new airport gates and terminals, hotels and other supportive infrastructure) to meet growing passenger and cargo traffic will add nearly 29 MW of power demand to DEN by 2050 apart from power demands resulting from electrification. However, this impact is small in comparison to the forecast power demands associated with electrification of space heating, a critical step in allowing DEN to meet its decarbonization targets. Projected to begin in the late 2030s, two features are projected to add 51 MW to DEN's power demand by 2050: (1) the installation of heat-pumps in cargo-handling facilities and other airport buildings, and (2) a geothermal system modeled to provide heating for the main terminals and passenger areas.

The industry and policy scenarios are illustrated in the DEN Power Demand Forecast chart above, with examples of current day equivalents.

DEN Policy Scenario

Under the policy scenario, power demand at DEN becomes almost five times its current level by 2050, reaching more than 235 MW. Two key drivers are responsible for the significant increase in power demand under this scenario. First, the conversion from gas to electric heating starts earlier and the majority of the terminal and other buildings space is modeled to be heated using a combination of air-source and geothermal heat pumps by 2040. Second, the cumulative EV charging impact is higher – 116 MW by 2050 as opposed to 94 MW due to predicted higher EV charging needs for airport employees and the public.

DEN Emissions Reductions

By 2050, electrification will reduce emissions by more than 100,000 tons of CO_2 and more than 100 tons of NO_x from 2023 baseline levels.

Forecast of Annual CO_2 and NO_x Emissions from Utility-delivered Gas and Electricity (DEN Industry Scenario)

	2023	2030	2040	2050
CO_2 (short tons)	128K	59K	33K	0
NOx (short tons)	63	25	16	2

25 Department of Energy Study on eGSE

MSP Case Study

MSP was selected as one of the case study airports because of the leading work it has already undertaken to assess the power demands of its ecosystems.[26] MSP has been working closely with Xcel Energy to forecast the growth of its own power demands, as well as future planned growth for the greater land area owned by the airport. MSP's close relationship with Xcel Energy has been critical in assisting both entities move toward their shared goals.

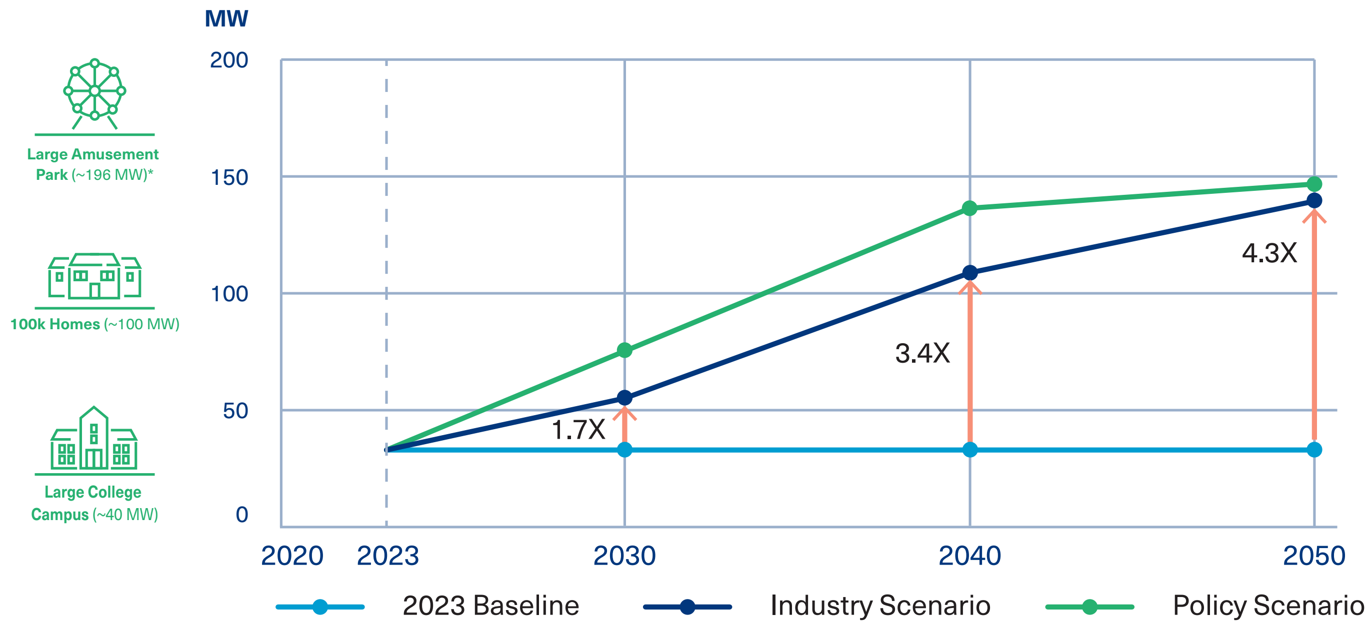
MSP has undertaken significant energy conservation and sustainability investments to date including installation of a 3 MW rooftop solar array, deployment of thousands of LED lights and implementation of energy management programs.

MSP has plans to electrify major components of its heating and cooling systems upon replacement prior to 2030. There has also been extensive planning surrounding the rapid integration of EVs for MSP tenants and MAC-owned fleet vehicles. To successfully implement these plans, MSP will depend upon electrical providers to deliver reliable and affordable electricity.

Currently, MSP's peak power demand is 32 MW, which serves as the MSP baseline.

26 The MAC's six reliever airports were excluded from this study.

MSP Power Demand Forecast



*Amusement park load is based on Disney World®.
https://www.oversightdistrict.org/doing-business/utilities/systems-services/

MSP Industry Scenario

In the industry scenario, growth in power demand at MSP in 2030 is driven by electrification of vehicle fleets, primarily rental car fleets and GSEs, based on aggregated data from stakeholders. EV charging (including charging for GSE) is projected to grow rapidly to nearly 65 MW by 2050, accounting for nearly half of the increase in the airport's power demand by that time. With new power demand due to the building of new spaces and expansion of facilities adding a little over 9 MW by 2050, the electrification of space heating is the second largest driver to new power demand at MSP. MSP is projected to initiate the conversion away from natural gas by around 2030, and it is forecasted to add more than 41 MW to airport power demand by 2050 – accounting for 30% of the increased power demand.

The industry and policy scenarios are illustrated in the MSP Power Demand Forecast chart above, with examples of current day equivalents.

MSP Policy Scenario

MSP's forecasted power demand under the policy scenario is slightly higher than the forecast under the industry scenario due to faster conversion of heating from natural gas to electric and increased non-rental car company (non-RAC) EV charging penetration at the airport. In this scenario, MSP's power demand in 2050 reaches close to 144 MW, about 4.6 times the current level of 32 MW.

MSP Emissions Reductions

By 2050, electrification at MSP will reduce emissions by 76,000 tons of CO_2 and 63 tons of NO_x from 2023 baseline levels.

Forecast of Annual CO_2 and NO_x Emissions from Utility-delivered Gas and Electricity (MSP Industry Scenario)

	2023	2030	2040	2050
CO_2 (short tons)	76K	31K	12K	0
NO_x (short tons)	49	15	4	0

Common Findings

While this case study is among the most comprehensive stakeholder-informed assessments of airport power demands conducted to date, its objective is to provide shared perspective, not precision, among utilities, airports and wider industry stakeholders.

