ELEVATORS

Center for Building in North America

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A report from
Center for Building in North America

Authored by Stephen Smith

Research help by
Kuba Snopek and Petro Vladimirov
(Direction) in Poland,
Geli Tadonki in France
and Moon Hoon in South Korea.

Designed by Studio Folder

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Center for Building in North America
Brooklyn, New York
centerforbuilding.org
info@centerforbuilding.org

Stephen Smith
stephen@centerforbuilding.org

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in North America

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PREFACE

In late 2020, tired of my old Brooklyn apartment – historic and charming, but loud and full of maintenance hassles – I put my co-op unit on the market and set out to buy a new condo. Common charges for apartments in New York City can be as high as rent in other cities, so I knew that I wanted to buy a walk-up. Soon after, I found an efficient little one-bedroom, one-bath in a new five-story walk-up building on a 2,000-sq. ft. lot. Technically an older building from the early 20th century with two new added floors, the plans were filed under an older New York City building code, and so the developer got away with not installing an elevator. The price was double the median sales price for a new house in the United States, but the common charges were only $226 per month – not particularly low by, say, Swiss or French standards, but very affordable for New York City. I was an in-shape 32-year-old, and had only ever lived in walk-ups in New York. An elevator just seemed like an unnecessary cost.

Almost as soon as I moved in, I would come to regret the decision. In 2017, after a routine viral infection, I had never felt quite right. Doctors dismissed my complaints of fatigue, constant thirst, and a strange tingling in my arms, and eventually I gave up looking for answers and dismissed them too. But in the spring of 2021, shortly after moving in, my health took a sharp turn for the worse. Riding a bike across the Williamsburg Bridge one morning to work, my vision almost went dark. I began to feel dizzy every time I stood up or ate. A few times, I fainted. A doctor would soon diagnose me with postural orthostatic tachycardia syndrome, a disease that often starts with a viral infection, on top of the myalgic encephalomyelitis (commonly, and sometimes derisively, called chronic fatigue syndrome) and small fiber neuropathy that no doctor had been willing to diagnose years prior.

My walk-up apartment quickly began to feel like a trap. Despite still being in good shape, I would get dizzy and winded walking up the two flights of stairs to my unit. My doctors advised me to limit exertion and stop exercising. I began to order delivery from a restaurant that was just across the street. Walking wasn't so bad, but the stairs were a barrier to leaving my home.

That next Christmas, I traveled to Romania to see my mother. While I was in Europe, a Minneapolis developer's tweet about a new three-story apartment building he'd developed went viral. It read, "12 units. Single-family lot. No elevator. No parking. Minneapolis." His intent was to show how it's still possible to build an affordable building in an American city by paring it down to the basics.

Urbanists and his fellow developers on Twitter were complimentary (the rents were remarkably low for new, unsubsidized construction), but eventually the tweet escaped those circles and the reactions were vicious. "Do you think disabled people don't live in Minnesota?" "Wait. How is it legal to build new housing without an elevator?" "God forbid an able-bodied tenant gets into an accident or becomes disabled."

As a newly disabled person, I got it. But as somebody who knew something about real estate development, I thought, have these people never seen a three-story apartment building in their own country? None of them have elevators. It's not affordable to spend $100,000 or more (plus recurring expenses) on an elevator that only serves eight apartments.

But then I thought about the continent where I was lying, in bed, reeling from the aftereffects of trying to walk for a few miles with an energy-limiting illness. Almost all new apartment buildings in Western Europe have elevators. My mother's building in Bucharest, a city dramatically poorer than Minneapolis, has 15 apartments and an elevator. My friend in Rome, who lives in a 12-unit building shorter than mine, has not one but two elevators. I asked an Italian architect I know how much an elevator there would cost to install in a mid-rise apartment building.

Not more than the low tens of thousands of euros, he said – a tiny fraction of the cost of an elevator in America.

As Americans, we pride ourselves on our accessibility laws. Traveling in Amsterdam, Paris, or London on vacation, all you see as a tourist are inaccessible, old walk-up buildings. The people are thinner, but you rarely see people in wheelchairs rolling down the sidewalk. In American architecture and building code circles, you often hear some variation on, “they don’t have the ADA in Europe.” (Very true – the ‘A’ stands for Americans.) And while it is true that in the United States you are more likely to see certain accessibility features than in Europe, the truth about disability and access is more complicated.

When my friend in Rome with two elevators in her 12-unit, four-story building came to see me in New York a few months later, she panted as she lugged her suitcase up the final step. I apologized for not being able to help her, given my limited energy. She said that’s alright, but asked, “You Americans love these buildings without elevators, why is that?” This report seeks to answer that question, and propose how North America can join the rest of the developed world and learn to love the elevator again. Because while many of us may be stair users for the moment, we’re all born disabled and, with any luck, we will die disabled as well.

1 INTRODUCTION

The United States of America is a sprawling, car-centric country, but one form of mass transit stands out above the rest in sheer ridership: the elevator. The earliest elevators date back to antiquity, but it was in the mid-1800s that technological advances and urban trends came together to create the elevator and elevator industry that we know today. Its center was in New York City, where the elevator made the leap from hotels and stores to the office building in 1869, with the construction of the Equitable Building. The elevator allowed Lower Manhattan to pierce through the de facto five-story height limit imposed by humans' willingness to climb stairs and, along with steel frame construction, led to the invention of the skyscraper, changing the skylines of American cities before conquering the rest of the planet.[1]

Americans make over 20 billion trips per year by elevator – twice the number of trips made by what people think of as mass transit. Despite the association between elevators and high-rises, the average elevator in the United States only has four landings, with elevators being as much a tool for convenience and accessibility as for able-bodied necessity.[2] The elevator – along with its lesser-used diagonal cousin, the escalator – makes up an entire axis of mechanized travel.

When elevators were first popularized in the 19th and early 20th centuries, they were found mostly in taller buildings. A mid-rise property of public significance like a hotel or office building might have one, but otherwise, they were too expensive for an apartment building of just a few stories, particularly back when they required a full-time human operator. But since World War II, the trend in Western Europe (and, later, East Asia) has been to install elevators not only in buildings that absolutely need them given their height, but in any new apartment building at all – and many older ones too. They've become as routine in high-income countries in Western Europe and East Asia as a washing machine or parking space, and moving into a building with an elevator has become a normal part of the aging process.

But despite being the birthplace of the modern passenger elevator, the United States has fallen far behind its peers. Elevators in the United States have remained a fairly niche item in residential settings – expected in a high-rise or a big new mid-rise apartment building, but otherwise largely absent from the middle-class home. Part of this absence is due to the dominance of freestanding single-family houses in North America, but even apartments in the United States are less likely to have elevators than those in much of Europe and Asia. The United States relies heavily on walk-up typologies like townhouses and garden apartment complexes for infill and multifamily development. In absolute terms, the United States has fewer elevators than Spain – a country with one-seventh the population, and fewer than half the number of apartments. With rapidly aging populations, countries from China to Croatia have embarked on ambitious programs to add elevators to their existing stock of occupied walk-up apartment buildings – a virtually unknown concept in the United States.

And behind its lack of elevators, North America faces a crippling cost problem. The price to install an elevator in a new mid-rise building in the United States or Canada is now at least three times the cost in Western Europe or East Asia. Ongoing expenses like service contracts, periodic inspections, repairs, and modernizations are just as overpriced. High-income countries with strong labor movements and high safety standards from South Korea to Switzerland have found ways to install wheelchair-accessible elevators in mid-rise apartment buildings for around $50,000 each, even after adjusting for America's typically higher general price levels. In the United States and Canada, on the other hand, these installations start at around $150,000 in even low-cost areas.

The cost problem tends to lead not to larger portions of individual project budgets allocated to elevators, but to fewer elevators overall. Small apartment buildings which would have elevators in Western Europe are built as walk-up buildings in the United States. Other projects throughout North America are built not as apartments at all, but as townhouses. Larger sites aren't broken up into smaller segments, each with their own elevator serving a dozen or so apartments, as in Europe, but rather are combined into large, double-loaded corridor buildings, with one elevator for every 50 to 100 units (or more).

This report takes the cost discrepancy as its major research question: why is there such a vast gap in prices, what are the effects, and how might prices for elevators in the United States and Canada be brought down to earth? The experiences of other high-income countries show us the bounds of what is realistic, and offer suggestions for policies to implement in North America that have proven track records abroad.

Three major differences between North America and the rest of the world emerged in our research, which drive up the cost of elevators in North America: the size of elevator cabins, the availability of skilled

1 Fogelson, *Downtown: Its Rise and Fall, 1880-1950*, 115–16.

2 "Elevator and Escalator Fact Sheet"; "Public Transportation Facts."

elevator labor, and the technical codes and standards governing the construction of elevators and the availability of parts.

Elevator cars in the United States and Canada are much larger than those in Europe in particular, with the typical new elevator being about twice the size. This difference in size is driven by regulations to accommodate people in wheelchairs and people experiencing medical emergencies who are taken out of buildings on stretchers, although these same groups are also the ones who suffer the most when elevators go unbuilt due to the expense.

Elevator labor is also much harder to come by in the United States and Canada. Immigration laws in North America are unfriendly to non-college-graduate workers. Domestic educational systems are oriented towards training white-collar workers, with weak technical and vocational instruction of the type that is more useful to the elevator industry. The union representing most North American elevator workers takes advantage of and exacerbates this skills shortage to bargain for inefficiencies in new installations and other elevator work, leading manufacturers to forgo some of the preassembly and prefabrication and other efficiencies common in the rest of the world.

And finally, the United States and Canada have walled themselves off from the global market for parts through a unique web of technical codes and standards for elevators, while virtually the entire rest of the world has pursued harmonization with the dominant European standards.

This report focuses on the policy details of the elevator industry, but broader differences in attitudes and expectations between North America and the rest of the developed world drive these industry-specific policies. Different mindsets around and approaches to accessibility, emergency medical services, fire protection, electrical equipment, architecture, and the logistics of the regulatory state deeply affect the elevator industry in ways that are beyond the industry's control. It's a philosophy that works better than anywhere in the world at fulfilling the desires of a diverse set of stakeholders in situations where resources are abundant, but which pays for it by withholding access where resources are more limited.

The North American approach is one of extremes. American and Canadian elevators have the largest cabins, the strongest doors, the most redundant communication systems, the best paid workers, and the most diversity of codes on the one hand. And in exchange, Americans and Canadians have the highest prices, the most limited access, the least competitive market for parts, and the most restricted labor markets.

Elevators are one of the most unique systems in a building, and the most inscrutable to those outside of the industry. They account for only around 2 percent of the total cost of construction, where installed. But the challenges of the industry and its regulatory environment are not unique to vertical transportation. Applying these ideas to other building systems and construction sub-sectors will be left as an exercise to the reader, but we hope the themes covered in this report can offer a lens into North America's construction challenges more broadly – the difficulty of building multifamily housing, the limited materials market, the ever-tightening labor market, and the challenges of providing accessibility in an aging and more inclusive world.

1.1 Notes on methodology

This report focuses on comparing the elevator industry in the United States and Canada, referred to as "North America" (which, in this report, does not include Mexico or Central America), to the elevator industry in Spain, France, Germany, Italy, and Switzerland in particular, while also drawing on experiences in other countries in Europe, East Asia, and Oceania. The main Western European comparator countries were chosen for their large installed elevator stocks, high incomes, high safety and labor standards, and the language abilities of the author. This report focuses on elevators in mid-rise apartment buildings (both rentals and condos), since these buildings are home to most elevators, and are where the decision to install an elevator is most variable according to cost.

Most elevator industry revenue and even more of its profit come from expenses incurred after a building is first built, but this report focuses on new installations. This is because new installations are more homogenous and easier to compare across different settings. The issues that contribute to high costs for new elevators – around labor, availability of components, and car sizes – apply in similar ways to repairs, maintenance, inspections, and modernizations, so the new installation issues that this report prioritizes are relevant throughout the elevator's lifecycle.

Because this report is the first public attempt to study the North American elevator industry through the lens of international comparison, there are many opportunities for future research, which are summarized at the end.

Both metric and United States customary units are used in this report, with conversions given where appropriate. Currencies are typically left as-is, except in pricing tables, where an adjusted total is listed which converts nominal prices into U.S. dollars using the OECD's purchasing power parity conversion factor (to account for cost-of-living differences), and then inflates them into December 2023 dollars to account for the high rate of inflation that the western world has experienced over the last few years.[3] Different tax policies can complicate price comparisons, but for new installation price comparisons, value-added taxes in Europe are noted separately as nominal costs and included in adjusted prices. For installations in the United States, sales taxes are not generally applied to final prices for elevators as they are classified as exempt capital improvements, though sales taxes may have been already paid

3 "Purchasing Power Parities (PPP)."

on intermediate components and are therefore already factored into prices.[4] Markups applied by contractors are left out of all prices.

All sources of data have imprecision, some more so than others – rough estimates of costs for certain components, national elevator stocks estimated to sometimes only a single significant digit by trade organizations or with uncertain inclusion of escalators, cabin sizes that vary according to manufacturer and model. Elevator sales are usually a private affair, and precise data on cost in particular is a trade secret that is difficult to track down. That said, the gaps in prices between North America and the rest of the world are so large that small imprecisions and adjustments do not meaningfully change the conclusions.

Assertions in this report based on publicly available information are cited. Other information is sourced from around 100 off-the-record interviews or informal conversations with elevator industry professionals, wheelchair users, architects, developers, and others, and is not cited to avoid crowding the text with unhelpful anonymous citations.

1.2 Acknowledgements

While this report was authored solely by Stephen Smith, executive director of the Center for Building in North America. Four researchers in particularly contributed to my understanding of the elevator industry abroad – Kuba Snopek and Petro Vladimirov in Poland with the firm Direction, who conducted interviews with individuals in both Poland and much of Western Europe, as well as Geli Tadonki in France and Moon Hoon in South Korea, who contributed information from their respective countries. They are not responsible for any errors or omissions regarding those countries, and did not participate in the writing of the report.

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4 “Publication 862: Sales and Use Tax Classifications of Capital Improvements and Repairs to Real Property”; “Sales Tax and Home Improvements: Tax Topic Bulletin S&U-2.”

The United States and Canada have fewer elevators per capita than any other high-income country for data could be found. This shortage of elevators in North America drives what types of buildings are constructed at all, and what types of buildings, when built, are equipped with elevators. While accessibility rules mandate elevators in certain situations, the reality is that regulations respond to market conditions as much as they shape them. And in the United States, regulations mandating elevator access for multifamily buildings can be much looser than in other high-income countries (which, despite generally being classified as "high-income," are almost always less wealthy than the United States).

At last count, the United States had over 1.03 million elevators.[1] America is tied with Italy and Spain for second place in total installed units, behind China's fleet of over 8 million elevators.[2] While 1.03 million installed units is in absolute terms among the highest in the world, America has fallen far behind when the number of elevators is adjusted for population. The U.S. has very few elevators on a per-capita basis for a highly developed nation, even accounting for its suburban character (the number of elevators in Canada is not known, but one rough estimate suggests it is similar to the United States on a per capita basis, and recent provincial figures back that up).[3] A major reason for the relatively few elevators in the U.S. and Canada is the cost of installation: American and Canadian developers pay roughly three times as much to install an elevator as developers in high-income peer countries in Europe and Asia.

High elevator costs conspire with other forces to push North American developers to build townhouses rather than the small condominium buildings more common abroad. Where small apartment buildings are built in North America, they are more likely to be walk-ups than similar buildings in Western Europe. North American apartment buildings have more units per elevator core than their similarly tall counterparts in Western Europe, in part to spread the high cost of elevators across more apartments. And unlike in Europe and Asia, elevators are almost never added to existing walk-up buildings in North America, depriving aging populations of improvements in access in apartments that have already been built.

2.1 Stock

Exact data on the number of elevator installations is hard to come by, but according to the data we were able to assemble, there is no high-income country on earth with fewer elevators per capita than the United States. The United States's total elevator stock, in absolute terms, roughly matches those of Spain or Italy, individually, despite having seven and five times the population, respectively.

America's vast geographic expanse and love of single-family houses explain some of the country's lack of elevators, but not all of it. Single-family houses aside, the United States has over 32 million apartments, while Spain has fewer than 13 million apartments but about the same number of elevators.[4] The U.S. has 40 percent fewer elevators per capita than the Netherlands, despite 30 percent of the American housing stock being in multifamily dwellings (and 19 percent in buildings with at least 10 units), compared to a total multifamily housing share of just 21 percent in the Netherlands.[5] New York City has roughly the same population as Switzerland and even more New Yorkers live in apartment buildings than Swiss residents do, but New York only has half the number of passenger elevators.[6] No matter how you slice the numbers, America has fallen behind on elevators.

1 "Elevator and Escalator Fact Sheet."

2 de Mas Latrie, "Closing the Distance Between Europe and China."

3 "Fact Sheet."

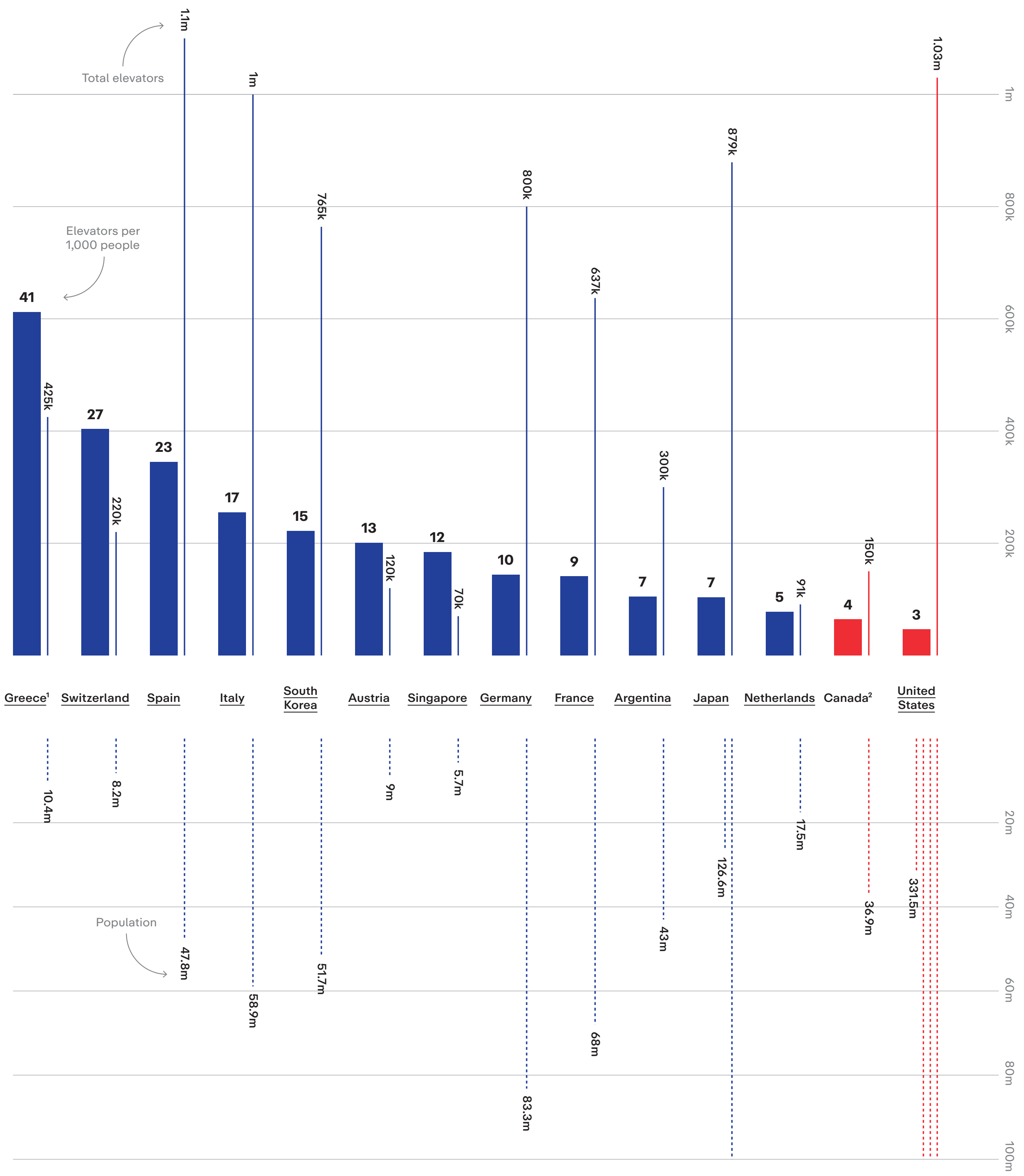
4 "American Housing Survey (AHS): 2021 National — General Housing Data — All Occupied Units"; "Número de viviendas principales según tipo de edificación y régimen de tenencia"; "Federación Empresarial Española de Ascensores."