Although DEN and MSP are unique airports, the results of the study demonstrate similar future peak power demand under both scenarios.

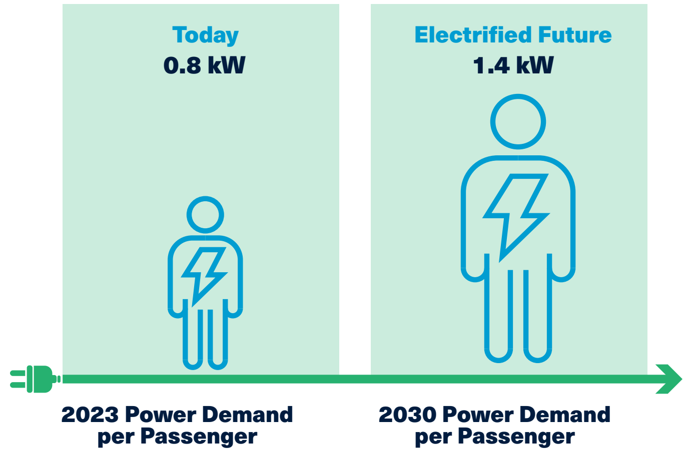
- For the industry scenario, accounting for current electrification plans, airports and industries will require a peak electric power demand that is 4.9 times at DEN and 4.3 times for MSP in the next 25 years
- For the policy scenario, to achieve airport, city and state sustainability goals, this power demand grows even larger to 5 times at DEN and 4.6 times at MSP in the next 25 years
- For both locations, the power demand forecast under the policy and industry scenarios are relatively close

The analysis surfaced the following common findings that are likely to hold true for airports across the country:

- Airports and the industries that operate in and around airports are projected to require almost double their industry scenario power demand by 2030 with the majority of the increase being attributed to EV and eGSE charging activity.
- Per passenger electric power demands increase from a 2023 baseline at both airports of 0.8 kW per passenger on average to 1.4 kilowatt (kW) by 2030 and 1.92 kW by 2050.
- The dramatic power demand increases projected at both airports are driven predominantly by:
  - Charging of vehicle batteries as mobility moves away from internal combustion engines – this will include rental cars, passenger and employee vehicles, GSE and vehicles, transit and cargo vehicles, etc
  - Expansion of airport facilities and operations driven by anticipated growth including new terminals, concourses and on-airport hotels, etc
  - Elimination of natural gas as the fuel for space heating as air-source heat pumps and geothermal installations replace gas-burning furnaces and boilers

Despite the significant increase in power demand at the airports their overall energy intensity on a per-passenger basis is anticipated to decline. In 2023 the combined electric and natural gas per-passenger energy intensity was calculated as 0.018 Metric Million British Thermal Unit (MMBTu) for DEN and 0.034 MMBTu for MSP, decreasing to 0.016 MMBTu at DEN and 0.021 MMBTu at MSP in 2050. [27]

Average per Passenger Power Demand in 2023 and 2030

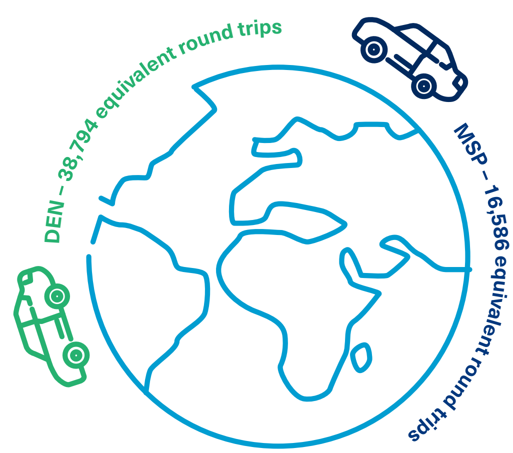


Emissions Reduction Benefits

The GHG emission and air quality improvements achieved by the airports through electrification is twofold. The electricity consumed becomes less emissions-intensive with low-carbon power generation. Additionally, the significant penetration of EVs at airports leads to the replacement of millions of miles of travel in internal combustion vehicles.

> The results of this study show that the enablement of electrification at key transportation nodes such as airports will be critical to meet city- and state-level targets for reducing GHG emissions.

The Emission Reduction Equivalent to Encircling the Globe by Car



In 2050 the CO_2 emissions reductions at **DEN** and **MSP** are forecasted to be equivalent to driving an internal combustion engine vehicle thousands of times around the earth.

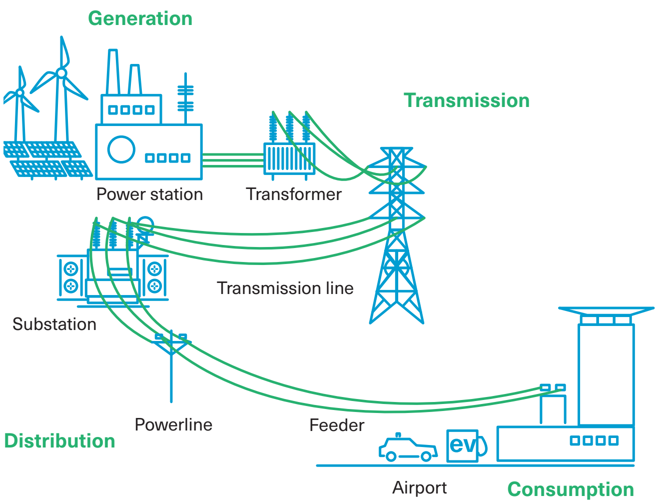
27 The energy intensity was calculated as the total electricity (converted to a common unit of 1.0 MMBTu) plus the total gas usage divided by the number of passengers. See appendices for additional details.

Insights – Call for National Awareness

Powering the Future Must Begin Today

Electrifying Airport Ecosystems aims to forecast electric power demands now through 2050, which presents an inherent level of uncertainty that exists in any long-term forecasting exercise. However, as the results show, even conservative estimates of power demands to meet industry needs by 2030 are significant enough to require large-scale power infrastructure, even when excluding the needs of electric aircraft and eVTOL. Power infrastructure of the scale needed by 2030 is complex and requires years of planning, permitting and construction to reach operational status.

Grid Infrastructure



Timeframes for Infrastructure Development

The *Airport Ecosystem Study* identified power demands that may require new or upgraded transmission lines, feeder lines and substations. As the data shows[28], the window of opportunity for planning the required infrastructure is now. Absent sufficient action to build power infrastructure of the scale this study has identified, airport ecosystems and the regions they support could face significant operational constraints and economic impacts.

A Shared Responsibility

Reaching the level of precision necessary to advance the infrastructure investments today that are needed for the future will be a responsibility shared by all entities that operate within an airport ecosystem. Many of the stakeholders who participated in *Electrifying Airport Ecosystems* have already begun this critical work to understand their power demands. Both DEN and MSP have robust internal teams proactively working to forecast how electrification changes will determine power demand, and their leadership has enabled this comprehensive view of cross-industry power demands. Their collaboration with Xcel Energy in proactive forecasting to better ensure that all parties understand the magnitude of future power demand is a model to be replicated across airports and utilities across the country.

> *Nationally, much of the work being done so far has been done industry by industry, resulting in a lack of consistent data across industries and across airports. As we've talked with dozens of stakeholders across industries, most have acknowledged the need to work together to move forward.*
>
> **Amy Edwards**
> Senior Stakeholder Manager, Jacobs

There is more work to be done at airports across the country. Both airport operators and electric utilities that serve the airport ecosystems will need support from all industry stakeholders at each airport to determine the comprehensive power demands with sufficient precision. It is only with these airport ecosystem specific power demand forecasts that airports and utilities can effectively undertake the timely and targeted investment plans needed.

The need to construct precise industry-specific power demand forecasts and supply them to electric utilities is exemplified by two current initiatives of which many stakeholders in this report are active members:

- **DOE (Department of Energy) Project Athena ZEV**. Athena ZEV is a collaborative effort funded by the DOE Vehicle Technologies Office and led by the National Renewable Energy Laboratory (NREL) in partnership with Oak Ridge National Laboratory and Dallas-Fort Worth International Airport. Athena ZEV will support development of tools and electrification pathways for U.S. airports with an initial focus on rental car fleets.[29]
- In 2023, the Electric Power Research Institute **(EPRI) launched EVs2Scale2030**, a three-year initiative to ready the electric grid in support of the accelerated development of EV charging infrastructure.[30]

28 Timeframes for transmission infrastructure construction from IEA. Timeframes for substation construction from recent Xcel Energy projects requiring 5-10 years. Timeframes for new feeder from EPRI.
29 Project Athena Source
30 EPRI

No-regrets Investment – A Closer Look

Utilities are the stewards of the large-scale power infrastructure that underpins modern society. Their ability to forecast power demand and construct the required large-scale power infrastructure is core to their mission and expertise.

With the increasing pace of electrification comes a corresponding need for electric utilities to be more proactive with investment in large-scale power infrastructure.[31] Xcel Energy and other leading electric utilities have already recognized this need and begun to propose proactive infrastructure investments to their PUCs, the entities that regulate electric utilities and who must approve all utility investments.[32]

With this understanding, utilities, PUCs and state and federal policy leaders can enable reasonable “no-regrets” action today to mitigate potential risks to travel in the future. Collectively, these actions can contribute to a future where power access becomes an enabler for sustainable electrification within airport ecosystems, rather than a constraint.

As a general matter, utilities traditionally do not propose (nor do regulators generally approve) anticipatory investments absent the utility’s ability to satisfy traditional criteria. Utility infrastructure planning, however, could evolve to provide more rapid response to changing conditions where regulatory structures enable planning based on longer-term and dynamic forecasting.

As demonstrated in a recent study focused on proactive infrastructure investment to enable fleet electrification conducted by the electric utility National Grid and global technology company Hitachi Energy, utilities are seeking to identify “no-regrets” investment locations.

> *The ideal solution in each fleet area may differ and depend on variables that will not always be clear, but utilities should seek to plan for “no-regrets” investments where possible. If large investments, such as a new substation, will be needed to accommodate large-scale adoption, it may be most cost-effective to design early solutions with those future projects in mind.*[33]
>
> **National Grid and Hitachi Energy Study**

Electrifying Airport Ecosystems aims to catalyze stakeholders across the country to perform power demand assessments to show that airport ecosystems are “no-regrets” locations for proactive power infrastructure investment.

Next Steps and a Path Forward

The shared responsibility of upgrades to power infrastructure nationwide requires action from all stakeholders. This section outlines just a few of the steps needed by each stakeholder to start the process at their airports.

Airport Industry Partners

- ☑ Assess electrification plans for the next 10 years, at a minimum, and ideally through 2050
- ☑ Produce estimated power demand profiles by year
- ☑ Engage airports, cross-industry stakeholders and utilities proactively to share data on anticipated power demands and explore solutions
- ☑ Participate in and support initiatives to collect data on industry power demands that enable informed, proactive infrastructure investment such as EPRI’s EVs2Scale and DOE Athena ZEV
- ☑ Collaborate on planning efforts to develop comprehensive, cost-effective solutions
- ☑ Collaborate to evaluate other technologies

Airports

- ☑ Engage all industries within the airport ecosystem to solicit power demand forecasts for the next 10 years, at a minimum, and ideally through 2050
- ☑ Collaborate with electric utilities to share data on anticipated power demands
- ☑ Collaborate with electric utilities to identify infrastructure solutions that can be scaled cost effectively as airport industries electrify
- ☑ Coordinate with utility providers along with state and federal officials to identify funding opportunities to support detailed power demand needs and solution assessments
- ☑ Perform assessments of capacity on existing electric infrastructure within airport property
- ☑ Seek funding opportunities that can support the costs associated with detailed power demand needs and solution assessments
- ☑ Collaborate to evaluate other technologies

31 "Global electricity demand is projected to increase at a rate of 2.7% per year in the [Announced Pledges Scenario], more than doubling from just under 25,000 TWh in 2021 to nearly 54,000 TWh in 2050.” Electricity Grids and Secure Energy Transitions – Analysis - IEA.
32 " See Appendix A: Additional Details on the Analysis," p.23.
33 "The Road to Transportation Decarbonization: Readying the Grid for Electric Fleets," prepared jointly by National Grid and Hitachi Energy.

Utilities

- Proactively coordinate with airport authorities to identify power demands of the airport ecosystem for the next 10 years, at a minimum, and ideally through 2050
- Review existing processes and policies to identify opportunities to invest in proactive, no-regrets grid infrastructure that supports airport ecosystems
- Collaborate with utility commissions and other stakeholders to bring awareness to the cross-industry power demands at airports and the benefits of proactive, no-regrets infrastructure investment
- Participate in and support initiatives to collect data on industry power demands that enable informed proactive, infrastructure investment such as EPRI's EVs2Scale

State and Federal Officials

- Coordinate with airports and utilities to identify funding or create funding opportunities to support detailed power needs and solution assessments
- Support utility commission decisions that enable proactive, no-regrets infrastructure investment at airports through industry-provided, data driven forecasting methodologies

Utility Commissions

- Support utility proposals to invest in no-regrets infrastructure investments now that can be scaled cost effectively as airport industries electrify
- Support utility processes, proposals and policies that enable proactive infrastructure investment at airports through industry provided data-driven, forecasting methodologies

Conclusion

Airports are major economic drivers in the U.S., and meeting the power demands of airport ecosystems is crucial for the economy. Due to projected growth in power demand resulting from electrification and the time required to build power infrastructure, our nation's airports and their electric utility providers must begin to prepare now.

The energy transition is occuring nationwide, and critically, in the transportation sector as mobility shifts from internal combustion engines towards electrification. This is underway within airport ecosystems with rental cars, passenger vehicles, GSE, transit and cargo vehicles. Additional electrification will be driven by space heating and water heating. Meeting the growing power demands of airports and their related services will require collaboration and shared resources among airports, technology providers, utilities and regulators to enable a coordinated transition and to achieve industry electrification objectives and city, state and federal GHG emission reduction targets.

Airports and the industries that operate within the airport ecosystem must understand the scope of the problems that they will face if infrastructure is not upgraded in time for the projected growth in power demand. Enterprise Mobility and Xcel Energy look forward to engaging with the crucial industry, utility and public-sector partners to plan infrastructure and time its arrival with new power demand.