5 "Distribution of Population by Degree of Urbanisation, Dwelling Type and Income Group - EU-SILC Survey."

6 "PLUTO and MapPLUTO"; "SNEL: Sicherheit für bestehende Aufzüge, SIA 370.080"; "Wohnungen nach Kanton, Gebäudekategorie, Anzahl Zimmer, Wohnungsfläche und Bauperiode"; "DOB Celebrates National Elevator and Escalator Safety Awareness Week."

Figure 1

National elevator stocks per capita



Some figures may include devices other than elevators, such as escalators and construction hoists, but the vast majority of devices in any country are elevators. Population figures correspond as closely as possible to the year of the elevator data.

Links to original sources.

1 This estimate is conservative, and there may be up to 600,000 elevators in the country.

2 No nationwide figure was available for Canada, so data from Ontario, British Columbia, and Saskatchewan was extrapolated to arrive at a nationwide estimate.

2.1.1 Walk-ups and elevator buildings

With far higher costs and fewer elevators per capita, elevators are provided in new apartment buildings in Western Europe at building heights and unit counts which are deemed too low to justify the cost in the United States. Federal accessibility law and locally adopted building codes in the U.S. are far more permissive of walk-up apartment buildings than regulations in Western Europe, likely as a consequence of high elevator costs. Developers in the U.S. build new walk-up rental apartments and condos to sizes, heights, and rents that shock Western Europeans, and developers in the U.S. seek out loopholes and vagueness in codes to avoid building elevators in circumstances where not only building regulators, but also the market, would demand accessibility in Europe. In high-cost coastal American cities, elevator access for new luxury apartments can fall behind access found in middle-class housing in Southern Europe built more than half a century ago.

Europe

The early history of elevators in Europe largely mirrors that of North America, with elevators first coming to the continent in the 19th century, but largely limited to commercial and institutional buildings. Elevators began to be used in residential buildings in Europe in the early 20th century and particularly after World War I, but due to their cost relative to local incomes, they were relegated largely to luxury buildings. Early hints of Italy's modern elevator abundance can be seen in six- and seven-story buildings from the 1930s, with a dozen or fewer apartments and two elevators – one for residents and the other for domestic staff.[7]

After World War II, Europe's elevator industry took off in a much bigger way. Southern European countries emerged as the largest markets, with rapid post-war urbanization and densification in Italy, Spain, and Greece bringing small elevators to middle-class condominium buildings (though not yet, for the most part, social housing).[8] Northern Europe was less aggressive with elevator building, perhaps due to the preference among elites and middle class for single-family houses, and walk-up buildings of three stories remained common for longer than in Southern Europe.

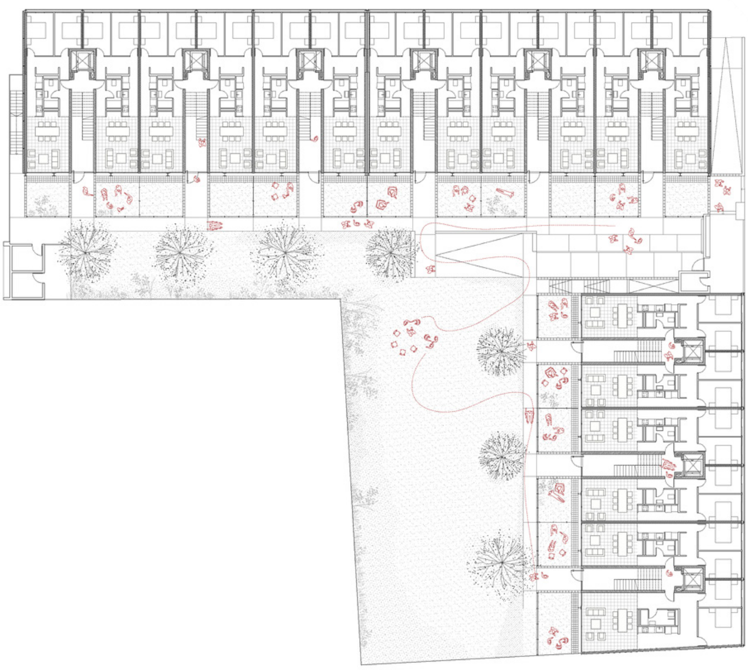
Today, Northern Europe has caught up to Southern Europe in access to elevators in new buildings, and elevators are an expected feature of virtually all new multifamily buildings – whether rentals or condos, social or private housing, and almost any size – across Western Europe. On the Spanish island of Mallorca, a recently built 54-unit social housing project includes a total of nine elevators – one for each stairwell, with four stops (at the underground parking, the ground floor, and the two upper floors) serving six units each, with only four of the apartments above the ground floor.[9] In Switzerland, elevators are so ubiquitous in new buildings that proper commercial elevators can be found even in some luxury two-family houses.[10]

7 Primari, "La Ca' Brütta di Muzio e il IV libro del Serlio: l'invenzione del linguaggio"; Garnerone, "Casa Rustici"; Garnerone, "Edificio per abitazioni 'Casa a ville sovrapposte.'"

8 "Rosta Nova INA-CASA"; "Franco Albini _ Via Felice Orsini 68 _ 1953."

9 Ott, "54 Social Housing in Inca, Illes Balears / Joan Josep Fortuny Giró + Alventosa Morell Arquitectes."

10 "Generationenhaus Schauburg"; "Neubau Zweifamilienhaus Emmen."



Carrer del Canonge Sebastià Garcias Palou, 54, 07300 Inca, Illes Balears, Spain, photograph by José Hevia

2.1.1 Accessibility laws and codes in Western Europe have varying requirements for the installation of elevators in multifamily buildings, but for the most part, market supply and demand provides elevators even for buildings that don't reach these required thresholds.

France recently strengthened its accessibility rules, and now requires elevators for apartment buildings of at least four stories, compared to the previous five-story threshold. But about 80 percent of new four-story apartment buildings built in France around a decade before the law was updated already had elevators, rising to almost 100 percent for private housing, and the stricter rules were mainly aimed at ensuring that four-story social housing projects are equipped with elevators.[11]

In Germany, the national model building code requires elevators in apartment buildings where the floor of the uppermost level is at least 13 meters above grade in a section more or less adopted in all states, and at least one floor must be accessible in any building with more than two apartments (effectively requiring an elevator for buildings where the ground floor is parking or non-residential).[12] But while five-story apartment buildings can legally be built without elevators, in practice even most small three-story buildings are provided with them, as the expense is low enough that it is justified by the additional rent or higher purchase price that more accessible units can command.

Elevator requirements for new multifamily buildings vary in other countries in Europe. Italy and Spain, with the largest installed elevator fleets in Europe, also have some of the strictest accessibility requirements. They require an elevator (or room to add one at a later point) in all multistory apartment buildings, as does Sweden.[13] In some countries – for example in Norway or Denmark, where an elevator is required starting at three stories – a developer will sometimes try to dodge the requirement by having bilevel apartments on the top two floors, making the second level the tallest level of entry.[14] In Switzerland, the law varies by canton, but the Canton of Geneva requires an elevator for any building with at least three levels (including any underground levels, which nearly all new apartment buildings have for parking and storage), while the Canton of Zurich requires ground floor accessibility starting at five units and full-building access by elevator or ramp above eight units.[15] Given market preference though, it is rare to find a new multi-unit building of any size in Switzerland without an elevator.

United States

The United States was the birthplace of the modern elevator in the 1850s, and for the first half of the device's life, American cities likely had the most elevators. The elevator was a key enabler of the commercial skyscraper, a building typology born in the United States that would come to define its cities. High-rise American downtowns stood in contrast to European city centers, which were mostly capped at mid-rise

11 Dal Secco, "Ascenseurs à R+3 sans condition : S. Cluzel explique !"

12 "Bauordnungen/ VV Technische Baubestimmungen."

13 "Documento Básico SUA: Seguridad de utilización y accesibilidad," Sección SUA 9 Accesibilidad, 1.1.2; "Testo aggiornato della legge 9 gennaio 1989, n. 13, recante: 'Disposizioni per favorire il superamento e l'eliminazione delle barriere architettoniche negli edifici privati'.," Art. 1; "Boverket's Mandatory Provisions and General Recommendations, BBR: BFS 2011:6 with Amendments up to BFS 2018:4."

14 "Byggteknisk forskrift (TEK17) med veiledning," § 12-3; "Executive Order Nº 1615 of 13 Dec. 2017 (in Force)," Chapter 10, Section 244.

15 "Règlement concernant l'accessibilité des constructions et installations diverses (RACI), L 5 05.06," Chapitre II, Art. 8; "Planungs- und Baugesetz (PBG), 700.1," § 239.

2.1.1 heights. The elevator began to be used at scale in American apartment buildings in the early 20th century, starting in upper-class buildings and working its way down the income scale as the century progressed.

New York City had a high concentration of elevators, with Manhattan already having 10,000 passenger installations by 1914, a quarter of which were in residential buildings.[16] Russian revolutionary Leon Trotsky chose an apartment in a Bronx "workers' district" to rent for a three-month stint in New York City in 1917 after being run out of Europe, where an "automatic service-elevator" (likely some type of dumbwaiter) was among his list of "all sorts of conveniences that we Europeans were quite unused to."[17] Elevators figured prominently in New York City's uptown and outer borough apartment booms in the years between the two world wars and in the two decades after the end of World War II, in buildings typically of five or more stories in neighborhoods opened up to development by the new subway system.

America's elevator-fueled urban building boom would come to an end as the country turned away from its cities and towards suburban growth as the post-war decades wore on. New York City adopted a new zoning code in 1961 that severely curtailed infill development tall enough to make use of an elevator, and cities and suburbs across the nation passed similar restrictions around the same time and in the decades following. Multifamily development continued, but in more suburban areas, and at lower heights. One of the most popular building types was the garden apartment. This two- and later three-story multifamily style featured a few apartments per landing off of a series of separate, often exterior stairways, chained together in a row (sometimes winding around a courtyard) to form a larger building. Like the similar building typology in Germany and other Northern European countries, these were walk-up buildings, as were the smaller two-story infill versions popular in West Coast cities like Los Angeles and Oakland. Elevatored apartments were still being built in smaller numbers in dense cities like New York and Chicago, but the elevator industry turned more to commercial buildings like offices and hotels, and special residential uses like senior living, as the nation's homebuilders turned to the suburbs.

Today, demand – and in many cases zoning – for elevatored multifamily buildings has returned. In 2016, the industry was back to installing around 40,000 elevators each year in the United States and Canada.[18] Elevators continue to be installed in high-rise condo and rental apartment towers, but are also now found in large mid-rise apartment buildings with dozens or even hundreds of apartments. Units in these four- to six-story buildings, sometimes called "5-over-1s," are arrayed along either side of long, straight, hotel-like "double-loaded corridors" in urban and suburban locations across the U.S.

But while many elevatored apartment buildings are now being built across the United States, many walk-up complexes are also still being built, at a scale and to heights that are unique in the developed world.

16 "Building Code Ordinances Modified," 1034.

17 Trotsky, *My Life*, Chapter 22.

18 "Elevator and Escalator Fact Sheet."

2.1.1 Three-story garden apartment complexes, with four apartments per floor around each staircase, are still a popular typology in suburban and exurban areas in the American Sunbelt. On the fringes of Austin or the exurbs of Charlotte or Tampa, for example, these buildings continue to be built as walk-ups, much as they were over half a century ago. These types of buildings largely have elevators in Europe even when not legally required, but six to 12 units in each core (four to eight of which would be above the ground floor) are not enough to justify the high cost of elevators in America. And in some cases even much larger buildings are, in developers' estimation, not worth the cost of an elevator. One newly built market-rate apartment complex on the outskirts of Austin has two three-story buildings with 60 units each, and no elevator.[19] Another in a downtown-adjacent neighborhood in Dallas has a three-story walk-up with 86 units and no elevator (the developer said that the concern was less the cost of installation than the high operating costs, since the local market could not support the rents of luxury buildings).

Within the denser cores of American cities, developers sometimes build even taller walk-ups. Particularly in New York City, Seattle, and Hawaii, building codes allow up to six stories (rather than the usual three in the U.S.) to be served by a single staircase, enabling the development of buildings on small lots with only a few units per floor. With fewer apartments in each building, the per-unit cost of an elevator rises, and it becomes tempting for developers to test the rental market's tolerance for walk-ups, pushing them to four, five, and even six stories. Unlike two- and three-story garden apartments farther from city centers, these types of buildings can, especially on the mainland, have quite high rents. In the author's own condo building in Brooklyn, a fifth-floor one-bedroom, one-bathroom apartment built in a mid-2010s walk-up recently rented for $3,800 per month.

New York City's high-quality property and elevator data allow for a quantitative analysis of developers' propensity to build elevators. It shows that four-story buildings (which are the tallest that can be built without an elevator according to the city's building code, at least without some occasionally exploited loopholes) almost never have elevators. The analysis found that the likelihood of a new four-story multifamily building having an elevator in New York City does not exceed 50 percent until the building reaches a total gross floor area of 24,000 square feet.[20]

New five-story walk-ups are also in various stages of development in Los Angeles and Honolulu. Both cities have programs that offer zoning relief for buildings with rents that do not exceed a certain level, but without any particular design standards that require elevators even where ordinary codes and laws do not. A zoning relief bill in Honolulu was written with taller walk-ups in mind, with the text specifying that no elevator is required to take advantage of the program, and developers have built apartments up to five stories tall using the law.[21] In Los Angeles, developers have filed plans to build five-story walk-ups with as many as 72 small studio units using the city's ED1 program.[22]

19 "Interactive Property Map."

20 "PLUTO and MapPLUTO"; "Elevator Device Data - FOIL."

21 "A Bill for an Ordinance: 7 (2019)"; Pang, "Developer Credits Bills with Making 5-Story Walk-up Complex Feasible."

22 Aaron Brumer & Assoc., Architects, "69-Unit Multifamily Building: 1726 & 1728 N. Alexandria Ave., Los Angeles, CA 90027"; Jeff Zbikowski Architecture, "Mariposa Apts: Entitlement Set."

A row of walk-up apartment buildings built in 2010 at 315-325 Greene Ave., Brooklyn. Photo by Andressa Randis.

2.1.1 And in Seattle, developers have gone even taller in recent years, developing a number of new six-story buildings, mostly market-rate, without elevators without any difficulty leasing the units, according to somebody involved in the development of one. Not only does omitting an elevator save developers money on construction and operations, but it also allows developers to squeeze more leasable space from both the unbuilt elevator shaft and from space saved in apartment bathrooms that are not wheelchair-accessible since they can't be reached in one anyway (see "Areas for further research").

Tall walk-ups are allowed under the model building code used in the United States, which does not require an elevator for apartment buildings of any height, deferring to federal law on the matter. Federal law, since the passage of the Fair Housing Amendments Act of 1988, only requires an elevator for new multifamily buildings if the ground floor contains no apartments (if it is reserved for parking or retail, for example), and even in that case, the elevator only has to reach the first level with apartments, not all of the floors above.[23]

The International Building Code, the model building code adopted in almost every U.S. jurisdiction (and in no other major country), has a section titled "Elevators required," numbered as Section 1009.2.1, which, confusingly, does not in fact require elevators:

> In buildings where a required accessible floor or occupied roof is four or more stories above or below a *level of exit discharge*, not less than one required *accessible means of egress* shall be an elevator complying with Section 1009.4.[24]

The section is confusing in two ways. For one, "four or more stories above…a level of exit discharge" means what an ordinary American would call the fifth story, as the level of exit discharge is typically the ground floor, the first story above it is the second floor, and so on. More consequentially, the section starts out by referring to "a required accessible floor" without defining it – the term is unitalicized in the text, meaning there is no definition in Section 202, "Definitions." According to those involved in drafting the model code, "a required accessible floor" is a reference to federal law. As long as federal law allows only the ground floor of a multifamily building to be accessible, adopted building codes generally impose no further requirements. As far as this author is aware, only New York City modifies the text to require elevators in buildings of at least five stories.[25]

And while New York City is not as permissive as the rest of the country, developers in New York still seek out loopholes to avoid the high cost of elevators for relatively small buildings. One common way to push the four-story walk-up limit is to restrict the fifth floor to at most one-third of the area of the lower floors and make it accessible only through a private staircase from within a dwelling unit that starts on the fourth

23 Barrier Free Environments, Inc., "Fair Housing Act Design Manual: A Manual to Assist Designers and Builders in Meeting the Accessibility Requirements of the Fair Housing Act."

24 "International Building Code," Section 1009.2.1.

25 "2022 New York City Building Code," Section 3002.4.

2.1.1 story, a trick commonly executed in new buildings. Buildings of this "4⅓-story" type range from relatively low-cost rentals to full-floor condos selling for more than $2 million. Another path to taller walk-up buildings is to extend an older building upwards, grandfathering it into an older building code (as in the author's own building). There is a strong market for tall walk-up buildings across the city at a range of different price points, with tenants, condo buyers, and developers alike comfortable buying, selling, and renting units on and above the fourth floor without elevators, where allowed.[26]

Going forward, recent trends in urban planning call into question North America's commitment to elevators and accessibility in new apartment buildings. Pro-housing advocates, identifying with the slogan "yes in my backyard" (or YIMBY – a play on "not in my backyard," or NIMBY), are beginning to win changes to zoning and other planning laws that restrict development on most urbanized land in North America to single-family houses. Zoning for "missing middle" housing – a term for housing typologies denser than a detached single-family house but less costly than large mid- and high-rise apartments, which have gone "missing" in modern planning – involves making room for small two- through four-story buildings. These buildings are not tall enough to require or justify elevators in the U.S., a fact which does not go unnoticed by proponents. In one report, builders described the most viable type of missing middle multifamily housing to researchers at the Terner Center for Housing Innovation at the University of California, Berkeley as having eight to 12 units, "without elevators."[27]

Minneapolis made headlines in 2018 by abolishing single-family zoning across the entire city, but most land is only zoned for three units up to three stories, which is not tall enough to justify an elevator given North American costs.[28] An update to Sacramento's general plan will allow more units on each single-family lot, hoping to stimulate more infill than Minneapolis has, but still limited to around three stories, also shy of the height where an American developer could afford to install an elevator.[29] In Canada, Toronto's city council recently voted to allow up to four units on land previously zoned for single-family houses, and Vancouver's upcoming "multiplex proposal" will allow buildings of up to six units and three stories, all of which will largely be walk-ups.[30] And townhouses – defined as small-lot, often attached single-family houses of two to four stories – are an increasingly popular dense infill building type in cities like Houston, Denver, Philadelphia, and Calgary, which sidestep even ground floor accessibility requirements and offer no elevators (except, occasionally, slow models allowed to be built to lesser standards in very high-end homes).[31]

Urbanist ambivalence towards elevators and idolization of walk-ups has a long history in North America, dating back to ur-urbanist Jane Jacobs. In *The Death and Life of Great American Cities*, the New York City- and later Toronto-based writer repeatedly portrayed elevator buildings as anti-urban and sterile, with the cabs being filthy and dangerous. While

26 "164 S. Oxford Street #PH"; "625 Warren Street #4."

27 Garcia et al., "Unlocking the Potential of Missing Middle Housing."

28 "Height."

29 Dyett & Bhatia Urban and Regional Planners, "Sacramento 2040 General Plan, Public Review Draft."

30 "Multiplex Proposal Update: Adding Missing Middle Housing + Simplifying Regulations In Low Density Neighbourhoods"; Jeffords, "Toronto City Council Approves Multiplexes to Address Growing Housing Crisis."

31 Hamilton, "Learning from Houston's Townhouse Reforms."

2.1.1 she took pains to clarify that she wasn't against all buildings with elevators, she wrote that "[e]levator apartments" can be "probably the most dangerous way of doing [density]." Later in the book she devoted a page to the problem of elevators in high-rise public housing projects, listing all of the evils that can occur in them: "children urinat[ing]," "extortion and sexual molestation of younger children by older children" by day, and "adult attacks, muggings, and robberies" by night. She proposed full-time elevator attendants as the "only solution that I can see to this problem," validated by what she'd heard of some buildings in Caracas, Venezuela, where female tenants operated elevators by day and were replaced by men at night.[32] Writing in 1962, Boston-based planner and sociologist Herbert Gans echoed Jacobs's criticisms, writing in a review of her book that "the interior streets and elevators" of public housing projects "invite rape, theft, and vandalism. Areas like this are blighted by dullness from the start, and are destined to become slums before their time."[33]

The distaste from Jane Jacobs and her mid-century urbanist peers for elevator buildings would eventually leap off the page and into real world planning in New York. In 1959, Jacobs led a group of local activists who tried to convince the New York City Housing Authority to scrap their plans for high-rises at the future site of the DeWitt Clinton Houses in East Harlem, and instead opt for an alternative design of four- and five-story walk-ups. The public housing authority ignored the group's proposal and instead built something close to the original plan, but the anti-elevator contingent would eventually prevail upon the city at the planned West Village Houses in Jacobs's own West Village neighborhood. Along half a dozen blocks of Washington Street, a block inland from the deindustrialized Hudson River waterfront, Jacobs and activists in her orbit agitated against high-rise towers, or even mid-rises tall enough for elevators. "The dangers of unattended elevators to children – and adults," read a brochure, "are already too well known to require retelling here," and anyway, in the Village, they wrote, "walking upstairs is considered a sound and healthy diversion."[34]

In 1969, the group won their fight. Blocks of five-story walk-ups were approved for the sites, and the city's Housing and Development Administrator told the *New York Times* that "[o]pposition to the plan had centered around" the lack of elevators, but "[i]n my opinion, the design is the plan's greatest strength. It conforms to our commitment that new housing must not destroy a community," as elevator buildings presumably would, "but should, instead, strengthen it." Like 19th century brownstones, the austere red brick buildings were designed with steps leading to even the ground floor apartments to offer privacy from the street, so none of the units are accessible to this day.[35] The lack of elevators would make the West Village Houses ineligible for a federal mortgage, so the city had to redirect funding from lower-income neighborhoods to subsidize it, with financial assistance to the project continuing for generations.[36]

Jane Jacobs's and Herbert Gans's dislike of elevator buildings was tied to what Jacobs called "the related corridor problem." By this she meant

32 Jacobs, *The Death and Life of Great American Cities*.

33 Gans, "The Death & Life of Great American Cities, by Jane Jacobs."

34 Kanigel, *Eyes on the Street*.

35 Shipler, "'Village' Group Wins 8-Year Battle to Build 5-Story Walk-Up Apartments."

36 Martin, "West Village Houses a Monument to a 1960s Development Battle."

the North American habit, which grew stronger in the latter half of the 20th century, of arraying apartments off of long corridors. This stands in contrast to the more common pattern in the rest of the world of a few apartments organized around the landing of a single staircase. American and Canadian building codes don't usually allow these so-called "point access blocks," as they require two stairways in even small buildings. North American codes result in long corridors, as architects and developers pile as many apartments as possible onto each floor to avoid expensive duplication of these two required staircases. This tendency to load a single corridor with many apartments also makes North America's very expensive elevators more affordable on a per-unit basis.

Americans and Canadians are rethinking these code requirements, and smaller single-stair point access blocks are coming back in style among planners and architects, and perhaps soon, in building codes themselves.[37] If these new buildings are equipped with elevators, they would solve many of the problems of anonymous, hotel-like corridors that Jacobs and Gans associated with elevator buildings. But if left unchecked, the high cost of North American elevators would become even more of a problem as the number of apartments in a building falls, discouraging construction beyond certain heights and causing developers to forgo elevators where they are optional.

2.1.2 Elevator retrofits in existing buildings

People in the developed world are rapidly aging, and housing stock growth is slowing down as population growth is too. It's a common saying in architecture that 80 percent of buildings that will exist by 2050 have already been built, driving home the need to retrofit existing buildings for sustainability in addition to perfecting techniques for new construction.[38] The same logic applies to accessibility and elevators – if most of the homes that we'll grow old with have already been built, then it is necessary to find ways to bring elevators to buildings that don't currently have them. And so across Europe and Asia, governments are using subsidies and other policies to support the construction of elevators in older walk-up apartment buildings. Critical to those efforts, though, is the affordability of the installations, as subsidy and private funds for retrofit projects are limited.

Adding elevators to older buildings is more expensive and logistically challenging than installing them in new ones, especially if the building is occupied and access must be maintained throughout the construction project. One of the biggest challenges is the issue of placement. Ideally, the staircase has enough room inside of it to build the shaft, making it possible to offer step-free access to upper floor apartments without leaving the footprint of the building, altering the staircase, or taking living space away from apartments. If that room is not available, then the shaft can be built outside of the building and attached with a balcony, or space can be carved out of dwelling units.

37 Speckert, "The Second Egress: Building a Code Change"; Eliason, "Unlocking Livable, Resilient, Decarbonized Housing with Point Access Blocks"; Smith, "Single-Stair Tracker."

38 "'80% of the Buildings That Will Exist in 2050 Already Exist' – Bringing Net Zero to the Masses."

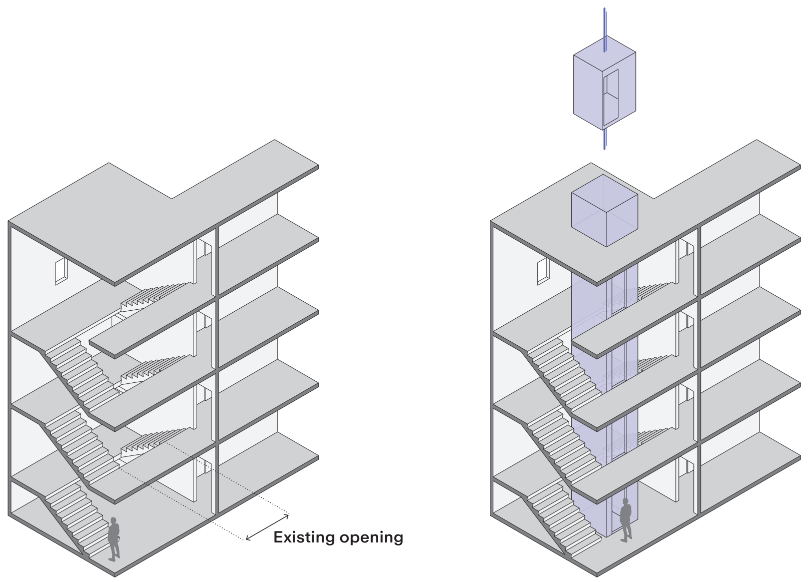
Figure 2

Elevator retrofit drawings

Reference drawings by Alfred Twu.

Existing opening

An existing opening large enough for a shaft and elevator offer the cheapest retrofit option. The work can be performed with little demolition, and with little disruption during construction.



Enlarged opening

An existing opening that is not large enough for a shaft and elevator can still sometimes accommodate a similar design. The work requires some demolition and narrowing of the stairs (which may sometimes require building code relief for the width of the stairs), and involves more disruption during construction.

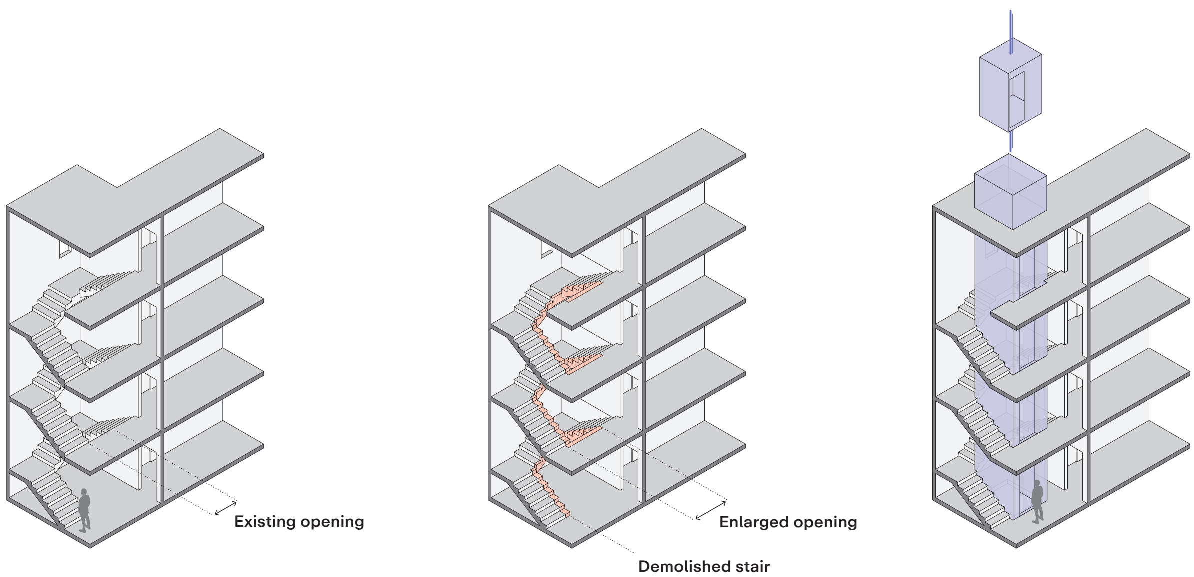
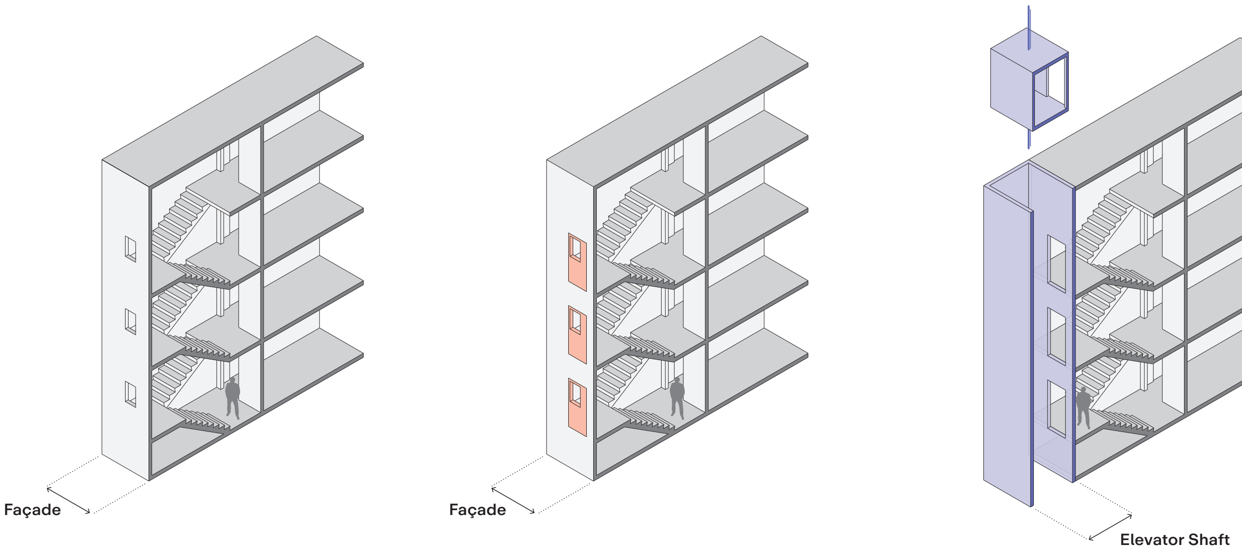


Figure 2

Reference drawings
by Alfred Twu.

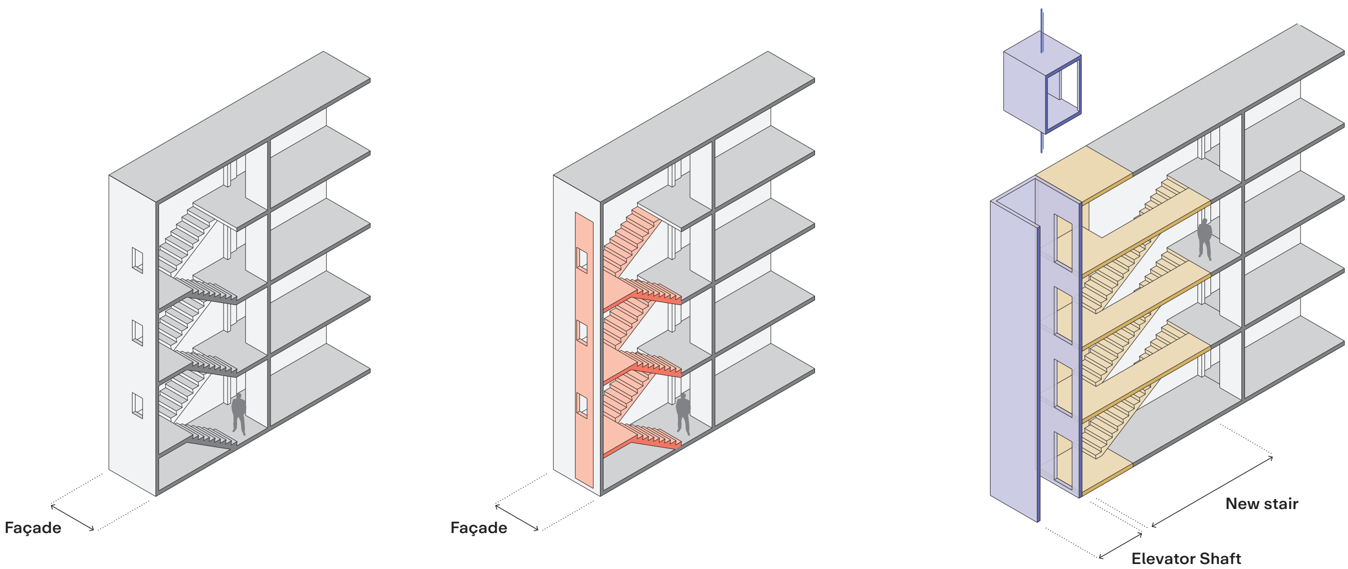
Mid-landing façade addition

If there is no room within the building but “switchback stairs” sit against the façade of the building, an elevator can be added which reaches the landings between floors. This does not offer full accessibility, but is useful for people with ambulatory disabilities (like the elderly or parents with young children) and is cheaper than providing full step-free access.



New stair façade addition

A more expensive alternative to the mid-landing façade addition involves demolishing the staircase and rebuilding it to extend beyond the old face of the building, with an elevator provided at the same level as the units. This provides full accessibility but costs more money, and requires a larger addition to the footprint of the building.



2.1.2 U-shaped, or switchback, staircases with landings halfway between stories present special design challenges, since the easiest place to put the elevator is on the outside of the building, where residents would still have to climb half a flight of stairs to get from the elevator to their apartment. Sometimes this is simply accepted as a compromise – wheelchair users won't be able to move independently, but the elderly and ambulatory disabled who can manage a few stairs, parents with young children, or movers or anybody else carrying large items can at least avoid most of the steps in the building. But for more ambitious property owners who want full accessibility, the staircase can be demolished and rebuilt to extend beyond the old façade of the building, replacing switchback stairs with a straight flight of stairs heading down and beyond the old façade to an elevator at the end, and then a narrow corridor heading back to the apartments.[39]

Europe and China

Costs in Europe can start around the low tens of thousands of euros for installations that can sit inside of a stairwell – not much more than an elevator installed in an already built shaft in a new building – and rise to over €100,000 for an elevator that has to be attached to the façade or break through existing floors.[40] In Chinese retrofits, elevators typically attach to the façade, and cost less than $100,000.[41] Since older apartment buildings in Europe and Asia are typically designed with only a few units per floor off of a single staircase and apartments are usually individually owned, as few as a handful and up to a few dozen different owners have to come together to agree to move forward with a project – enough owners to create a coordination hassle, but few enough that the cost of the project has to be carefully controlled lest the installation become unaffordable.

As with all things elevators, China has the largest market for retrofits. A whopping 51,000 elevators were retrofitted into older buildings in China in 2021 – about as many elevators as were sold in total in North America. Elevators were not common in new Chinese apartment buildings until the late 1990s, so some walk-ups are taller than the five or six stories that was normally the limit in the West, with one 24-story walk-up sitting on a steep slope in Chongqing attracting particular attention (though, to be fair, it has entrances on multiple levels).[42] China's retrofit installations are part of a broader goal, with high-level government backing, to retrofit up to 3 million older walk-up apartment buildings for the country's rapidly aging population, with one source claiming that over 70 percent of "old buildings inhabited by the urban elderly do not have elevators installed." Apartment owners pay into projects in proportion to their benefit, with those on upper floors paying more than those on lower floors. Owners near the ground who won't benefit at all sometimes are sometimes compensated for the noise and loss of light.[43] Local governments offer subsidies in the tens of thousands of dollars per new elevator, and contracts to display advertisements in cabins can even cover ongoing maintenance.[44]

39 "Nachgerüstete Aufzugsanlagen."