Appendices

Appendix A: Additional Details on the Analysis

Forecast Methodology

This section provides an overview of the methodology used to develop the long-term power demand forecasts for DEN and MSP. Jacobs used the stakeholder data alongside other data sources, leveraging its forecasting expertise to ensure accurate interpretation. Additionally, Jacobs took steps to ensure consistency among data from different sources, recognizing that different stakeholders reported data in distinct ways and with varying levels of detail. Data from the stakeholders were aggregated to ensure the confidentiality of company-specific information.

Baseline Energy Usage

The first step in developing the industry and policy scenarios for both airports was to determine the baseline electricity and natural gas usage. Xcel Energy provides electricity to the two airports and natural gas to the DEN airport. CenterPoint Energy provides natural gas service to MSP. Jacobs coordinated with DEN and MSP to request historic monthly gas and electric data. For MSP, Jacobs received two years of historic monthly electric data and eight years of historic gas data. For DEN, Jacobs received two years of historic monthly gas and electric data.

Stakeholder Engagement

As noted, a unique feature of *Electrifying Airport Ecosystems* is the extensive stakeholder engagement to understand the business growth and electrification needs of industries across the airports. Jacobs first met with each group of stakeholders (rental car companies, cargo, airport operations, etc.) to outline the study and request information. The stakeholder meetings were followed up with sector-specific surveys asking for information about growth projections and associated projections for more electricity. Subject matter experts across industries helped develop the content for the data requests. Respondents provided varying levels of detail with respect to their business operations, forecasted energy demand and electrification.

Stakeholder Targets

Stakeholder targets for emission reductions were used to inform the different pace of electrification. Frequently, the targets were directly provided by the stakeholders participating in *Electrifying Airport Ecosystems*. Jacobs also used public documents from the stakeholder websites to identify specific GHG reduction targets. Depending on the stakeholder, the GHG reduction targets could be more aggressive than the city and state policy mandates. Furthermore, the rate of electrification adoption to achieve any policy-mandated GHG reductions often varied among stakeholders.

Data Acquisition and Sources

The forecast of power demand growth and electric consumption incorporated information from the following sources:

- Primary data regarding projected electrification collected from stakeholders
- Review of historical and current electricity and natural gas consumption
- Review of secondary data sources

Historical electricity use was provided by the two airports in conjunction with Xcel Energy. Natural gas consumption for DEN and MSP was also provided by the airports. The data were reviewed to identify any missing data or any potential meter reading issues. The energy usage data was first analyzed to identify historical relationships between energy use and airport operations (for example, passenger traffic, cargo activity, rental car activity, etc.). While the drivers of these relationships are anticipated to hold true for the forecast period (for example, increasing passenger traffic will require increasing heating and cooling of the airport terminals), exactly how these needs will be met is likely to change (for example, retrofit of spaces to reduce energy loss, shifting of cooling loads). In addition, consistent with the scope of *Electrifying Airport Ecosystems*, there is an anticipated evolution associated with electrification, so past trends are not likely to be a good predictor of long-term electricity needs.

Besides the extensive reliance on stakeholder-provided data, Jacobs incorporated other data sources to inform the long-term projections. These data sources included:

- Airport-specific passenger growth projections developed by the Federation Aviation Administration (FAA)
- County-level/metropolitan macro-economic growth projections
- EV ownership and trends in the Denver and Minneapolis metropolitan areas
- Studies of energy use at airports other than DEN and MSP
- Integrated Resource Plans (IRP) for Public Service Company of Colorado and Northern States Power Company

The FAA publishes an annual Terminal Area Forecast (TAF) containing historical and forecast data for enplanements and airport operations.[34] Historical data is submitted annually to the U.S. Department of Transportation and Bureau of Transportation Statistics through T-100 reports. Reports consist of originating and connecting enplanement data for domestic and foreign, commercial air carriers and aircraft with ten or more seats. Forecasts are developed through a demand-driven approach with considerations for airline fares, regional demographics, national and local economic conditions.

34 Source of TAF Data: Terminal Area Forecast (TAF) | Federal Aviation Administration (faa.gov)

The analysis relied primarily on FAA passenger growth projections and also considered regional macroeconomic trends including historical and projected population growth. In addition, while the vehicle electrification forecasts were primarily driven by the business plans of stakeholders as well as any mandated requirements, Jacobs also looked at the metropolitan trends in EV adoption based upon vehicle registration data. Finally, to overcome limited end-use data for natural gas consumption at the two airports, Jacobs reviewed seasonal usage patterns and data from other airports to estimate energy use for space heating, water heating, cooking and miscellaneous uses.

Xcel Energy's Minnesota and Colorado operating company IRPs were used to identify the current and projected generation mix.[35] The vintage of IRPs used include Public Service Company of Colorado's (PSCo) IRP released in 2021 and Northern States Power Company's (NSP) IRP approved in 2022.[36] The mix of sources of electric generation were used to identify the average amount of GHG and Nitrogen Oxides (NO_X) emissions associated with each MWh of electricity consumed. This analysis was used to estimate the decline in air emissions over the study period based upon the planned mix of generation resources.

Electric Demand Forecast Methodology

Separate electric consumption and peak power demand forecasts were developed for different sectors within the airports: rental car companies, on-airport fleets, third-party vehicles traveling to the airport terminals and cargo facilities. While a more detailed breakdown of airport operations could define the bottom-up forecast, the definition of the separate forecasts was based upon expected stakeholder participation and available data. The stakeholder's current plans for electrification were developed as the industry scenario and electrification driven by policy objectives was developed as the policy scenario. The industry scenario envisions the power demands of the airport under each stakeholder's stated future plans including electrification measures targeted for meeting their emissions reductions targets. Examples of stated plans include MSP's plans for replacing the existing heating and cooling equipment within the Central Plant by 2029 or DEN's plans to reduce terminal/concourse energy use by 20% via efficiency measures.[37,38] The policy scenario envisions a more aggressive pathway to vehicle and broader technology electrification to meet decarbonization targets.

Significant growth in electricity consumption at the DEN and MSP airports will be driven by the electrification of transportation, space heating and water heating. The penetration of EVs in the consumer auto market and on-airport vehicles will create significant growth in electricity consumption associated with charging those vehicles. For both airports Jacobs derived a forecast of rental EVs and separately a forecast of non-rental EVs (representing both passenger/employee-owned EVs and airport fleet EVs).[39] The electrification of space and water heating was driven by terminal and cargo electrification targets, coupled with assumed equipment replacement schedules and facility growth expectations. Additional information on developing the forecast follows.

Rental Cars

The forecast of the number of rental EVs that would charge at each airport was derived from a combination of historical revenue data and estimates of current rental car fleet size as well as forecasts of EV penetration in rental car stock from stakeholders. Additionally, power demand forecasts previously created by a subset of stakeholders were leveraged where available.

Stakeholders provided insight into forecasts of EV penetration as a percent of each stakeholders' fleet size. However, not all stakeholders were able to make fleet size available. For companies that declined to share fleet size, the fleet size was estimated based upon historical rental car revenue data and aerial photos. The combination of revenue data and data provided by each operator was analyzed to determine the share of rental car business for each company. Total fleet size was projected through 2050 by first deriving a relationship between historical rental car revenue (presumed to broadly reflect fleet size) and passenger traffic at each airport and then using that relationship to project the change in fleet size through the forecast period.