40 "Instalación de ascensores en Barcelona: Solicite precios para instalar ascensores en su edificio"; "Ascensor Comunidad de Vecinos, Precios, Instalación y Ayudas"; "¿Cuánto cuesta poner un ascensor?"; Torío, "¿Te han dicho que tu edificio no puede tener ascensor? Esta es la solución"; "Aufzug nachträglich einbauen ist einfacher als gedacht!"

41 Bradsher, "As China Ages, a Push to Add Elevators Offers a New Kind of Economic Relief."

42 "Chongqing Building with 24 Floors and No Elevator Goes Viral."

43 Ma, Li, and Yang, "Housing Price Appreciation Effects of Elevator Installation in Old Residential Areas: Empirical Evidence Based on a Multiperiod DID Model"; Bradsher, "As China Ages, a Push to Add Elevators Offers a New Kind of Economic Relief."

44 Chen et al., "Analysis of Adding Elevator to Multi-Storey Residential Buildings in Xining Based on Cost Benefit Analysis."

2.1.2 In the West, Spain is one of the leaders in infill elevators. Adding elevators to occupied apartment buildings is so common that Spain has developed a consistent legal framework to make the process easier for owners, and in rarer cases even require that the work move forward against the wishes of a building's majority. The most common path to a retrofit is a law that allows the majority of owners within an apartment building to vote to undertake accessibility projects, such as the installation of an elevator, with mandatory contributions from everybody who owns a unit in the building. But even without majority consent, a single owner who is disabled or over the age of 70 can compel the rest of the building to contribute to such a project, as long as the additional annual cost of the work – after subsidies by the government, or even residents themselves – does not exceed that of 12 months of ordinary condominium fees.[45] And to facilitate the work even beyond government subsidy programs, public sidewalk space must be made available by local governments to accommodate the elevator if needed.[46]

Beyond Spain, retrofit projects can be found all across Europe. In the 1980s, the Swedish government began a program of working with municipal housing corporations to install prefabricated elevators into post-war walk-up apartment buildings.[47] Germany has offered both grants and loans for projects, while the Croatian Lift Association claims that two-thirds of all buildings in Croatia with at least four stories have expressed interest in installing elevators.[48] In Italy, the government will rebate 75 percent of the costs to install an elevator and do other accessibility work in condominium buildings, up to €30,000 or €40,000 per unit, depending on the building's size.[49]

North America

In North America, elevator retrofits to occupied walk-up apartment buildings are much rarer. Americans and Canadians are just as concerned with accessibility as Europeans, but the cost of projects tends to be prohibitive. Installations in existing buildings are concentrated in loft conversions, or residential renovations of obsolete industrial or commercial buildings. Wealthy homeowners will sometimes install so-called limited use/limited application (LULA) elevators within their own existing single-family homes, but these are much slower than elevators used for multifamily or commercial projects, and typically only move residents between floors within a single dwelling unit.

In New York City, there were a flurry of private tenement house rehabilitations starting around the 1930s that added elevators, with the intention of making worn-out housing more desirable.[50] The renovations were rare, though, and involved clearing the buildings and often substantially reconfiguring the floor plans. Towards the end of the 20th century, there was a trend of non-profit housing operators combining vacant Old Law tenements and driving double-loaded corridors through the middle of the buildings, with an elevator located off the new corridor (sometimes

45 Ley 49/1960, de 21 de julio, sobre propiedad horizontal.

46 "Ref: c.u. 62-11."

47 Westling, "Elevators for Existing Buildings – Prefabrication and Pilot Series for Continued Development."

48 "Barrierereduzierung – Investitionszuschuss, Zuschuss 455-B"; "Altersgerecht Umbauen – Kredit, Kredit 159"; Yılmaz, "SEElift Zagreb Meeting."

49 Mammarella, "Bonus 75% barriere architettoniche prorogato al 2025."

50 "To Spend $300,000 on Bronx Houses"; "Urges Remodeling of Old Buildings."

in an old air shaft). Each tenement would start out with around 10 or 12 larger apartments, so combining multiple buildings would provide the economies of scale to justify costly elevator installations, especially since non-profit landlords had access to government subsidy.[51] More European- or Chinese-style exterior elevator retrofits to at least partly-occupied market-rate buildings did happen in New York, but were much rarer, and have never been offered government subsidy.[52]

Outside of New York, elevator retrofits in the rest of the United States are no more common. Chicago's tradition of back porches in small walk-up buildings could easily accommodate infill elevators, as could deck-access buildings (resembling motels, with an outside corridor connecting units next to each other) in mid-century buildings across cities in the American Sun Belt. Honolulu has many three-story deck-access buildings, where a dozen or more upper-floor units could be served by a single elevator. But with rare exceptions, the high cost of elevators in the United States precludes accessibility retrofits of even ideal building types. While subsidy programs would help, the five-figure sums offered by governments in Europe and China would not go very far in the much more expensive American elevator market.

2.1.3 Multifamily elevator ratios

User interviews show that some of the main concerns about elevators by North American wheelchair users who live in apartment buildings are redundancy and reliability. Multiple wheelchair users said they would not consider renting or buying an apartment that did not have access to at least two elevators, and many interviewed had experiences being trapped in (or out of) their apartment due to the lack of a working elevator. Single-elevator buildings (or segments of buildings) are common throughout the world, but fewer elevators are typically provided per apartment in North America than in Europe, due to the size and cost of the installations, as well as the relative lack of small elevator buildings in North America. Very few countries have legal requirements to install more than one elevator, with the market typically left to determine redundancy and elevator ratios.

Where an elevator is included in a project, the number of cabs is determined in different ways in North America and Europe. Due to much lower prices and smaller sizes in Europe, each elevator typically serves far fewer apartments than in North America. However, due to differences in building design and much larger apartment buildings in North America (only tangentially driven by elevator costs), multifamily residents there appear more likely to have access to more than one elevator. Mid-rise point access blocks of just a few apartments per floor served by each stairway and elevator are more common in Europe, with mid- and high-rise double-loaded corridor buildings with a single bank of elevators serving many more units more common in North America.

51 Oser, "Making Tenements Modern"; Peterson, "Tenements of the 1880's Are Adapting to the 1980's."

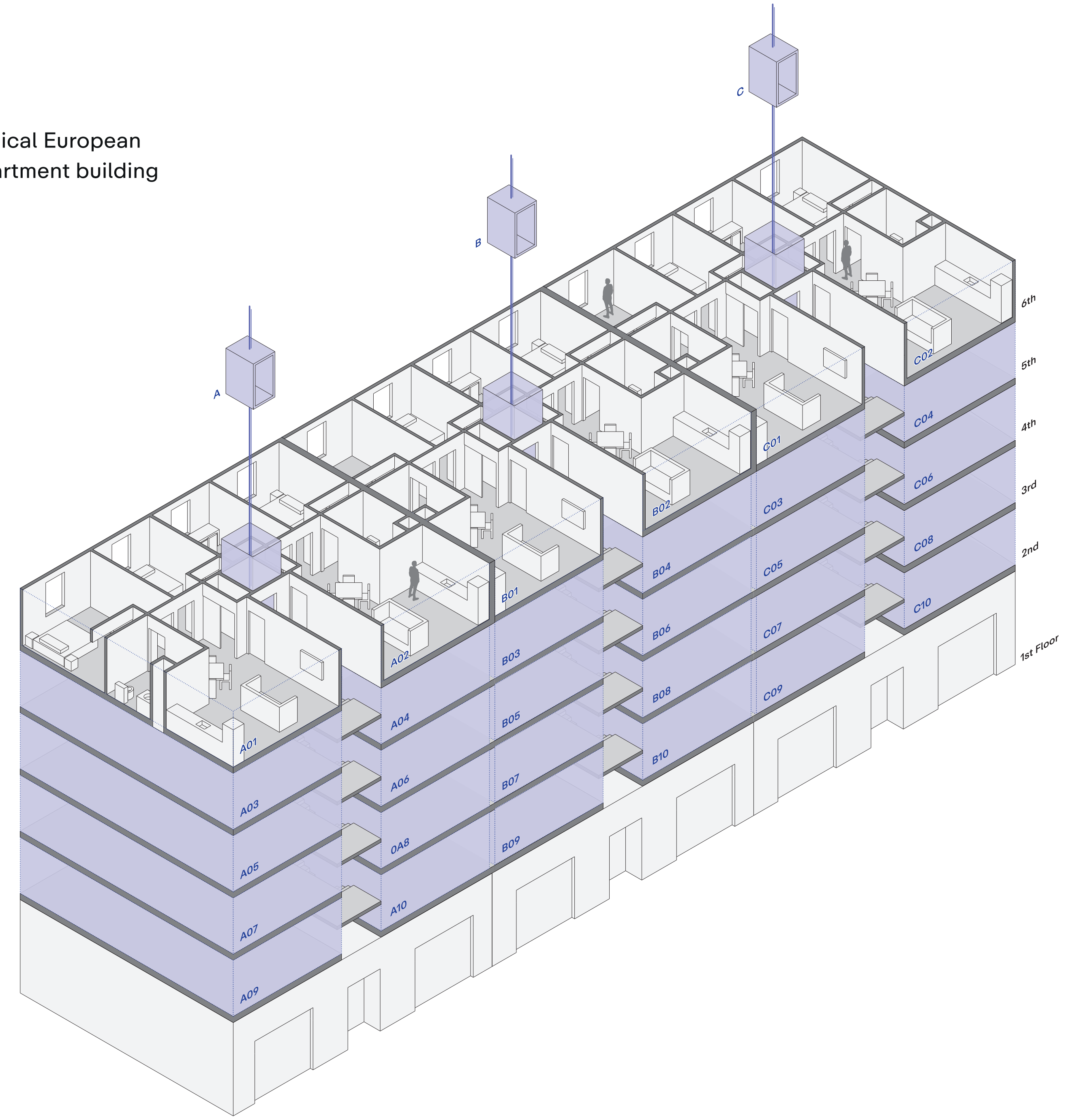
52 Oser, "Outside Elevators May Help Sell Renovated Walk-Ups."

Figure 3

European and North American elevator plans

Reference drawings by Alfred Twu.

Typical European apartment building



Floor composition

5,825 sq. ft.

Efficiency ratio 90%

6 2BR/1BAs

3 elevators

3 stairs

12 beds

6 bathrooms

6 kitchens

Circulation

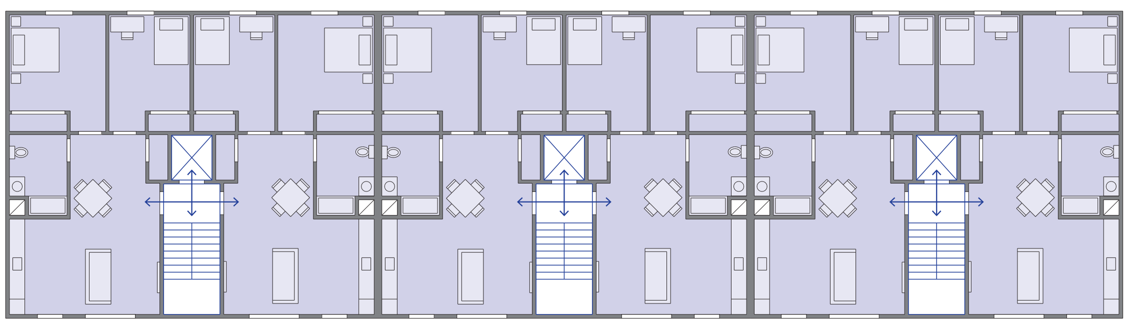
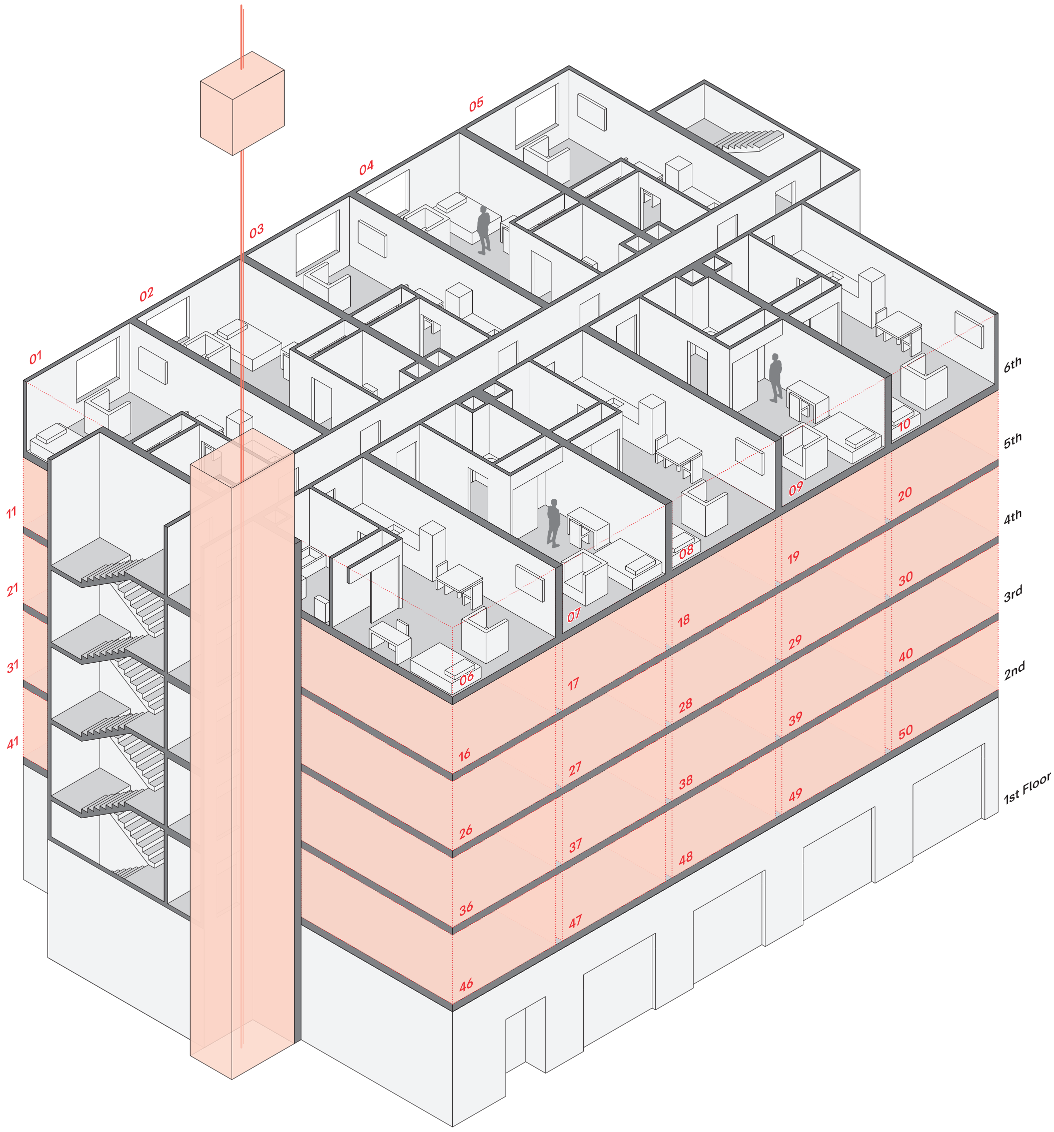


Figure 3

Reference drawings
by Alfred Twu.

Typical North American apartment building



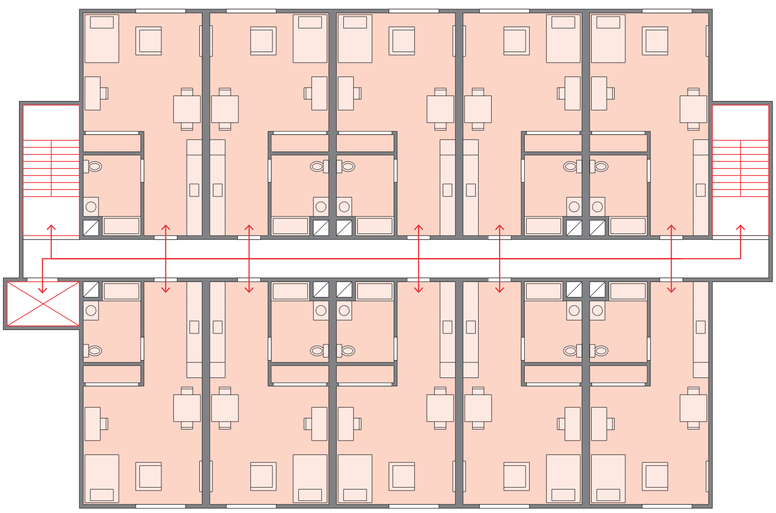
Floor composition

5,825 sq. ft.

Efficiency ratio 85%

- 10 studios
- 1 elevator
- 2 stairs
- 10 beds
- 10 bathrooms
- 10 kitchens

Circulation



In the U.S., the typical rule of thumb is that one elevator should be provided for every 50 to 100 apartments, with a second elevator usually provided if a building reaches around eight stories for redundancy and reasonable wait times, regardless of unit count (buildings this tall often but not always have more than 100 units, though New York City is sometimes an exception, with its small lots and more efficient vertical circulation requirements). In Canadian high-rises, it is common to have even more units served by a single elevator. One analysis conducted by a Toronto real estate professional of over 100 condo towers under development or recently completed in that city showed that the median ratio for buildings completed or with finalized designs is one elevator serving every 112 apartments, with some projects having 150 units or more units to each elevator.

In Europe, on the other hand, it is less common for buildings to be large enough that residents have access to more than one elevator. When buildings have multiple elevators, it is usually because they are broken up into multiple point access block segments, with each elevator serving a separate section. When buildings or segments thereof are large enough for two elevators, it's often because of height rather than unit count. As such, buildings in Europe with multiple elevators tend to have much lower ratios of units to elevators, with perhaps 30 units to each elevator rather than the 100 often found in North America.

This lower ratio of units to elevators in Europe likely has ramifications for reliability and availability, since mechanics say that breakdowns are correlated with use rather than time, although data is proprietary and unavailable (see "Areas for further research").

One consistency observed over a number of mid-rise multifamily projects in both the United States and Europe is that elevator costs, in buildings that have them, tend to equal roughly 2 percent of total construction costs, irrespective of the price of individual installations. In other words, developers respond to price by adding or removing elevators from their projects. Smaller developments in Europe have elevators where similarly sized ones in North America do not, while larger buildings in Europe have more elevators per apartment compared to those in North America.

2.2 **Cost**

Elevators in the United States and Canada are dramatically more expensive than those in the rest of the developed world. There are many ways to measure cost, but on the most basic level, new elevator installations – defined as the parts and labor to install a device in a new building, including the rails, support structure, machine, elevator cabin, car and landing doors, controller, and all other ancillary systems, but not the structure of the hoistway that it sits inside – are at least three times as expensive in the United States and Canada as in Western Europe.

Beyond new installations, there are other associated costs that are much higher in the United States and Canada than abroad. Elevator hoistways (also known as shafts) are more expensive to build, and their larger size in North America crowds out other productive uses of building space. Costs incurred after initial installation – money spent on service, maintenance, repairs, monitoring, and modernizations – are also much higher in North America than in Europe, with building owners paying a premium similar to that of new installations.

2.2.1 New installation costs

New elevators in North America cost at least three times as much as in Western Europe, after accounting for cost-of-living differences (in nominal terms, the North American cost premium is even higher). Elevators on both continents are sold as complete packages, and developers or general contractors are quoted a single fixed price that includes parts and labor, making costs easy to compare across regions. A few typical installations serve to illustrate the differences in price, which were confirmed by other proposals viewed.

In order to keep the installations analyzed as consistent as possible, only four- and six-stop elevators (plus one slightly more complicated five-stop installation from France) are presented. While high-rise elevators are the most technologically interesting and tall buildings would not be possible without elevators, most elevators in the world are in fact low- and mid-rise installations. These are also the most homogenous, with machine room less (MRL) electric traction models being most popular for these heights in both Europe and the United States (hydraulic elevators, which are an older technology that has largely fallen out of use in new installations in Europe, still have significant market share in North America, and are slightly cheaper to install, but come with higher operating costs). Elevator companies also often present a single quote for all elevators when bidding on larger projects, so taller buildings with multiple elevators complicate price comparisons.

One consequence of using mid-rise installations was that we were not able to find any Canadian proposals with enough detail to include in the comparison table. Canada has a higher housing stock growth rate than the United States, and tends to build more high-rises and larger and taller mid-rises, beyond the four- to six-stop, single-cab jobs analyzed in our table. However, figures viewed with less detail suggest that Canada is much closer to the U.S. than to Western Europe on price, with Canadian dollar-denominated costs coming in roughly equal to American dollar-denominated ones in the United States. When applying a purchasing power parity conversion, this would make Canadian examples only about 15 percent cheaper than those in the U.S.

We were also not able to find enough high-quality information for installations in high-income countries in East Asia to include any quotes in the

Figure 4

Elevator cost comparison

Nominal price

Adjusted price, including VAT where applicable (in USD, adjusted for purchasing power parity and then inflated to Dec. 2023 prices)

Vaud, Switzerland
2020

Schindler 3300
MRL electric traction

30,500 CHF + 2,349 VAT CHF

$35,348

Lombardy, Italy
2022

Kone MonoSpace 300 DX
MRL electric traction

€26,000 + €2,600 VAT

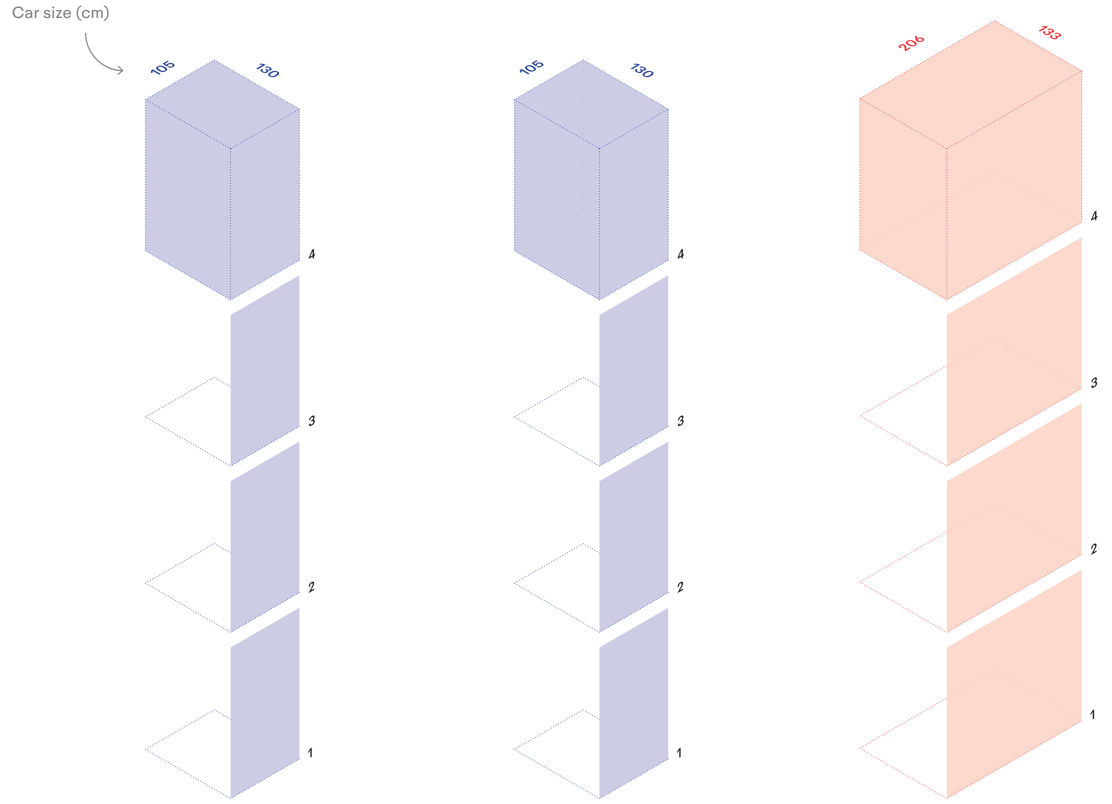
$49,393

New York, USA
2023

Kone MonoSpace 300 DX
MRL electric traction

$158,000

$157,856



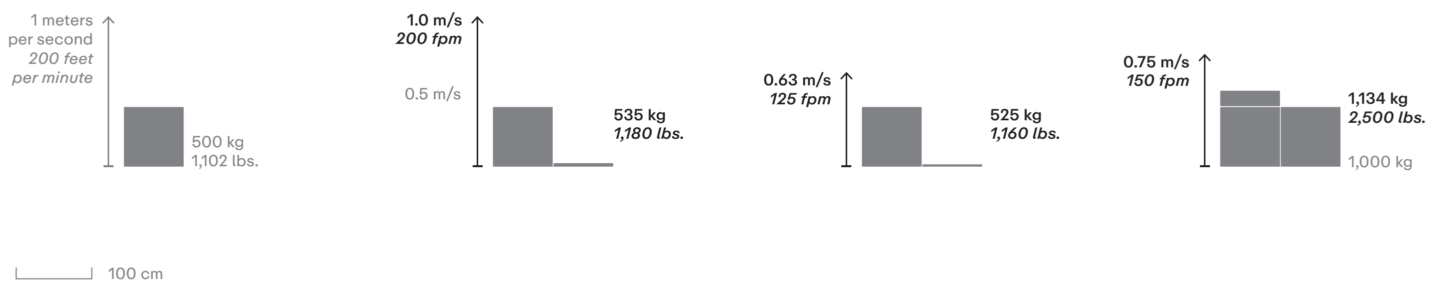


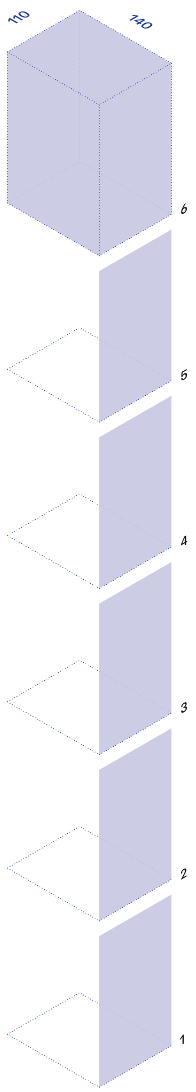
Figure 4

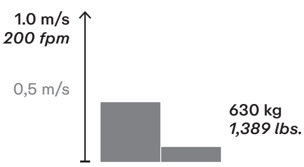
Flanders, Belgium
2020

Orona 3G
MRL electric traction

€25,700 + €5,397 VAT

$51,195



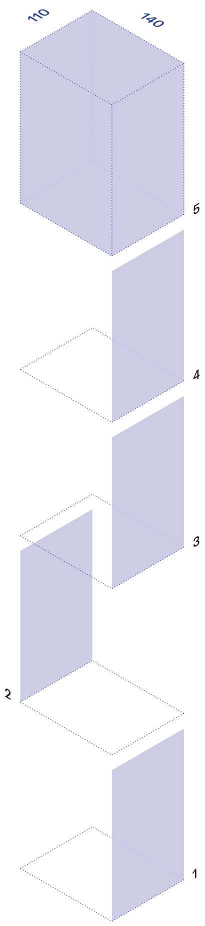


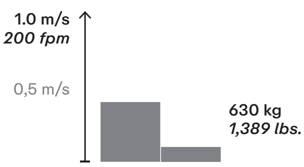
Île-de-France, France
2019

Otis Gen2
MRL electric traction

€31,000 + €6,200 VAT

$62,839



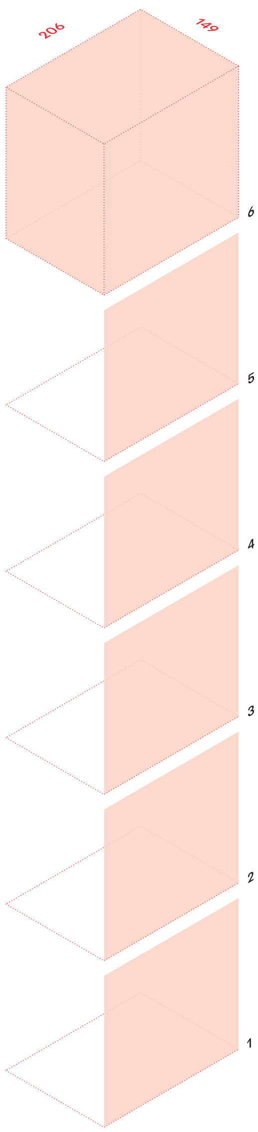


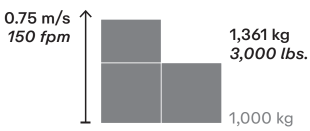
Pennsylvania, USA
2021

Schindler 3300
MRL electric traction

$160,000

$176,037



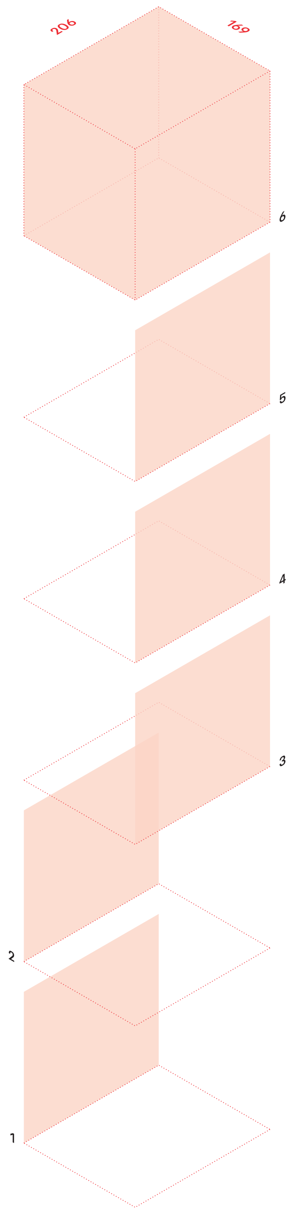


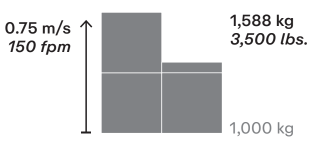
New Jersey, USA
2022

Schindler 3300
MRL electric traction

$172,200

$178,264





comparison table. However, our research suggests that in South Korea, a six-stop, 16-person (roughly 2,500-lb.) elevator might cost around $32,500, or around $53,000 with a purchasing power parity conversion applied, in line with six-stop costs in Western Europe, but for a larger car.

2.2.2 Post-installation costs

Elevators are expensive to install, but most of the industry's revenue – and therefore building owners' expense – comes from things other than the initial installation, particularly in developed markets like Europe and the United States with low population growth. Profits are even more tilted towards post-installation services, and many manufacturers offer new installations at or near wholesale cost in order to win more lucrative service and maintenance contracts.[53] As a rule of thumb, annual ongoing costs equal around 3.5 to 5 percent of the installation cost for the elevator in any given market.[54]

Comparing costs to operate elevators can be difficult, since the equipment is less standardized than a new installation. Costs can vary greatly depending on the age and type of elevator, the use it receives, and size-related factors. There are many different kinds of costs in owning an elevator, from predictable recurring expenses like electricity, inspection, monitoring, and preventative maintenance, to less predictable but still frequent outlays for services like repairs and disentrapments, to very high and infrequent costs like modernizations (where many components are replaced at once every generation or so). One thing that almost all of these costs have in common is that they are far higher in North America than in Western Europe.

Affordable housing developers in New York City underwrite total annual elevator operating and maintenance expenses of $7,500 per device.[55] A review of actual expenses for a handful of multifamily rental, condo, and co-op buildings around New York and Washington, D.C., shows similar or slightly higher elevator expenditures, with a little over $5,000 per device going to regular maintenance contracts, and the remainder split between inspections and repairs.

Annual costs in Europe are dramatically lower. In Spain, one academic analysis put the annual cost of preventative maintenance contracts at around €900 per year, plus €300 for typical repairs.[56] One German elevator maintenance company advertises maintenance contracts at €59 per month (€708 per year) for elevators with up to six stops, or a more affordable €420 per year for low-maintenance MRL models that only require one visit every six months.[57] A 2010 report by the City of Paris on the French capital's notoriously poorly maintained and un-modernized elevators (at least at the time) cited an elevator maintenance company as saying that the average annual maintenance contract cost for a condominium building was €2,000 per elevator, with France requiring service visits every six weeks.[58] An independent Belgian elevator

53 Kukhnin et al., "Global Elevators & Escalators."

54 Smith, Interview.

55 "Maintenance & Operating Expense Guidelines, New Construction."

56 de la Guardia Garcia-Lomas, Palacios, and Palomo Zurdo, "Mergers & Acquisitions in the Elevator Industry: The Use of Information and Communication Technologies to Avoid Information Asymmetry."

57 "Preisliste Aufzug – Wartung."

58 Berthault, "Rapport relatif aux difficultés rencontrées dans l'entretien, la maintenance, la réparation et la mise aux normes des ascenseurs à Paris et dans l'application des dispositions de la loi « urbanisme et habitat » du 2 juillet 2003 dite « de Robien »," 30.

2.2.2

company claims that annual maintenance contracts there average a similar amount, with a separate Belgian landlord paying roughly €1,000 per year to Orona for maintenance and monitoring for each 630-kg MRL elevator in newer mid-rise buildings.[59]

Codes in both Europe and North America require constant monitoring of in-cab communications devices intended for entrapped riders, and these monitoring costs are often folded into general service and maintenance contracts. Regulators on both continents require telephone monitoring, but newer devices in North America must also provide two-way visual communication devices – video monitoring, screens that can display text written from within a call center, and basic input devices for riders – so that people who are deaf, hard of hearing, and mute and who don't have working cell phones can be reassured that help is on the way after they call for it. This requirement is still being rolled out and only applies to new or modernized devices, but early indications are that it could nearly double monthly monitoring costs (see 5.3.3, "Two-way audiovisual communication," for further discussion).

As for periodic inspections, the most intensive test required in North America is called the Category 5 (or Cat 5) test, which happens every five years (typically at the same time as the annual Category 1 test), whose scope is described in a later section titled "Alternative testing." In New York City, one local independent elevator service company charges $2,000 for the roughly four-hour Cat 5 test (or $1,300 for the roughly two-hour annual Cat 1 test in other years), and a separate company charges an additional $780 for the required third-party "witnessing" to ensure the integrity of the test and guard against corruption. In Toronto the price is similar, with one firm advertising Cat 5 tests starting at $2,995 (CAD).[60]

In Europe, prices for inspections are, as usual, much lower. France's five-year test costs around €250 before tax, and usually takes at most two hours.[61] A major testing firm in Austria offers the required annual test for €280.80 (taxes included) for elevators with up to five stops.[62] In Italy, testing must be done every two years, and can be carried out by either government entities or so-called notified bodies (whose responsibilities are covered in greater depth in chapter 5, "Technical codes and standards"), with prices of around €140 plus tax being typical.[63]

Once every generation or so, elevators must be completely overhauled, called a "modernization." These projects can vary in scope and price, with modernizations of more recently installed elevators costing less than modernizations of older devices. Modernization costs for the oldest elevators tend to very roughly match new installations in price, with a similar disparity between U.S. and European costs.

Public procurement documents can be a rich source of modernization cost information in the United States. TK Elevator quoted a municipality outside of Denver $133,236 in 2021 to modernize a two-stop, city-owned 3,500-lb. outdoor hydraulic elevator installed over 20 years earlier that

59 Konaté, "Quel est le prix de l'entretien d'un ascenseur."

60 "Elevator Testing: Annual and 5 Year Elevator Testing."

61 "Contrôle technique quinquennal des ascenseurs - 'Loi SAE - Loi de Robien'"; "Contrôle technique des ascenseurs suivant la Loi de Robien."

62 "Aufzugsprüfung Österreich, Personen- und Lastenaufzug, S41-705-10-RI0104-01-0001."

63 "Tariffario Divisione Ascensori"; "Elenco prezzi unitari"; "Tariffario delle prestazioni e degli interventi erogati dal Dipartimento di Igiene e Prevenzione Sanitaria richiesti da terzi nel proprio interesse"; "Informazioni sulle tariffe delle verifiche periodiche."

had been damaged by the fire department while rescuing an entrapped homeless person. In 2023, a Florida airport contracted with Schindler to modernize four low-rise hydraulic elevators first installed in 1989 for $540,991, or around $135,000 per device.[64]

The Belgian government in 2014 put the median cost of modernizing an elevator up to 30 years old at €8,000, or €20,000 for a slightly older elevator (equivalent to around $13,000 and $32,000, respectively, in 2023 after adjusting for purchasing power parity and inflation).[65] One social housing operator in Paris estimated that modernizing 95 percent of its 475-device fleet of elevators would cost a bit over €18 million according to a 2010 report (or nearly $66,000 per cab after adjustments).[66] A French consumer group estimated the typical modernization at €30,000 in 2018, with a different source in 2022 putting the cost at €20,000 to €50,000 per elevator.[67] One German website estimated €65,000 for a substantial modernization of a 20-year-old, six-stop office building elevator.[68]

2.3 Work timelines

Labor is the major cost in installing and maintaining elevators, and basic rules of thumb suggest that it takes roughly twice as long to install an elevator in a new building in the United States as in Europe. In the U.S., the variable length portion of an installation requires around one week per floor of labor from a full-time, two-person crew, plus perhaps some extra time for fixed components that don't vary according to height.[69] In Western Europe, typically elevators are installed by the same crews at a rate of at least two stops per week.[70]

Generalizing about the time to complete a modernization of an existing elevator is more difficult given the heterogeneity of this work, but evidence points towards longer timelines in the United States, with accessibility consequences for those who depend on elevators. In Europe, Schindler cites three to five weeks for a complete replacement of an elevator, and the Berlin Tenants' Association wrote about a case where a modernization in high-rise of well over a dozen stories was planned to take three to four weeks. The German *Lift Journal* put the timeline for a partial modernization in what they called a tall building at two to four weeks, or around eight weeks for a complete modernization.[71] A representative from a firm in Italy specializing in modernizations said that typical modernizations of a six-stop elevator can take anywhere from just one week to, for example, replace the controller and electrical control system (including buttons), to three or four weeks to do more intensive work like the aforementioned work plus replacement of the traction motor and landing and cabin doors, while a complete replacement of an entire elevator (beyond the normal scope of a modernization) takes eight to 10 weeks.