The forecast of the number of EVs associated with the forecast of total rental cars at each airport leveraged datasets provided from a subset of stakeholders that summarized their forecast of EV adoption from 2023 to 2050. These datasets provided forecasts, for our industry and policy scenarios. These forecasts combined with the projection of operator-specific fleet size, provided an estimate of the number of rental EVs through time.[40] Charging impacts for the projected number of rental EVs (both peak power demand and energy consumption) were estimated using stakeholder-provided input.

Stakeholder surveys provided insight into the size of associated fleets during the on-peak (presumed to be summer) and off-peak rental season (presumed to be winter).[41] A reduced demand for EVs in the winter is anticipated to reduce the peak rental power demand associated with charging, but this reduction is anticipated to be offset by the decreased efficiency of charging at colder temperatures.

35 PSCO's 2021 Electric Resource Plan and Clean Energy Plan
36 NSP initially filed their last IRP in 2019 and it was approved after multiple rounds of revisions in 2022.
37 Metropolitan Airports Commission Terminal 1 EMC Boiler and Chiller Study (Kimley Horn, 2023)
38 Denver International Airport's 2021 Annual Environmental Report
39 Data provided by MSP from commissioned Kimley Horn study on EV Parking Recommendations.
40 For those operators that did not provide guidance on EV penetration for their rental car fleets, Jacobs assumed a forecast that was relatively less aggressive than those provided by the three responding operators.
41 Historical monthly rental car revenue for DEN corroborated this inference, showing that revenue in July was 55% higher than revenue in December/January.

On-airport Vehicles and Third-party Party Vehicles Traveling to the Airport

The charging impact of vehicles associated with either passengers or airport employees was estimated by first identifying the number of existing EV charging ports for passenger-owned and employee-owned vehicles at each airport. The number of ports were then projected forward on the basis that 75% of all short-term public parking spots would be electrified by 2050 under the policy scenario and 38% would be electrified by 2050 under the industry scenario.[42,43] The same penetration was assumed under the two scenarios for employee parking. The associated impact of these charging ports on power demand was estimated assuming a mixture of Level 2 and Level 3 charging profiles.

The additional impact attributable to medium- and heavy-duty EVs associated with ground support and cargo handling vehicles was estimated by assuming a mixture of fast chargers for vehicles with batteries greater than 200 kilowatt-hour (kWh). It was assumed the average charger for these types of vehicles would be 450 kW to allow for sufficiently fast charging. The number of estimated ports at each airport was assessed by reviewing the number of large-scale cargo operators and grossed up to account for remaining electrification of non-cargo related airline operations. Ultimately, the same magnitude of charging impact was assumed for these types of vehicles under both the industry and policy scenarios, but the timing of the installation of these chargers was made more aggressive under the policy scenario.

Electrification of Terminals

For the airports to meet stated emissions reductions goals (that is, reaching net-zero by 2050), it will be necessary to convert present-day operations that rely on natural gas to other fuels that could include renewable natural gas or electricity from renewable energy sources. Presently, heating loads are estimated to represent ~90% of total natural gas usage for DEN's terminals, concourses and other buildings – estimated by comparing summer time natural gas usage (when heating needs are minimal if not nonexistent) to winter time natural gas usage. A similar pattern is seen in the natural gas consumption data for DEN's cargo operations. While monthly gas usage data was not available for MSP, a similar usage pattern is assumed given the cold climate (MSP averages daily winter temperatures 10°F below that for DEN) and the magnitude of natural gas usage for the airport compared to electric usage.[44]

While different technologies exist to substitute for gas-powered space and water heating, it's assumed for this study that both airports will ultimately meet 100% of space- and water-heating needs through a combination of ground source and air source heat pumps (GSHP and ASHP respectively). Indeed, MSP has already announced plans to install a GSHP as a part of the plan to replace the existing gas steam boilers that provide space- and water-heating for Terminal 1.[45]

The building electrification model is based on converting gas heating loads to electric loads. A combination of ground and air-source heat pumps for the two airports was modeled. GSHPs were assumed to serve the terminals/concourses as well as currently operating natural gas snowmelt operations, and ASHPs were assumed to serve cargo facilities and other flat-roofed buildings such as maintenance and administration buildings not directly located near the concourses.

For timing of these natural gas conversions for the industry scenario, Jacobs leveraged stakeholder-provided material that indicated that ~94% of MSP's natural gas usage for Terminal 1 would be reduced as a part of the Central Plant renovation beginning in 2029.[46] It was assumed that Terminal 2 would likely have its heating loads converted to electric via similar technology substitutions in the late 2030s and that the last of Terminal 1's gas loads would be converted before 2050. For DEN, Jacobs' understanding is that the natural gas heating systems were only recently installed/upgraded and thus, it was assumed terminal and concourse space and water heating electrification would not likely occur before 2040.

For the policy scenario, Jacobs assumed a more aggressive timeline for electrification with complete conversion of MSP's Terminal 1 heating load to GSHP by 2030. For DEN, Jacobs assumed that electrification of the existing terminal and two-thirds of the existing concourse space- and water-heating load by 2040.

Electrification of Cargo and Other Structures

Cargo facilities at both airports are also characterized by high natural gas usage in the winter and low natural gas usage in the summer pointing to the dominating end-use of space heating. Monthly data highlight that cargo facilities at DEN used less than 10 Therms a month in the late summer months of 2020 and 2021 compared to annual peaks of more than 12,000 Therms in the late winter months of January and February.[47]

For the industry scenario, Jacobs leveraged stakeholder input and publicly available cargo operator commitments to emissions reductions to determining the approximate timing of conversion of natural gas loads for the different cargo facilities. Those operators with the earliest commitments were presumed to electrify their natural gas loads first followed by operators with later commitments and finally, any operators where commitments to specific emissions reductions were not readily available. While the shared natural gas consumption associated with each operator was not readily available, Jacobs leveraged estimates of facility square footage (a key driver in

42 MSP has a stated target of electrifying 25% of all parking spots by 2050, which has been increased under the Current Plans scenario to allow for sufficient charging ports given the high anticipated level of vehicle electrification.
43 Data provided by MSP from commissioned Kimley Horn study on EV Parking Recommendations.
44 NOAA hourly observations 2013-2022
45 Current plans presume the boreholes and associated infrastructure will be installed as a part of a separate project for the airport.
46 Metropolitan Airports Commission Terminal 1 EMC Boiler and Chiller Study (Kimley Horn, 2023).
47 DEN Premises E_G 07-10-2023.xlsx

space-heating load) to determine the magnitude of heating load to be converted to electric in a given time period.

Like the policy scenario for terminals and concourses, the policy scenario developed for cargo and other structures assumed a more aggressive timeline for heating load conversion with the 100% of cargo facilities converting to ASHP heating by 2040. While aggressive, this timeline reflects the fact that conversion of heating loads for these operators is one of the most straightforward methods for reducing GHG emissions in the context of the complex challenge of reducing emissions associated with jet fuel.