Modernizations in the United States take about twice as long. A facility management trade publication put the typical modernization downtime

64 "Modernization Proposal: 1011 Englewood Pkwy."; "Request for Approval: P-220001, Elevator Modernization Project."

65 "Question écrite n° 5-11230."

66 Berthault, "Rapport relatif aux difficultés rencontrées dans l'entretien, la maintenance, la réparation et la mise aux normes des ascenseurs à Paris et dans l'application des dispositions de la loi « urbanisme et habitat » du 2 juillet 2003 dite « de Robien »," 52.

67 Marten-Pérolin, "En France, un quart des ascenseurs ont plus de 40 ans et vont devoir être rénovés rapidement"; Coulaud, "Copropriété : comment les ascensoristes poussent à la consommation."

68 "Aufzugsmodernisierung – Kosten und Fristen."

69 "The Benefits of GMV North America's 100% Complete Packages."

70 Retolaza et al., "New Design for Installation (DfI) Methodology for Large Size and Long Life Cycle Products: Application to an Elevator"; Fehler, "Die Aufzugsmontage – Vorbereitung bis Inbetriebnahme."

71 Berliner Mieterverein, "Aufzug gesperrt: Stuhl auf halber Treppe ist kein Ersatz"; "Comment planifier un projet de modernisation d'un ascenseur d'appartement: Informations indispensables pour planifier la rénovation de votre ascenseur"; Zeisberg, "Aufzugsmodernisierung – aber wann und wie?"

at four weeks for a two- or three-stop hydraulic elevator, or 10 to 12 weeks for a high-rise traction elevator.[72] One modernization consultant in Toronto put the timeline for a more intensive six-stop elevator modernization at eight to 20 weeks depending on different variables, a timeline which matches what a New York City consultant told a magazine covering homeowners associations in the region.[73] Experts said that greater elevator capacities in North America make modernizations more time-consuming, and also cited increased use of preassembly and prefabrication and better-trained mechanics as possible contributing factors to quicker projects in Europe.

Compared to new installations, the modernization sector globally is more dominated by independent firms, which in North America are less likely to be unionized (or, in the case of New York City, are more likely to be signatories to the only-in-New-York International Brotherhood of Electrical Workers' Local 3 Elevator Division, which does not impose the same restrictive work rules as the IUEC). Controllers, machines, and other components used in modernizations in North America are more likely to be sourced from independent firms which manufacture only for the North American market, as parts made for the global market and certified to European norms used globally are often not allowed to be used in North America. This more limited availability of components (see chapter 5, "Technical codes and standards") may also contribute to longer modernization timelines in the U.S. and Canada.

2.4 Safety outcomes

In 1911, when the consolidated Otis Elevator Company was only 13 years old, Charles Otis set out to celebrate the 100-year anniversary of the birth of his late father, Elisha Otis. Otis the corporation was the largest elevator company in the world, but Elisha Otis had not been a particularly important figure in the elevator's history up until that point. He performed a number of fairly unremarkable demonstrations of a safety device in 1854 at a World's Fair in New York City, and the company was a minor player in the city's burgeoning elevator market. The elevator had been invented millennia earlier, and incremental improvements had been made, often independently, throughout the United States and Europe in the 19th century. So when Charles Otis sought to commemorate his father's birth, he could not claim that he invented the device itself, and instead related a mostly apocryphal scene at the World's Fair involving a rapt crowd watching on as Elisha Otis cut the cable holding up the platform that he was standing on. Rather than plunging to his death, a safety device engaged, free fall was averted, and the modern safety elevator was born.[74]

The choice to exaggerate the World's Fair demonstration was driven by the importance of safety in popularizing the elevator, an emphasis which remains to this day in the elevator industry and its regulation. Nowadays, elevator free falls have been mostly eliminated through

72 Hussey, "Elevator Modernization: Is It Time?"

73 Chin, "An Elevator Overhaul Is Both Headache and Opportunity."

74 Bernard, *Lifted: A Cultural History of the Elevator*, 1–33.

redundant steel elevator ropes and the use of safety brakes like the one that Otis demonstrated in 1854, and the hundreds of millions of elevator trips taken worldwide each day pose very little risk to users.[75]

2.4.1 Elevator safety

Around 12,000 Americans are seen in emergency rooms for elevator-related injuries each year, according to the U.S. Consumer Product Safety Commission, but that includes incidents as minor as cuts and scrapes from tripping on the threshold. The commission does not report statistics on elevator user fatalities, as there are too few to generate an estimate based on their sampling.[76]

The risk of elevators throughout their history has long been to the workers who build, maintain, and work around them, as they often have to work in unprotected shafts and in other situations that do not involve the full suite of safety precautions afforded to users.[77] Vertical transportation mechanics face an elevated risk of dying on the job relative to other occupations, with five workplace fatalities across a total elevator and escalator installer and maintainer workforce of 22,510 people in 2021 in the United States.[78] The Bureau of Labor Statistics does not track data on the elevator occupation to directly to make proper comparisons to other jobs, but it is safe to say that elevator mechanics die on the job at much higher rate than that of the general U.S. workforce, and somewhat more often than construction workers as a whole, but at a much lower rate than roofers and structural iron and steel workers (the most dangerous construction occupations) and other dangerous non-construction occupations like loggers, fishers, and hunters.[79]

Just as the American construction industry as a whole is less safe than the European construction industry, with workers having a higher likelihood of dying on the job, the U.S. also appears to see more elevator mechanic deaths relative to its stock of elevators.[80] From 2003 through 2020, the United States saw 74 fatal on-the-job injuries among elevator or escalator workers according to the Bureau of Labor Statistics – on average, a little over four fatalities per year.[81] Relative to the total installed stock of elevators in 2020, that works out to 3.9 occupational fatalities per million elevators per year.

The European Lift Association, on the other hand, tallied an average of nearly a dozen fatal accidents per year among elevator workers across 24 reporting countries from 2013 through 2021, with only two total fatalities among escalator workers in that period.[82] It is unclear which 24 countries those numbers come from, but given that the European Lift Association collects market data across 31 countries with nearly 6.5 installed elevators in 2021 – mostly in higher-income countries in Western Europe, which are more likely to collect and report occupational fatality data – it is likely that the United States has a higher occupational fatality rate for elevator workers per device than Europe.[83]

75 Shrestha, "Safety Considerations for the Design of Modern Elevator Systems"; *The A17.1 Code: A Century of Progress for Safety, 1921-2021*, 12.

76 Consumer Product Safety Commission, "National Electronic Injury Surveillance System 2003-2022."

77 Bernard, *Lifted: A Cultural History of the Elevator*, 32.

78 "Injuries, Illnesses, and Fatalities: Table A-5. Fatal Occupational Injuries by Occupation and Event or Exposure, All United States," 2021; "National Occupational Employment and Wage Estimates."

79 "News Release: National Census of Fatal Occupational Injuries in 2022"; "Fatal Occupational Injuries, Total Hours Worked, and Rates of Fatal Occupational Injuries by Selected Worker Characteristics, Occupations, and Industries, Civilian Workers."

80 Wiatrowski and Janocha, "Comparing Fatal Work Injuries in the United States and the European Union."

81 "Injuries, Illnesses, and Fatalities: Table A-5. Fatal Occupational Injuries by Occupation and Event or Exposure, All United States," 2021; "Injuries, Illnesses, and Fatalities: Table A-5. Fatal Occupational Injuries by Occupation and Event or Exposure, All United States," 2020; "Injuries, Illnesses, and Fatalities: Table A-5. Fatal Occupational Injuries by Occupation and Event or Exposure, All United States," 2019; "Fatal Occupational Injuries by Selected Characteristics."

82 "Accidents of Lifts and Escalators."

83 Gemici-Loukas, "Basic and Industrial Statistics."

(Non-fatal injury data exists in both the U.S. and Europe, but different definitions and healthcare systems make the data difficult to compare.)

2.4.2 Alternative transportation safety

Elevator safety is usually considered in isolation, but in reality, elevators form just one part of the vertical circulation in buildings, and safety outcomes should be considered holistically for all ways to move around the built environment. Elevators are never the only option for moving up and down a building, and compete for use with stairs, and, to a lesser extent, escalators, trash chutes, and even cranes during the construction phase of a building's life. On some level, elevators even compete with cars and other forms of horizontal transportation, since traveling up and down taller buildings and between lower-density homes, stores, offices, and other places are in competition with each other for people's travel habits. An even rough quantification of the risk tradeoff is beyond the scope of this study, but a broad overview of the statistics and anecdotes conveys the importance of thinking not only about the safety of elevators themselves, but also about how the human body copes with their absence.

Stairs are the most viable alternative to elevators in most cases. As early as 1900, stairs were identified in Germany as a greater risk to people moving up and down a building than elevators.[84] From 1990 through 2012, an average of over 1 million Americans were treated annually in emergency rooms for stair-related injuries.[85] Statistics on stair-related fatalities are generally unavailable in the United States, but in 1980, 652 people in England and Wales – which, like the U.S., have a built environment oriented around single-family houses with stairs as the primary means of vertical circulation – died from accidental falls on stairs or steps, with 85 percent of these deaths happening in the home.[86] By the 1990s, stairs were likely killing over 1,100 residents of the United Kingdom per year.[87] Extrapolated to the current population of the United States, this suggests more than 6,000 Americans might die each year falling down stairs.

Thinking about transportation more broadly, the biggest competitor to the elevator is probably not stairs and one's own two feet, but the automobile. North America's relative lack of elevators is only in part due to our greater acceptance of walk-up apartment buildings, and is also driven by a built environment of single-family houses on quarter-acre lots, connected to each other and to other buildings by an extensive network of roads and highways that most people travel on in single-occupancy personal vehicles. As a result, Americans travel more than twice as much by car as Europeans do.[88] Nearly 43,000 people died on America's roads in 2022, giving the United States the highest rate of per capita traffic fatalities in the developed world.[89] Cars are, and likely always will be, held to a much lower safety standard than elevators, so every trip shifted from automobiles to walking or transit with a short elevator ride at the beginning or end is likely to increase safety.

84 Bernard, *Lifted: A Cultural History of the Elevator*, 30.

85 Blazewick et al., "Stair-Related Injuries Treated in United States Emergency Departments."

86 Webber, "Accidental Falls on Stairs or Steps in England and Wales: A Study of Time Trends of Fatalities."

87 Cayless, "Slip, Trip and Fall Accidents: Relationship to Building Features and Use of Coroners' Reports in Ascribing Cause."

88 Huxley-Reicher, "Fact File: Americans Drive the Most."

89 "Early Estimate of Motor Vehicle Traffic Fatalities in 2022"; Yellman and Sauber-Schatz, "Motor Vehicle Crash Deaths — United States and 28 Other High-Income Countries, 2015 and 2019."

Elevator cabins (also known as elevator cars) come in a range of different sizes, with ramifications for accessibility, emergency operations, price, building design, and prevalence. Elevator cabins have gotten larger over time, and are larger in the United States and Canada than in other developed countries. Cab sizes generally grow in response to regulation mandating access to varying degrees for disabled people and emergency medical services, but the growth in size comes with tradeoffs for cost and overall access, including by disabled people and paramedics. In general, the number of elevators – both within a building but also in any given society – is inversely proportional to the elevators' size, though correlation and causation are difficult to untangle given limited and anecdotal data.

Elevator cabin size regulation in residential buildings is driven by accommodation for two groups: people in wheelchairs, and emergency services – paramedics transporting people on gurneys (also known as stretchers) and firefighters. Beyond those groups, there are other considerations like passenger traffic capacity, redundancy in case of maintenance or breakdowns, and accommodation of furniture during moves in and out of the building, but these are not usually regulated by government and are instead left to the market, although they may be incidentally provided for through regulation. Cabin sizes can range from very small, accommodating just one or two standing passengers (as with some elevators retrofitted into very old walk-up buildings in Europe), to very large, accommodating everybody who might conceivably want to use an elevator in any way they would like to use it (as in new North American buildings).

3.1 **Europe**

Elevator cabins in Europe are and historically have been some of the smallest in the world. Elevators with a rated capacity of around 320 kg are common in older apartment buildings, which might be barely large enough for one person seated in a small wheelchair. Today, regulations require much larger cabins for new installations, with two sizes being the most common: what is known according to the European norm as a type 2 car for wheelchairs (with the cabin interior having a clear width of 1.1 m, a clear depth of 1.4 m, and a rated capacity of 630 kg), and a type 3 car for stretchers (measuring 1.1 m × 2.1 m with a rated capacity of 1,000 kg).[1] Both cars comfortably accommodate somebody seated in a very large powered wheelchair with at least one person standing behind them, but both cabins typically require wheelchair users to enter facing forward and then back out without turning (or vice versa), without enough room to turn within the cabin to accommodate both entry and exit facing forward (unless the elevator has doors on opposite sides, though this is not typical). Buttons inside of the elevator car are located on the side of the car, so turning the wheelchair is not required for a user to push them on their own.

While these are the most standard required sizes in Europe, there is variation across the continent in law, both in terms of exact cabin size required and the building height at which a cabin must accommodate a stretcher. As a general rule, the countries with the most elevators per capita have the loosest rules on size. Geographically, this means that Southern European countries with vast elevatored housing stocks tend to allow the smallest elevators, while Northern European countries with more walk-ups and single-family homes tend to require larger elevators at lower thresholds.

Spain and Italy, as discussed in section 2, “Access,” of this report, have the largest elevator fleets in Europe and some of the strictest rules about when an elevator is required, and also tend to allow the smallest cabins. In Spain, the standard type 2 car of 630 kilograms fulfills the requirement for accessibility, with a door span of 90 cm.[2] However, what makes Spain fairly unique in Europe is that

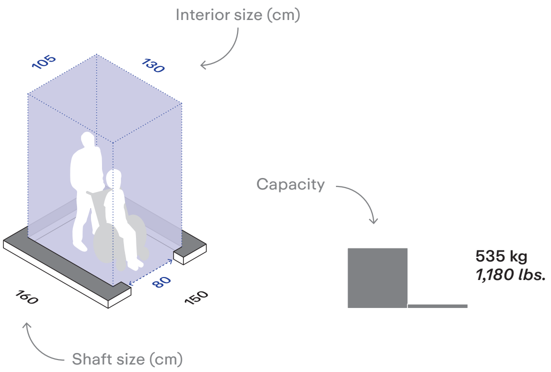
1 “Safety Rules for the Construction and Installation of Lifts - Particular Applications for Passenger and Goods Passenger Lift - Part 70: Accessibility to Lifts for Persons Including Persons with Disability.”

2 “Documento Básico SUA: Seguridad de utilización y accesibilidad,” Anejo A, Ascensor accesible.

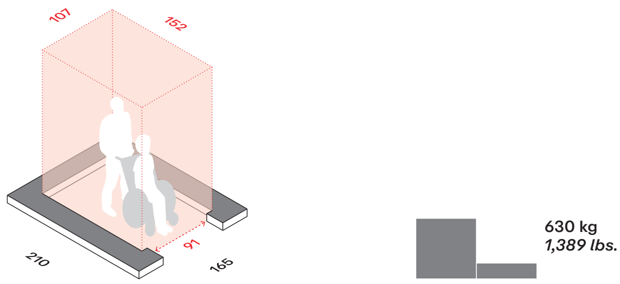
Figure 5

Elevator car and shaft sizes

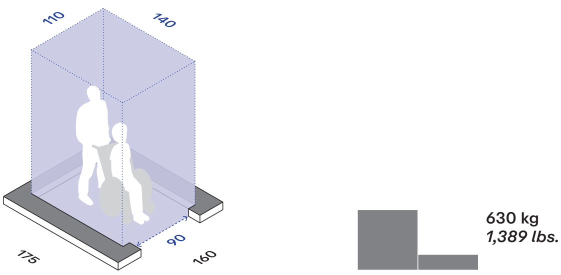
Low-rise/Italian wheelchair
Europe



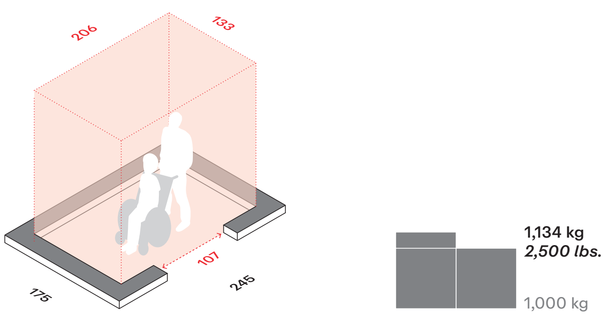
Limited use/limited application (LULA)
North America



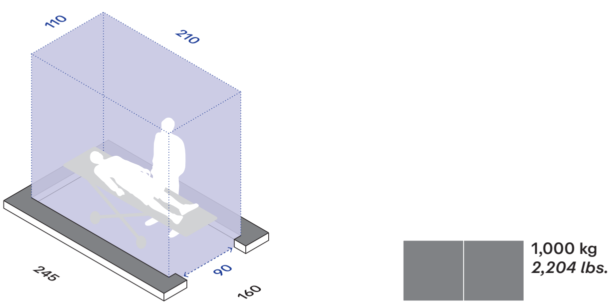
Standard wheelchair
Europe



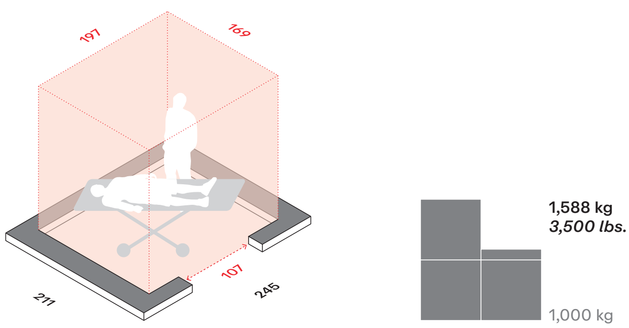
Wheelchair
North America



Stretcher
Europe



Stretcher (IBC)
North America



there is no requirement for residential buildings at any height to install a larger cabin that can accommodate a stretcher, and high-rises can be found with only elevators of this size.[3] In Italy, the minimum size of a wheelchair elevator in an apartment building is smaller than usual, at 0.95 m × 1.3 m (accommodating 480 kg) with a 80-cm doorspan (or 31.5 in., which is still large enough for the vast majority of powerchairs).[4]

At the other end of the size spectrum is the Netherlands. The Netherlands has a long tradition of single-family dwellings, and the second-largest proportion of single-family houses in the European Union, after Ireland.[5] Dutch cities and suburbs are full of two- and three-story townhouses with steep staircases, and means of egress rules for apartment buildings are some of the strictest in Europe, making it challenging to build small multifamily apartment buildings. This tends to bifurcate the new housing stock between townhouses on the one hand, and larger apartment buildings on the other, with fewer small and mid-sized multifamily buildings than many other countries in Europe (much like the United States).[6] The Netherlands has one of the smallest per capita elevator stocks in Europe, with one-fifth as many elevators per capita as Switzerland or Spain and about half as many as France or Germany.[7] It also has some of the strictest rules about cabin sizes, requiring them to be 1.05 m × 2.05 m (slightly smaller than the standard type 3 requirement) for any building with more than six units, and to have space to accommodate such an elevator in any new multistory building, meaning that there is rarely a circumstance where the standard European type 2 wheelchair elevator is provided in new buildings.[8]

In other countries in Western Europe, rules about elevator cabin sizes typically lie somewhere between the two extremes. In Sweden and Norway, the requirement for a stretcher-sized type 3 elevator starts at four stories.[9] In Germany, it's required for stories whose finished floor level is above 13 m (so, starting at five or six stories).[10] In France, a stretcher elevator is never legally required, but a norm advises their use beginning at eight stories.[11] In Vienna and Denmark, they are required for buildings where the floor of the top story is more than 22 m above grade, or beginning at around nine stories.[12]

The often dramatically lower ratios of units to elevators (see section 2.1.3, "Multifamily elevator ratios") in European apartment buildings means that residents are much less likely to encounter other people outside of their household in an elevator, making it easier and less awkward to enter and exit an elevator without turning.

3.2 Asia and Oceania

Due to linguistic limitations, our research into cabin size requirements in Asia and Oceania was not as extensive as in Europe. However, we were able to identify regulations in South Korea, Singapore, and Australia. All of them follow the same general trend of offering some accommodation

3 "Documento Básico SI: Seguridad en caso de incendio," Sección SI 4, Tabla 1.1; Anejo SI A, Ascensor de emergencia.

4 "Prescrizioni tecniche necessarie a garantire l'accessibilità, l'adattabilità e la visitabilità degli edifici privati e di edilizia residenziale pubblica sovvenzionata e agevolata, ai fini del superamento e dell'eliminazione delle barriere architettoniche. (GU Serie Generale n.145 del 23-06-1989 - Suppl. Ordinario n. 47)," 8.1.12(b).

5 "Distribution of Population by Degree of Urbanisation, Dwelling Type and Income Group - EU-SILC Survey."

6 Speckert, "Jurisdictions - The Second Egress: Building a Code Change."

7 "Liften: risico's, aanpak en effect."

8 "Bouwbesluit Online."

9 "Boverket's Mandatory Provisions and General Recommendations, BBR: BFS 2011:6 with Amendments up to BFS 2018:4."

10 "Musterbauordnung (MBO), geändert durch Beschluss der BMK vom 22./23.09.2022."

11 "Réglementation Ascenseurs."

12 "Executive Order Nº 1615 of 13 Dec. 2017 (in Force)"; Eder, "Personenaufzüge gemäß Bauordnung für Wien (BO) - WBTV 2015, Barrierefreie Erschließung."

of wheelchair turning radii and/or stretchers, but rarely both, and not to the same standard as in North America. In the Asian countries whose rules we were able to identify, wheelchair elevators are slightly roomier than they are in Europe, but there is never any requirement to accommodate a stretcher in a residential building.

In Singapore, wheelchair elevators are a bit larger than their European equivalent, at 1.2 m × 1.4 m (10 cm wider than the European type 2 standard), while so-called "fire lifts," at 1.5 m × 1.7 m, are also slightly larger than their type 3 European stretcher equivalent, but with more square dimensions. Both are 25 percent smaller by floor area than their American equivalents, and the fire lift requirement does not kick in until a residential building exceeds 40 stories.[13]

In South Korea, the government strongly encourages the installation of elevators that can accommodate a wheelchair with a turning radius through planning policy, though with somewhat less space than in U.S. elevators. Developers are allowed to deduct the floor area of the elevator shaft from their total allowed building area only if the elevator car has 1.35 m × 1.6 m dimensions. While this is intended to produce enough room for a wheelchair user to turn 180 degrees, the interior area of the cabin is 21 percent smaller than the minimum size of a wheelchair elevator in the United States.

There is no requirement or incentive in South Korea to provide a larger cabin for fully extended stretchers. In the absence of this stretcher accommodation, there has been some research by emergency medicine doctors and others to develop a way to perform mechanical cardiopulmonary resuscitation on patients experiencing cardiac arrest being transported on a reducible stretcher that can be shortened to 1.2 m in order to fit into smaller elevators.[14] In Japan, one person said that when he was taken to the hospital for a back injury sustained in his apartment, the apartment building's stretcher was tilted upwards to fit in a small multifamily elevator.

Australia's building code takes a hybrid approach to elevator cabin sizes, with European-style requirements up to about five stories, and then a more American approach above that height. Up to about five stories (defined as an effective height of up to 12 m, measured from the bottom to the top floor), the minimum elevator cabin size is 1.1 m × 1.4 m, just like a type 2 wheelchair elevator in Europe. Above this height, at least one elevator must have dimensions of at least 1.4 m × 1.6 m to accommodate wheelchairs with a turning radius, in line with what is required in South Korea, and at least one fitting a stretcher that's 2 m deep.[15]

3.3 United States

North America, and in particular New York City, historically had much larger elevator cabins than were typical in Europe. The reasons have not

13 "Code on Accessibility in the Built Environment," 4.9.2.1; "Fire Code," 6.6.5(b).

14 Kim et al., "Quality between Mechanical Compression on Reducible Stretcher versus Manual Compression on Standard Stretcher in Small Elevator"; Kim et al., "Chest Compression Fraction between Mechanical Compressions on a Reducible Stretcher and Manual Compressions on a Standard Stretcher during Transport in Out-of-Hospital Cardiac Arrests."

15 "National Construction Code, Volume One, Section E, Part E3."

3.3 been researched in any depth, but among the possibilities are America's greater economic wealth, less restricted space within American buildings (regulations historically allowed buildings in U.S. to cover much more of their lot than in Europe), America's historically taller buildings (by 1914, the average elevator in New York City had 10 landings), the greater adoption of elevators in the U.S. at a time when elevators still required operators, or the complex interplay of means of egress rules that still bias architects towards larger floor areas served by each elevator landing.[16] Whatever the reasons, this historical market trend has now been written into code. Before there were any regulations driving elevator size in, for example, New York City, cars generally were of a size that translated to a 1,800-lb. carrying capacity, larger than the code minimum size today for most new buildings in Europe. Over the years, a number of regulations aimed at accommodating different uses have incrementally increased cabin sizes, each one fairly de minimis, but with the long-term effect of doubling cabin sizes in even fairly small buildings.

This means that the United States and Canada now require the largest elevator cars in the world. Whereas jurisdictions in Europe and Asia tend to require or encourage elevator cabins that can accommodate at most either a wheelchair turning radius or a stretcher, the United States and Canada typically require both in almost any situation where an elevator is provided, including in situations where there is no requirement to provide an elevator at all – a perverse disincentive that some developers respond to by simply building walk-ups (see section 2.1.1, "Walk-ups and elevator buildings").

The requirements to accommodate wheelchair turning radii and stretchers are found, at least in the United States, in separate parts of the building code, and they affect size in different ways, and will be treated separately in this section. But the requirements join together to result in manufacturers designing cars with up to 3,500-lb. capacities to meet minimum requirements for most mid-rise residential buildings, or slightly over 2.5 times as much weight and a bit over twice as much interior floor space as the standard 630-kg European type 2 car with a 1.1 m × 1.4 m cabin.

Because elevator car dimensional requirements in the United States are much more complex than in Europe, there is greater variation in how manufacturers meet code requirements, leading to less flexibility to change manufacturers once a plan is drawn, and less competition within the sector. The difference in shaft depth required by Kone's code minimum model in a mid-rise building and Otis's, for example, is over a foot, whereas in Switzerland it's only a few inches of difference in depth and the specified widths are exactly the same.[17] Despite the National Elevator Industry, Inc.'s attempts to standardize hoistway dimensions, the complicated requirements, ambiguity in the code, and local jurisdictions' different implementations leave the United States in a situation where dimensional standardization – and along with it, the competitive advantages to consumers of being able to easily swap out one manufacturer for another at any point in the development process – is not possible.[18]

16 "Building Code Ordinances Modified."

17 "Kone MonoSpace 500 DX: Configurations & Dimensions"; "Gen3 Elevator: Hoistway Dimensional Data"; "Planungsdaten Schindler 3000: Standard-Schachtabmessungen"; "Kone MonoSpace 300 DX | Planungsdaten: Schachtgrundriss," 300.

18 "NEII-1: Building Transportation Standards and Guidelines."

3.3.1 Wheelchair turning radius requirement

The ICC's A117.1 standard, titled "Accessible and Usable Buildings and Facilities," governs the interior area of elevators in multifamily buildings in the United States.[19] It provides a number of options for elevators in new buildings, which allow for a wheelchair user to enter and then turn to push buttons that are assumed to be located on the same wall of the car as the door. In practice, the designs allow a user to enter facing more or less forward and then exit facing forward as well, assuming that the elevator is not too crowded with other riders to make the turn (the details of what constitutes a proper turning radius are more complicated and have grown more demanding in recent years than what the standard requires, but we will refer to what is required by A117.1 as a turning radius in this report). This differs from European and other standards, where elevator cars accommodate wheelchairs, but do not allow as much room to turn. To meet American interior dimensional requirements, the Big Four manufacturers usually design cars with capacities of 2,500 lbs. for cars with centered doors, or 2,000 to 2,100 lbs. (roughly 900 to 950 kg) for off-center, or side-opening, doors.

An analysis of New York City Department of Buildings records shows that this wheelchair turning radius requirement only marginally increased the size of elevator cabins after it was added to the A117.1 standard in 1980.[20] Elevators built in the decades after World War II but before the requirement was introduced had capacities of 1,800 to 2,000 lbs., closer to the A117.1 requirement than to the size of 320-kg (700-lb.) cars common in Europe around this time. Dimensions in New York City before accessibility laws were passed were dictated by a number of concerns – one article in the city's real estate trade press in 1914 recommended making cabs wider than they are deep in commercial loft buildings, for example, to facilitate loading and unloading – but wheelchair accessibility was not among them.[21] Buildings in post-war America almost always had a few steps between the sidewalk and the elevator, for example, rendering them unusable by wheelchair users anyway. Given the common historical pattern of the market shaping elevator regulations as often as the reverse, it raises the question of whether the wheelchair turning radius was a carefully considered requirement arrived at by weighing the benefits of roomier cabins for wheelchair users against the costs of making elevators more difficult to provide, or whether the standard's writers were simply roughly codifying existing market practice with a small boost to, in their minds, enhance accessibility.

For older cars that already exist in American buildings, today's A117.1 cabin size standard is looser, with a minimum requirement of 36 in. × 54 in. (0.915 m × 1.37 m) – smaller than the European type 2 standard for new buildings, and more in line with Italy's requirement.[22] Furthermore, in new buildings in the United States, there is a smaller style of elevator called a limited-use/limited-application (or LULA) elevator. The LULA elevator is very limited in height and speed and is typically found in commercial buildings. It is, designed for accessibility rather than general access, and

19 "A117.1: Accessible and Usable Buildings and Facilities," 407.4.1.

20 "Uniform Federal Accessibility Standards"; "Elevator Device Data - FOIL."

21 Knox, "Building Management: Installation of Elevators in Lofts."

22 "A117.1: Accessible and Usable Buildings and Facilities," 407.4.1.

has an car interior size requirement of, in effect, 1.065 m × 1.37 m – also slightly smaller than a European type 2 car.[23] Both of these options recognize that the European type 2 car meets a certain minimum standard for accessibility, allowing a wheelchair user plus at least one ambulatory rider to move between floors with room to maneuver, even if they do not have the range of motion that they would in a larger car.

Interviews with wheelchair users suggest that design and practice with regards to accessibility often but do not always overlap. Larger elevator cars – even ones much larger than necessary to meet the A117.1 wheelchair standard – usually do not allow a wheelchair user to both enter and leave face-forward if there are more than one or two other riders in the cab, which is common in high-rise buildings. On the other hand, some cars that would not meet A117.1's wheelchair standard for new construction (including elevators sized to the European wheelchair standard) can nevertheless allow a manual wheelchair user in particular to turn.

3.3.2 **Stretcher requirement**

The 2,000- to 2,500-lb. cars now required in the United States to accommodate wheelchair users are roughly as large as the 1,000-kg type 3 cars in Europe built to accommodate stretchers, but due to the shape of the cabin – more square than a narrow and deep European car – typically do not accommodate a stretcher of the size dictated by code in a fully reclined position. The modern American code requirements to accommodate a stretcher in buildings of at least four (or, in some cases, three) stories with elevators were inherited from the old Uniform Building Code, where the requirement was added in the 1988 edition.[24] At the time, the code required accommodation of a stretcher measuring 24 in. × 76 in., or 6 ft., 4 in. in depth, which was then copied into the first edition, in 2000, of the International Building Code.[25]

In the 2006 edition of the IBC, the length of the stretcher to be accommodated was raised to 84 in., or 7 ft. (2.13 m). The code change was proposed by a member of the Glendale Fire Department, in Arizona, where there are still very few apartment buildings with elevators. The firefighter who proposed it said that he was concerned that a sports arena being constructed would have elevators that would not accommodate his local emergency responders' stretchers extended into a fully flat position. The cost impact was stated simply as "None." "Just think about if the patient was you," the proponent concluded in his reason statement.[26] There was some debate and tweaking of the language that year and in a subsequent version at the urging of the elevator industry, but the proposal ultimately survived in a modified form, incrementally increasing the capacity of multifamily elevators to today's typical 3,500 lbs.[27]

Canadian building codes have similar but slightly less exacting requirements compared to U.S. codes. They require accommodation of a stretcher measuring 0.61 m × 2.01 m (24 in. × 79 in.).[28]

23 "A117.1: Accessible and Usable Buildings and Facilities," 408.4.1.24 "1988 Uniform Building Code," 5103(e); "2022 California Building Code, Title 24, Part 2 (Volumes 1 & 2) with Jan 2023 Errata," 3002.4a.

25 "2000 International Building Code," 3002.4.

26 International Code Council, *Code Changes Resource Collection: Approved Code Changes Resulting in the 2006 IBC*, 86.

27 International Code Council, "ICC Public Hearing," G188-07/08.

28 Canadian Commission on Building and Fire Codes, "National Building Code – 2023 Alberta Edition," 3.5.4.1.

3.3.2 The stretcher requirement has at times led to confusion among authorities having jurisdiction, because the exact dimensions of the elevator cabin that can accommodate a stretcher are not explicitly stated in the code. In Europe, building codes are generally written to require 1.1 m × 2.1 m cabins where stretchers are meant to be accommodated, but America's IBC merely states that elevators cabins "shall be of such a size and arrangement to accommodate an ambulance stretcher 24 inches by 84 inches (610 mm by 2134 mm) with not less than 5-inch (127 mm) radius corners, in the horizontal, open position."[29] Since the wheelchair turning requirement requires more square cabs, while stretchers are long, the most space-efficient way to accommodate stretchers is usually diagonally, sometimes requiring multi-part maneuvers, as noted in example drawings in the IBC commentary.[30] Elevator industry professionals have described frustrating conversations with fire officials over whether stretchers will fit inside of cars, with one person describing an incident involving a mock-up of a stretcher using a refrigerator box to try to convince an official that a cabin meets code.

The situation in California is further complicated by an additional provision explicitly requiring that the cab must accommodate two emergency responders in addition to the stretcher, along with an exception in the 2016 version – removed in later versions – allowing slightly smaller cabs if it can be demonstrated that they will accommodate the typical stretcher in use in the jurisdiction.[31] This has led the Los Angeles Fire Department to issue a series of ever-changing and poorly versioned memoranda listing the elevators that it will accept, along with a set of procedures for manufacturers to submit, in writing, to the department to prove compliance with the rules of the code, plus an additional accommodation of bariatric extenders (that is, extension wings for obese patients) that is not written in any code.[32]

While there are many ambulance stretchers in the United States that fully recline to a length greater than the old 76-in. standard, and extra equipment can add additional length, paramedics very often encounter situations without elevators that can accommodate 84-in. stretchers and have to be prepared for them in spite of the latest codes. New York City, for example, didn't adopt the longer 84-in. requirement until 2014.[33] Larger elevator standards only apply to buildings built after the adoption of the new code, and elevators are very rarely enlarged after construction. As a result, more than two-thirds of passenger elevators in New York City, for example, have capacities under 3,000 lbs., making them unlikely to fit 84-in. stretchers.[34] And Florida never adopted the new longer stretcher standard at all, with the latest edition of its building code only requiring elevators to fit a 76-in. stretcher.[35] This allows elevator manufacturers to sell slightly smaller cars in Florida, with Schindler, for example, selling a 2,500-lb. model with a single side opening that meets the stretcher requirement, rather than its 3,000-lb. stretcher model in the rest of the United States.[36] And even when an elevator that meets the largest size requirements is provided, only one serving each floor needs to meet this standard. In a bank of more than one elevator,

29 "International Building Code," 3002.4.

30 *2021 IBC Code and Commentary*, 2:3002.4.

31 *2016 California Building Code*, 3002.4.

32 Laurent, "Elevator Car to Accommodate Ambulance Stretcher - Exemptions to the Minimum Dimensions."

33 "iNX Integrated Patient Transport & Loading System"; "Power-Pro 2, Powered Ambulance Cot," 201; "2014 New York City Building Code," 3002.4.2.

34 "PLUTO and MapPLUTO"; "Elevator Device Data - FOIL."

35 *2023 Florida Building Code, Building*, 3002.4.

36 "Schindler Low-Rise MRL Traction Elevators Meet IBC Stretcher Requirements."

the stretcher-sized cab can be specifically called using a key to enable the car's emergency operation mode, but these keys are not always accessible when needed, so paramedics can sometimes be stuck taking the first elevator that arrives. As a result, ambulance stretchers can be manipulated and tilted in various ways to fit into tighter spaces.

While there are a number of medical emergencies where one would benefit from an elevator car that can accommodate a fully extended gurney, there are no measurable clinical outcomes where North America outperforms Europe or Asia. One of the most common use cases for a larger elevator is an out-of-hospital cardiac arrest, where somebody's heart stops beating and their survival rate is improved by receiving continuous chest compressions, which are difficult to carry out in an elevator that cannot accommodate a supine patient. However, out-of-hospital cardiac arrest survival rates are very low, with one meta-analysis finding that only 22 percent of patients survived to hospital admission. North Americans, despite their much larger elevator cars, were even less likely to survive to hospital discharge (7.7 percent) than Europeans (11.7 percent). One-year survival rates were even worse for North Americans – only 4 percent survived, significantly lower than any other region studied.[37] The survival rate for cardiac arrest occurring in apartment buildings is likely even lower, since they are less likely to be witnessed by bystanders who can perform resuscitation or defibrillation, a key survival factor.[38]

3.4 Cost impact of cabin sizes

Larger cabin sizes raise costs in a number of different ways: they increase parts and labor requirements, and they require larger shafts, which often displace rentable or saleable building area and cost more money to build. The exact magnitude of these costs is worth quantifying since larger cabins do come with benefits in terms of accessibility, and if the costs are minor, then the larger cabins found in the United States and Canada as compared to Europe might be worth the extra costs. What data is available though suggests that the costs are not minor. Costs rise more slowly than capacity as measured in weight – 3,500-lb. code minimum North American elevator cars do not appear to cost two-and-a-half times as much as the 630-kg cars more typical in Europe if other variables (like labor environments and technical standards) are held constant – but the difference in cost still appears to be substantial.