Both airports have natural gas loads associated with separate administration and maintenance buildings as well as airline hangars and warehouses associated with aircraft operations (for example, airplane meal preparation). Like cargo facilities, because these buildings tend to be located separate from the main terminal and many have flat roofs, it was assumed that associated heating loads would be converted away from natural gas to electric via the installation of ASHPs. Timing of load conversion mimicked that for cargo facilities where operators were the same or where facilities were associated with air carrier operations (for example, food service). Where facilities were associated with airport operations, the timing of conversion was set to match the general conversion of heating loads for the broader terminals and concourses.

Lastly, both airports boast lodging within their footprints – DEN has the Westin Hotel and Conference Center and MSP has the InterContinental Hotel. Present-day electric and natural gas loads were estimated for these structures (these loads were presumed to not have been included in the usage data provided by the utilities). Similar to the non-terminal buildings, it was assumed in the analysis that natural gas associated with these facilities would ultimately be eliminated over the forecast period in favor of electric space and water heating as well as electric cooking. These structures, like other non-terminal or concourse structures, were assumed to rely on ASHPs for space and water heating once they converted away from natural gas.

Heat Pump Assumptions

Heat pumps work by transferring heat energy from one space to another. In the summer the heat pump transfers heat energy from within a building to the outside air (or into the ground in the case of a GSHP) and in the winter months the heat pump works in reverse by transferring heat energy from the air outside (or in the ground) inside. While both types of heat pumps operate in cold climates, GSHP's leverage the insulating properties of ground and thus have greater access to heat energy to transfer indoors during the winter compared to ASHPs that must rely on a decreasing amount of heat energy as the air temperature decreases. A growing number of airports including Nashville, Vancouver and Louisville have installed GSHP systems as airports typically have the land available to install the numerous boreholes that are required for the systems.

A combination of ground and air-source heat pumps for the two airports were modeled. A key difference in the modeling of these two systems is the coefficient of performance (COP), a measure of how efficiently the heat pump can convert input energy into energy for heating. As mentioned, GSHPs benefit from the insulating properties of the subsurface and have more consistent and higher COPs even at cold temperatures while ASHPs see rapidly declining COPs at cold temperatures. The assumptions regarding COPs were based upon publicly available reports on GSHP and ASHP performance in cold climates.[48,49] Modeling for this study assumed heating COPs of 2.9 and 2.7 for DEN's and MSP's GSHPs, respectively. For the ASHPs a COP of 2.4 and 2.2 was assumed for DEN and MSP, respectively, with the peak electric demands for the systems determined assuming a COP of 1 (for example, during the coldest hours of the year).

City/State/Airport Sustainability Targets

Colorado and Minnesota, as well as Denver and Minneapolis, have a combination of targets and mandates that address GHG reductions, clean electricity supply and electric vehicle adoption. The DEN airport is owned and operated by the City and County of Denver while the MSP airport is owned and operated by the MAC and is not under the city jurisdiction of either Saint Paul or Minneapolis. The MAC has adopted goals for GHG reductions at MSP. State and local targets are summarized below. Both states target that the electricity supply will be carbon free by 2050 and that transportation will largely be electrified except legacy vehicles still operating. The targets highlighted below informed projections and timing related to electrification of buildings and vehicles.

State-level Clean Energy Targets for Electricity

Colorado has a target of 100% renewable electricity by 2050 while Minnesota has a target of 100% carbon-free electricity and 55% renewable electricity by 2040. While the renewable energy targets do not address natural gas use in buildings, plans to phase out natural gas are under development in conjunction with aggressive GHG reduction targets.

State-level GHG Reduction Sector Targets

Currently, Colorado's GHG emissions reduction roadmap is to be 50% below 2005 levels by 2030 and 100% below 2005 levels by 2050.[50] Minnesota has a target of 80% below 2005 levels by 2050.[51]

State-level Transportation Electrification Targets

Colorado is targeting close to 100% light duty electric vehicles by 2050 with an interim target of EVs accounting for 70% of new light duty vehicle sales by 2030. The state is also

48 NREL, Field Validation of Air-Source Heat Pumps in Cold Climates
49 Spilter, J. D., Ghelin, S. (2019). "Measured Performance of a Mixed-Use Commercial Building Ground Source Heat Pump System in Sweden"; Energies (12)
50 Colorado SB23-16
51 MN - Next Generation Energy Act

seeking to transition to 100% medium- and heavy-duty electric vehicles.[52] Minnesota has a target of an 80% reduction in transportation emissions by 2050.

Denver Climate Protection Fund

The city of Denver is targeting the elimination of 100% of GHG emissions by 2040 with a separate target of 100% renewable energy by 2030.

Minneapolis Race to Zero Campaign

In October 2021, the Mayor of Minneapolis pledged to reach net-zero GHG emissions by 2050.[53]

MSP Targets

The MAC has established sustainability goals that include reducing GHG at MSP by 80% by 2030[54]. The MAC voluntarily publishes a greenhouse gas emissions report, which reports the GHG emissions footprint for MSP as a whole. MAC-owned and -controlled sources contribute 12% to the total MSP carbon footprint.[55]

Saint Paul Climate Action & Resilience Plan

The city of Saint Paul has set a goal to achieve carbon neutrality by 2050 with a suite of targets and actions to decrease emissions across every sector in the city.

GHG Emissions from Electric Utility Consumption

To determine the emissions associated with utility-delivered electricity Jacobs constructed a snapshot view of Xcel Energy's coal and natural gas generation fleets (the vast majority of every utility's thermal generation and associated emissions).[56] These snapshots accounted for planned unit retirements (for example, PSCo's Comanche Unit 3 in 2030) as well as planned future additions. Data from utility IRPs and FERC Form 1 filings were used to convert the nameplate capacity of these existing and current generation plants to megawatt hours of delivered electricity for which estimates of CO_2 and NO_X emissions are estimated. Jacobs compared these emissions estimates with those proposed by the utilities to ensure they were consistent with the most readily available data. The ultimate emissions associated with the electric forecasts derived herein were estimated by dividing the estimated emission for the coal and gas fleets by the total electric load served by the utility.

Emissions Reductions

Most of the entities that operate within the airports' ecosystems have made commitments to emissions reductions over the coming 30 years. The estimate of emissions reductions associated with electrification assumed utility-delivered gas and electric as well as avoided gasoline miles.

Emissions associated with utility-delivered electricity is defined by the specific utility's generation fleet (both owned and contracted). As noted, Jacobs used PSCo's and NSP's future plans for evolving its generation fleets to meet their commitments to reducing GHG emissions by 85% compared to 2005 levels by 2030, and to deliver electricity from 100% renewable resources by 2050.[57] Emissions associated with utility-delivered natural gas stem from the combustion of natural gas (whether in a furnace for space heating, a gas cooktop for cooking or a boiler for water heating[58]). Like utility-delivered natural gas, the emissions associated with avoided gasoline miles (miles now driven by EVs rather than gasoline-powered vehicles) is defined by the combustion of gasoline; however, the determination of the fuel efficiency and the number of miles for those vehicles is a more in-depth analysis.

Emissions reductions associated with utility-delivered natural gas were estimated by multiplying the forecast of airport natural gas snapshots by the estimate of CO_2 and NO_X emissions. As the airports electrify their natural gas loads, the associated emissions are forecast to drop significantly.

The final area of avoided emissions reviewed in this analysis is the number of avoided gasoline miles. As rental car fleets bring on EVs and as passenger and airport vehicles are also electrified, the amount of gasoline used to transport people will be reduced and the associated emissions will be substituted by the emissions associated with charging the EVs. The electricity associated with charging these vehicles is accounted for in the broader airport power demand forecasts and thus the utility-delivered electric emissions discussed above. Miles associated with rental cars were estimated based on the number of miles driven by rental cars in a given year and information provided by a subset of stakeholders. Miles associated with passenger and employee vehicles were estimated by backing out the number of miles associated with the energy forecast for the non-RAC EV chargers.

Detailed Results and Findings

Achieving state and local policy targets related to reductions in GHG emissions, along with meeting GHG reduction commitments of airport stakeholders, will create a significant need to expand the power infrastructure serving the airport. While in recent years energy efficiency has been an effective tool to offset airport growth, energy efficiency will not offset the large power demands created by the electrification of transportation and buildings. Based upon Jacobs bottom-up modeling, power demand for the industry scenario is expected to grow at least 386% at DEN in the next 25 years and more than 337% for MSP. The largest growth in power demand occurs in the next decade as transportation and building electrification efforts accelerate. The bottom-up forecast is more conservative than other forecasts that

52 Colorado 2023 Electric Vehicle Plan
53 Minneapolis Mayor's pledge to net zero
54 Sustainability Goals - Explainer (metroairports.org)
55 Environmental Sustainability | MSP Airport
56 We included capacity associated with known utility thermal contracts according to 2022 FERC Form 1 filings.
57 Xcel Energy's Upper Midwest Energy Plan 2020-2034; PSCo's 2021 Electric Resource Plan and Clean Energy Plan
58 For modeling purposes emissions associated with natural gas did not assume any mixing with carbon-free sources.

show higher power demand growth. One notable difference is that *Electrifying Airport Ecosystems* looked at only the power demands for the DEN campus and did not include power demands from the entire DEN-owned land mass and associated development plans.

While *Electrifying Airport Ecosystems* did not address the power demands associated with off-airport parking support facilities or power demands from electric aircraft and eVTOL, it is expected that these use cases will add a significant requirement for additional power infrastructure beyond the projections presented in this report.

Current Energy Use

Excluding aviation fuel, electricity and natural gas for the airport terminals represent the vast majority of energy use at these locations. The current breakdown between electric and natural gas consumption is almost 50% for both airports with MSP using slightly more natural gas in comparison to electric usage.

Both airports are summer peaking for electric, meaning they draw the greatest instantaneous consumption from the electric utility in the summer months. This seasonality is interpreted to speak to both higher passenger demand in the summer as well as the need to cool the airport terminals and other facilities during the hot summer afternoons. Without changes in end-use behavior (such as added electric loads related to conversion of natural gas heating equipment to electric), this baseline pattern is anticipated to continue.

Terminals represent the predominate electric and gas usage at the airport owing to their significant footprint, the density of people within the spaces (and the heating and cooling needs of those spaces), and the co-location of equipment such as escalators, baggage handling, lighting, etc. After terminals, maintenance and other facilities account for the next largest share of electric usage for the two airports. Maintenance and other facilities include additional airline hangars and maintenance buildings, snowmelt operations, airplane meal preparation facilities, car rental facilities and other miscellaneous on-site consumption. Cargo operations represent the third largest category of electric usage for both airports.

Near-term and Long-term Power Demand and Trends

The bottom-up forecast of power demand highlights the significant growth and need for new power infrastructure as a result of planned electrification at the MSP and DEN airports. The growth, while in part driven by increasing passenger and cargo activity, is primarily associated with electrification driven by a combination of government policy, corporate policy and consumer demand over the entire forecast period. The need for new infrastructure is demonstrated under the two scenarios analyzed. Under the industry scenario, by 2050, the forecast power demand for DEN is projected to be nearly five times current levels. For MSP, the power demand in 2050 is projected to nearly 4.5 times current levels. The power demand calculated is "coincident," meaning that it accounts for the reality that the max power demand for the different activities at the airport will not all occur at the same time.

The primary difference in the power demand forecasts between the two scenarios analyzed is the timing of the demand growth and the rate of EV adoption. The policy scenario sees greater upward pressure on the power demand for both airports by 2040 owing to more aggressive timelines for EV penetration into RAC, non-RAC and GSE fleets and earlier adoption of electric space and water heating. For example, by 2040 the policy scenario sees an additional 65 MW higher power demand than the industry scenario for DEN. For MSP, the primary difference between the two scenarios occurs earlier in the forecast (2030) when the electrification of all heating needs for Terminal 1 and earlier electrification of the GSE fleet adds an additional 20 MW combined of power demand with the remaining stemming from electrification of the RAC and non-RAC fleets.

Both scenarios modeled incorporate a complete substitution of efficient electric heat pump space and water heating for current natural gas usage as well as the substitution of electricity for natural gas for cooking. In both scenarios, the substitution is completed at both airports by 2050. The timing of conversion of natural gas loads (primarily space and water heating) drives the substitution of natural gas usage and associated GHG emission reductions for both airports. The dramatic reduction in natural gas consumption under both scenarios for MSP by 2030 is driven by a planned retrofit of the Central Plant for MSP's Terminal 1. For DEN the greatest reduction in natural gas consumption occurs by 2040 under the policy scenario which assumes the conversion of space and water heating natural gas loads for the majority of the terminals and concourses by 2040.

From 2023 to 2030, DEN is anticipated to see a slight increase in natural gas consumption as passenger traffic and the number of gates increase. The increase creates an associated demand for more natural gas-sourced space, and water heating increases ahead of electrification and change out of major equipment.

The conversion from natural gas uses for space and water heating as well as cooking needs places upward pressure on total delivered electricity from the utilities. Additional upward pressure on total electricity delivered to the airports stems from the installation of a significant number of EV chargers for rental vehicles, public and employee airport parking and cargo and other airport operations.

Both airports see significant increases in the associated electricity consumption by 2050. In 2050, DEN is estimated to consume more than three times the annual electric energy it is consuming today (equivalent to the annual electricity usage of 40,000 Colorado households).[59] By 2050, MSP is forecast to consume nearly three times the electricity it uses today (equivalent to approximately 27,000 Minnesota households).[60] The increases in total electricity consumption are not projected to grow linearly with the increase in the

59 Average household in Colorado is estimated to use ~9,700 kWh per year (source EnergySage).
60 Average household in Minnesota is estimated to use ~ 11,000 kWh per year (source: Energy Sage).

airports' power demands. Based upon the forecast, the power demand will grow faster than annual electricity consumption at both airports. This is the result of the primary drivers of added power demand over the forecast period stemming from activities with low load factors (for example, electric usage is not used at a high level for long periods of time).[61] Unmanaged EV charging tends to have low load factors as the chargers may sit unused for many hours of the day until a vehicle is plugged in (or multiple vehicles at co-located ports). The forecast of power demand assumes a degree of managed EV charging loads. However, the forecast could be lower depending on strategies to manage charging or higher depending on airport operational needs during critical periods. Similarly, electrification of heating loads is anticipated to be associated with low load factors owing to both the low performance of ASHPs during extreme cold weather (which dramatically increases the peak demand of the systems) as well as assumption of unmanaged heating. Load factors for both end uses can potentially be improved or mitigated and consequentially reduce the disparity in the growth of power demand over total electricity consumed.

Importantly, the significant increase in electricity consumption does not lead to an increase in associated emissions because as electric consumptions grows, the utilities are overhauling their generation fleets to meet their ultimate goals of providing 100% renewable energy by 2050 (discussed in more detail in the following section). Additionally, despite the significant increase in power demand at the airports the overall energy intensity (total energy used from electric and natural gas) of the airports on a per-passenger basis is anticipated to decline. In 2023 the combined electric and natural gas per-passenger energy intensity was calculated as 0.018 MMBTu for DEN and 0.034 MMBTu for MSP, decreasing to 0.016 MMBTu at DEN and 0.021 MMBTu at MSP in 2050. The energy intensity was calculated as the total electricity (converted to a common unit of one MMBTu) plus the total gas usage divided by the number of passengers. The decrease at DEN was found to be smaller because the airport presently uses less gas on a per-passenger basis compared to MSP (and thus the magnitude of efficiency gains when converting from gas to electric is less) and DEN has a greater EV forecast on a per-passenger basis compared to MSP leading to upward pressure on electricity use by 2050 all else equal.

However, as previously noted, electrification does significantly increase the electric power demands starting from a 2023 baseline at both airports of 0.8 kW per passenger on average. This number grows by 75% to 1.4 kW per passenger by 2030 and reaches 1.92 kW per passenger by 2050.

Drivers of DEN Electric Growth

The FAA projects that the airport's passenger traffic at DEN will increase more than 40% over the study period. However, as the table below illustrates, electrification of transportation and building heating to reduce GHG emissions is the larger driver of the need for new power infrastructure.

DEN Power Demand Growth

DEN	2023	2030	2040	2050
Baseline	43.8	43.8	43.8	43.8
Energy Efficiency Gains	0	-4	-4.3	-4.6
Facility Expansion/Construction	0	4.9	15.8	19.3
Hotel/Real Estate Construction	0.0	1.7	6.7	9.7
Terminal Natural Gas Conversion	0.0	0.0	10.0	34.6
Cargo & Operations Natural Gas Conversion	0.0	0.0	11.2	16.2
Rental Car EV Charging	0.0	6.0	13.1	17.1
Non-RAC EV Charging	0.0	10.6	12.6	14.4
eGSE Charging	0.0	16.5	39.5	62.5
Total MW	43.8	79.6	148.4	212.9

The primary contributor to power demand growth for DEN is the electrification of non-RAC vehicles (for example, installation of EV charging ports for public and employee parking), electrification of GSEs, the conversion of the terminal and concourse natural gas loads to electric and EV penetration into the RAC fleets. Secondary contributors to power demand growth through 2050 include the construction of a new concourse for DEN, the electrification of natural gas loads for cargo facilities and other operations and lastly, the construction of new hotels and/or other real estate and their associated heating and cooking loads.

Drivers of MSP Electric Growth

The FAA projects that the airport's passenger traffic at MSP will double over the study period.[62] The following table illustrates that electrification of transportation and building heating to reduce GHG emissions are the larger drivers of the need for new power infrastructure.

MSP Power Demand Growth

MSP	2023	2030	2040	2050
Baseline	31.9	31.9	31.9	31.9
Energy Efficiency Gains		-0.3	-7.8	-8.6
Facility Expansion/Construction	0	2.1	8.7	7.7
Hotel/Real Estate Construction	0	0	1	1.4
Terminal Natural Gas Conversion	0	1.8	24.1	30.0
Cargo & Operations Natural Gas Conversion	0	0.1	8.3	10.9
Rental Car EV Charging	0	3.5	10.5	17.2
Non-RAC EV Charging	0	4.8	5.7	6.5
eGSE Charging	0	10.8	25.8	40.8
Total MW	31.9	54.7	108.2	137.8

61 Load factor is the ratio of average hourly use over the full year divided by the highest hourly consumption in the year.
62 [Terminal Area Forecast (TAF) | Federal Aviation Administration (faa.gov)]

Appendix B: Related Electrification Efforts

Some key industries are focusing on identifying power needs, and building upon their work will be a primary next step for studies such as this. For example, American Association of Airport Executives (AAAE), Airports Council International – North America (ACI-NA) and the International Air Transport Association (IATA), are working with airports to develop best practices and certification programs for sustainable and electrified operations.

Select sustainability efforts of these leading U.S. organizations and recognized industry groups include:

1. American Association of Airport Executives (AAAE): Annual "Airports Going Green" conference and recently published Resiliency and Sustainability, Maturity Model and Electric GSE Chargers Pilot, June 2023[63]
2. Airports Council International-North America (ACI-NA): Falling under its Environmental Affairs Committee are numerous sustainability resources and sub-committees, including but not limited to: Sustainable Aviation Guidance Alliance, Airport Carbon Accreditation, Sustainability Working Group Newsletters, Sustainability Policy and ACI-NA Sustainable Conference Guidelines[64]
3. International Air Transport Association (IATA): In 2021 the association's member airlines passed a resolution to achieve net-zero carbon emissions by 2050. IATA fostered this commitment during recent annual conferences and various sustainability-focused meetings held throughout the year, for example CO_2 Data Workshop, World Sustainability Symposium and Aviation Energy Forum[65]
4. Department of Energy (DOE) Project Athena: Athena is a collaborative effort funded by the DOE Vehicle Technologies Office and industry and led by the National Renewable Energy Laboratory (NREL) in partnership with Oak Ridge National Laboratory and Dallas-Fort Worth International Airport. Using data-driven statistical modeling and artificial intelligence, Athena's model simulates the impacts of future capacity expansion scenarios. It identifies options that maximize the value of passenger and freight mobility per unit of energy and/or cost. The collaborative holds periodic meetings and publishes relevant airport and industry papers.[66]
5. EPRI: In 2023, EPRI launched EVs2Scale2030, a three-year initiative to ready the electric grid in support of the accelerated development of EV charging infrastructure.[67]

63 AAAE Source
64 ACI-NA Source
65 IATA Source
66 NREL Project Athena
67 EPRI

Appendix C: Acronym List

AAAE	American Association of Airport Executives
ACI-NA	Airports Council International – North America
ASHP	Air Source Heat Pump
CAPEX	Capital Expenditure
CO_2	Carbon Dioxide
ConRAC	Consolidated Rental Car facility
COP	Coefficient of performance
DEN	Denver International Airport
DOE	U.S. Department of Energy
eGSE	Electric Ground Support Equipment
EPRI	Electric Power Research Institute
EV	Electric Vehicle
eVTOL	Electric Vehicle Take-off and Landing
FAA	Federal Aviation Administration
GHG	Greenhouse Gas
GSE	Ground Support Equipment
GSHP	Ground Source Heat Pump
GT	Ground Transportation
IATA	International Air Transport Association
IRP	Integrated Resource Plans
kW	Kilowatt
L2	Level 2 Electric Vehicle Charger
L3	Level 3 Electric Vehicle Charger
MMBTu	Metric Million British Thermal Unit
MSP	Minneapolis–Saint Paul International Airport
MW	Megawatt
NREL	National Renewable Energy Laboratory
NO_x	Nitrogen Oxides
NSP	Northern States Power Company
PSCo	Public Service Company of Colorado
PUC	Public Utility Commissions
RAC	Rental Car Company
TNC	Transportation Network Companies (ride share companies)