3.4.1 New elevator installation costs

It is difficult to determine the full effect that elevator size has on cost, because European-sized elevators are not legal in enough situations in North America to be worth producing as a standard product, and North American-sized elevators are never required or built in Europe outside of specialized settings like hospitals and industrial buildings, where other unique characteristics also drive cost and quotes are

37 Yan et al., "The Global Survival Rate among Adult Out-of-Hospital Cardiac Arrest Patients Who Received Cardiopulmonary Resuscitation."

38 Mao and Ong, "High-Rise Residential Resuscitation."

3.4.1 difficult to obtain. As such, it is not possible to simply request a quote from a manufacturer of a much larger or smaller size and measure the difference in order to arrive at the expected cost savings from moving from North American standards to European ones. However, different sizes are sold on both continents, and while pricing is not very transparent, quotes and standardized price lists can give a hint as to how cabin size affects overall pricing.

Out of concern for the cost of public works and in order to introduce transparency into the market for public procurement, Italy requires regional governments to publish lists of benchmark unit prices for a wide range of construction projects, including elevators.[39] When compared to actual quotes received from elevator vendors, these benchmark price lists are accurate. The benchmark price list published in 2023 for Milan contains line items for six-stop MRL elevators of four different capacities, ranging from 400 kg (typically used in existing buildings) to 835 kg (sized for a gurney).[40] While this 835-kg car falls well short of the size of the 3,500-lb. (1,588-kg) car often used in the United States and Canada, the progression of prices for the four capacities follows a fairly linear pattern. Extrapolating using a basic linear regression, a six-stop, 3,500-lb. installation would cost around $97,000 in adjusted terms, compared to the listed price of around $54,000 (adjusted) for a 630-kg installation.

In the United States, pricing is not as transparent. The public sector does not publish any benchmark prices, and private cost estimation databases like RSMeans offer unrealistic estimates for elevators. However, two quotes were obtained from a Big Four manufacturer for an installation in the same four-story building in Brooklyn: a 2,500-lb. car (sized for a wheelchair with turning radius) was quoted at $158,000, while a 3,500-lb. one (sized for a gurney) was quoted at $168,000. These prices imply a shallower slope for the resulting linear regression, with cost being less responsive to size, on top of a higher fixed price. Extrapolating from only these two data points, a 630-kg version of this four-stop installation would be priced at around $147,000.

Accurately determining the expected savings in cost to developers if 630-kg, European-style elevators were allowed in the United States is not possible from these limited data points, given the limited sample size, as well as the complex interplay of other non-size factors (for example, if the labor market were loosened and global prefabrication and preassembly practices were introduced to the United States, and manufacturers were allowed to import parts certified for the global market rather than buying for the limited North American market, cost might change). However, they do suggest an upper and lower bound on expected cost savings from moving from a 3,500-lb. effective code minimum to a 630-kg one for a mid-rise installation: 13 percent to 44 percent. Anecdotally, interviews with employees at elevator firms in the United States cited expected cost savings estimates somewhere in the middle of these two figures.

39 Chitti et al., "Transit Costs Project: The Italian Case."

40 "Prezzario regionale delle opere pubbliche."

3.4.2 Elevator hoistway costs

Elevator manufacturers quote a fixed price for installations, but the hoistway (or shaft) that the elevator sits in also has a substantial cost. Comparing the direct costs to build hoistways in North America and Europe is beyond the scope of this report due to deeper-rooted differences in construction cultures and materials, but one cost that is easier to tabulate and perhaps more significant is the forgone value of the space that larger North American shafts consume.

In most zoning codes and land use regimes, developers face a direct tradeoff between space occupied by elevators and space that can otherwise be rented or sold. Of six major U.S. jurisdictions reviewed (New York City; Los Angeles; Portland, OR; Philadelphia; Arlington County, VA; and Jersey City, NJ), all either require developers to count space occupied by elevators towards their total allowed floor area, or regulate building size in such a way that only accounts for a building's outer walls.[41] This means that every square foot occupied by an elevator shaft and the elevator inside of it comes at the opportunity cost of whatever the prevailing price for land is, as measured per buildable square foot.

Based on the architectural planning specifications provided by Otis, Schindler, and Kone for their typical code minimum models on each continent, assuming a constant 8-inch thickness for hoistway walls, elevator shafts take up almost twice as much space in North America (around 76 sq. ft.) as in Europe (41 sq. ft.). The cost impact is dramatic: for a six-story building, if the price of land is $150 per buildable square foot (typical for urban land in large coastal cities), the opportunity cost of an elevator shaft built to European specifications is $37,000, as opposed to $69,000 in North America.

41 "New York City Zoning Resolution," 12–10; "Los Angeles Planning and Zoning," 12.03; "Article 14, General Rules," 1.7.A.1.c.vi; "Portland Zoning Code (Title 33)," 33.91; "The Philadelphia Code," 14-202(4); "Zoning Ordinance, Arlington County, Virginia," 3.1.1.C; "Jersey City, New Jersey - Code of Ordinances," Article V.

Most of the cost of modern elevators lies in the human labor needed to assemble, test, maintain, repair, and modernize the devices. While labor is central to the elevator industry, the issues around it – prefabrication and preassembly vs. on-site construction, union vs. non-union, International Union of Elevator Constructors vs. International Brotherhood of Electrical Workers, local workers vs. foreign workers, in-house vs. subcontracted – are sensitive, and open discussions can be taboo. Labor is the elephant in the room of the elevator industry – public policy disputes are couched in terms of safety, and the main trade publication for the vertical transportation field, *Elevator World*, rarely mentions labor directly.

In both North America and Europe, the broad outlines of training elevator workers are similar. Elevator mechanics have traditionally learned the trade on the job, in teams of two, with an experienced mechanic accompanied by a less seasoned helper. On both continents, education is becoming more formalized and licensure is becoming stricter, with more classroom training and book study and formal accreditation at the end of the process. However the bulk of knowledge is still passed down through the apprenticeship system, from the trained mechanic to the novice helper, with most learning still taking place inside the elevator shaft.

There are, however, broad differences in elevator industry labor between North America and Europe. North American labor costs are much higher than those in Europe, and labor availability is tighter. Europe has an established system of state-sponsored technical education that is well suited to supplying the construction industry with workers, while the United States and Canada are nations of desk workers where the skilled trades are a less common career path. Particularly in new installations, Europe has far more foreign workers in the sector and efficiencies in production, while North America has much stronger organized labor. The International Union of Elevator Constructors is one of the most powerful construction unions in North America, and it resists trends like preassembly and prefabrication, creating more work and causing further tightening in the labor market. Labor relations in the European elevator field, on the other hand, are more subject to market forces.

4.1 **Europe**

In Europe, jobs within the elevator industry are much like jobs in any other industry, with open recruitment by companies, a mobile workforce, and a technology-led push to substitute capital for labor, shifting work from the construction site to the factory and automating tasks. Employers and manufacturers complain of persistent shortages of willing and able workers, but compared to their counterparts in North America, they have wider access to domestic workers with a technical educational background, and a growing number of foreign workers. The European single market's "four freedoms" – free movement across national borders for goods, capital, services, and people – gives the industry, especially in Western Europe, access to foreign workers, ranging from immigrants who move permanently to higher-income countries to work and live, to more temporary arrangements like subcontractors who bus workers in to Western Europe from lower-wage countries in Eastern Europe to install elevators for a few weeks as demand permits and then return home.

4.1.1 Training

Entry into the European elevator trade is much like entry into any other technical field. Young people typically graduate from high school, often from a technical track, and then find a job listing looking for workers to be trained as elevator technicians. Some people have experience in other fields before getting into elevators (for example, in the automotive industry), but most technicians interviewed entered it soon after their highest level of formal education. Job openings are listed by firms themselves on online platforms – by one of the Big Four elevator manufacturers, for example, or by smaller firms with a regional focus or a specific niche – and there are few barriers to entering the trade.

Before any elevator-specific education or work experience, many people in Europe who eventually become elevator mechanics start with a state-sponsored vocational secondary education in their teenage years. Roughly half of upper secondary students in Europe (the equivalent of high schoolers in the United States) are enrolled in vocational schools, with especially high numbers in Central Europe.[1] These schools often follow a dual education model, combining general classroom learning with career-specific training apprenticeships. Vocational schools and apprenticeships are technical in nature, often with the goal of training workers for the industrial sector (which includes both manufacturing and construction), home to a quarter of Europe's jobs.[2] The elevator industry is a small slice of the industrial sector, so apprenticeships and secondary schools focused exclusively on elevators are rare, but related education and training in electronics or mechanics is common, giving future workers a good base of knowledge funded by the government.

Elevator-specific training has traditionally taken place on the job, with two-person teams of an experienced technician and a younger and lower-paid apprentice. Training has become more formalized in recent years, as elevators become more advanced electronic devices and the demands of the job have grown. The labor shortage in Western Europe has become especially acute, forcing companies to become much more proactive in recruitment.[3] In Germany, elevator companies have banded together to offer common courses of varying lengths for new employees and those looking to improve their skills.[4] In Switzerland, Schindler runs "Liftcamps" that recruit workers from other technically oriented industries, like auto or farm equipment mechanics, and train a few hundred technicians each year.

Poland – the construction powerhouse of Europe, which has a rapidly expanding economy and a high rate of homebuilding, but which is also a large source of labor across the continent – offers an interesting example of state-supported technical education in the elevator industry. The end of communism and the restructuring and privatization of state-owned enterprises led to the dissolution of their associated vocational training programs, and changes to the state's technical and vocational school system in 1999 further eroded educational offerings.

1 "Spotlight on VET: Germany."

2 World Bank, "Employment in Industry (% of Total Employment) (Modeled ILO Estimate) - European Union."

3 Schenkel, "Schindler-Schweiz-CEO: «Fachkräftemangel hat sich verschärft»."

4 "Willkommen in der VFA-Akademie."

The accession of Poland into the European Union in 2004 accelerated the country's brain drain, and construction workers were particularly likely to leave the country for higher wages and opportunities in Western Europe. This skilled labor crisis forced the elevator industry and government to improve technical education within the country to fill the growing demand for skilled workers across trades, including the elevator sector.[5]

The Polish Association of Lift Manufacturers (PALM) was founded in 2003, and began running its own training programs the next year. Starting in the 2010s, the association began working with the Polish government to integrate training for the elevator industry into state-supported secondary education. After leaving eighth grade, students in Poland, as in some other countries in Europe, are given the option to continue into a few separate tracks, for the equivalent of American high school. One of those tracks is a so-called *technikum* – a five-year technical school for students who would like to pursue a skilled, technical career, which may or may not involve university education afterwards. These involve a specialization in anything from hairdressing to computer programming, with construction trades being popular choices. PALM, with a small subsidy from the European Union, worked with the Polish ministries of economy and national education to develop a curriculum for a specialization in lifting equipment (including elevators), which is now available at over a dozen technical secondary schools across Poland. Technical school students study general subjects like English, Polish, history, and sciences, and also learn the specifics of their specialization. Starting in the second year, those pursuing a lifting equipment specialization begin on-site apprenticeships with firms for one day a week, which grows in later years. By the time students graduate after the fifth year (at around age 19), they have earned a basic electrical equipment certificate and more specific state certification in elevator maintenance, and can work in the elevator industry without any further formal training needed. In addition to technical secondary schools, elevator firms themselves offer in-house training, and the government's Office of Technical Inspection also offers its own more advanced classes in elevator subspecialties.[6]

4.1.2 Subcontracting and migrant labor

The Polish government and industry's training efforts were linked to an increasingly mobile workforce across Europe, which had strong effects on the market for new elevator installations and modernizations of older devices. New installations and many modernizations are now handled by subcontractors for the major manufacturers, with these subcontractors working on projects in Western Europe often hiring temporary workers from lower-wage countries in Eastern Europe. These subsectors have therefore been cleaved off from the larger, more profitable, and more stable repair and maintenance fields, where work is still performed overwhelmingly by locals.

5 "System szkolnictwa zawodowego."

6 Popielas, "Polish Lift Industry Education & Training"; "Edukacja"; "Katalog szkoleń Akademii UDT: Specjalistyczne szkolenia techniczne"; "Projekt programu nauczania zawodu technik urządzeń dźwigowych."

4.1.2 Elevators in Europe were historically installed directly by the device manufacturers and their workers. In Finland around 2010, for example, only around 5 percent of installations were subcontracted out.[7] A 2000 report commissioned by IG Metall, a German labor union that is the country's largest and that represents many elevator industry workers, downplayed the significance of outsourcing in various German elevator subsectors.[8]

This changed with the accession into the European Union of lower-income countries on the periphery of Europe beginning in 2004 with Poland, the Baltics, and a number of formerly communist countries in central Europe, continuing in 2007 with Romania and Bulgaria, and ending in 2013 with Croatia. A core precept of the European Union is the creation of a single market, without trade barriers between member states. Foreigners, whether permanent immigrants or temporary workers, are held to the same legal labor standards as locals – minimum wages, paid holidays, and working conditions still have to be respected – but firms in higher-income countries in Western and Northern Europe are free to hire workers from lower-income countries in Eastern and Southern Europe on either a temporary or permanent basis.[9]

Labor was suddenly able to move freely from Bulgaria to Portugal and everywhere in between. Services were able to be traded within the same area. And rules on the goods installed – the elevators themselves – were also harmonized (discussed in Section 5.2, "EN 81/ISO 8100: Europe's global standard"), enabling a single market for elevator installations across most of Europe. The free movement of labor even extends now beyond the limits of the European Union, with high-income Switzerland and Norway participating through other agreements, and other mechanisms for citizens of lower-income countries like Moldova and Belarus to live and work in at least some E.U. member states.[10]

Seven years after its 2000 publication, IG Metall produced a follow-up report on the elevator industry that detailed dramatic changes in the German market for new elevator installations. It put the rate of outsourcing of new installations in Germany – that is, sales of devices by companies like Schindler or Otis that are ultimately installed by different entities – at 70 to 80 percent. Modernizations, which involve replacing significant components of existing elevators and which tend to be performed decades after the initial installation, were less likely to be outsourced, but it still put the rate at between 40 and 50 percent. The report fingered Eastern European subcontractors as a major culprit in the decline of direct installation work at the Big Four, but also noted the trend towards farming out work to affiliated or subsidiary companies, whose workers are either unrepresented by unions or are represented by different unions.[11] By 2015, another IG Metall report found the outsourcing trends had held, with the Big Four happy to let small- and mid-sized enterprises have the new installation business for standard elevators, since the profits had been competed away to almost nothing.[12]

7 Lehtinen, "Development of Elevator Installation Process from Workers' Commitment and Motivation Perspective," 45.

8 Iwer, "Innovationstrends in der Aufzugsindustrie und Folgen für die Beschäftigungssituation."

9 "Document 31996L0071."

10 Fati, "De ce a început România să încurajeze eliberarea pașapoartelor pentru cei din R. Moldova"; "New Temporary Residence Permit for Belarusians Holding Humanitarian Visas."

11 Dispan, "Aufzüge und Fahrtreppen — Branche im Wandel," 54.

12 Dispan, "Aufzugs- und Fahrtreppenbranche in Deutschland: Entwicklungstrends und Herausforderungen - Branchenreport 2015."

4.1.2 At Kone, the rate of outsourcing by 2020 reached 65 percent for its central and northern European division, and 68 percent for its southern and eastern European, African, and Middle Eastern division. And Europe was actually a laggard in outsourcing of new installations compared to Asia, where 78 percent of work was outsourced for its Asia Pacific business area, and 100 percent outsourced in Greater China. The Finnish report author noted that outsourcing allows companies to ramp up – and then down – installation activity without needing to scale their internal workforce accordingly, which would otherwise have trouble fitting both stable employment and reliability of service to the boom/bust cycle of real estate development.[13] New installations are also more amenable to outsourcing to foreign workers given the more uniform nature of the work, requiring more physical effort and less technical knowledge than service and maintenance ("the world of new installations belongs to the young," as one Spanish manager put it). As a result, occupational licensing rules in Europe tend not to require workers involved in the installation process to have a specific license – unlike repairs and maintenance, where licenses are required – with adjustments and commissioning taken over at the end of the installation process by local workers, internal to the manufacturer, before the elevators are finally released to building owners for use.

In the mid-2000s, when lower-income Eastern European countries were brought into the European Union and therefore the Western European elevator workforce, fear of so-called "social dumping," or the replacement of local workers with foreign ones who are paid a lower wage, was rampant in Western European politics. Europe's Bolkestein directive was drafted in 2004 to establish a single market for services across member states, and immediately the idea of the "Polish plumber," moving west to undercut wages in France, was popularized by Euroskeptic politicians. But within a short period of time, Western Europe adjusted to the newcomers, with wages rising rapidly in new European Union member states like Poland and Romania, leveling the playing field somewhat for local workers in more developed Western European economies. Today, it's common to find workers from even farther east in Poland's new installation elevator subsector, for example from Ukraine and Belarus, playing the part that Poles did in Western Europe in the 2000s.

One exception to the trend of a single European labor market in elevator installation is Norway, where the Heismontørenes Fagforening, or Elevator Constructors' Union, has resisted subcontracting trends. Its collective bargaining agreement does not allow the subcontracting of work out to workers, foreign or domestic, not covered by the agreement, and sets a wage that is high by European standards – 370.17 NOK per hour ($34.87 using a basic currency conversion, or $43.97 using a purchasing power parity adjustment) as a base for fully trained mechanics with at least one year of experience, with increases available for overtime, seniority, work on ships, work that is especially dirty, etc.[14] The union's position on subcontracting is supported by Norwegian law, which imposes certain educational and apprenticeship requirements

13 Lehtinen, "Development of Elevator Installation Process from Workers' Commitment and Motivation Perspective," 49–50.

14 "Overenskomst for Heisfaget 15.05.2022–14.05.2024."

on elevator installers that would make it difficult for foreign temporary workers to enter the market regardless of the union contract, in contrast to the lack of occupational licensing requirements elsewhere in Europe for installers. The Heismontørenes Fagforening does not, however, fight against preassembly and prefabrication in new elevator installations the way that the dominant American elevator constructors' union does (see the "Preassembly and prefabrication" subsection in 4.2.2), preferring to focus on maintenance, repair, and other work. It also does not control entry into the field – would-be elevator workers in Norway still applying directly to apprenticeships within companies after completing a two-year upper secondary school course in electrical engineering.[15] Norway's union (which may be the only union in Europe representing elevator mechanics organized along craft, rather than industrial, lines) has also succeeded in organizing employees at the Spanish firm Orona – a company that has traditionally resisted unionization efforts in Europe more strenuously than the Big Four manufacturers – working in Norway.[16]

4.1.3 Case study: France

France offers an interesting case study of a country with what was once a fairly backwards elevator industry, which made a concerted and successful effort to bring it up to more modern standards, aided on the labor side by both greater access to foreign workers and improved national education.

Historically, France has been a nation of walk-up apartment buildings and single-family houses. The wholesale demolition and reconstruction of Paris planned by Georges-Eugène Haussmann happened in the 19th century, before the widespread availability of elevators in apartment buildings. Buildings on boulevards rose to seven or even eight stories accessed only by stairs. The country's elevator stock – already smaller than Spain's or Italy's, and according to the City of Paris the oldest in Europe – was in a sorry state in 2002, when a child in Strasbourg fell to his death down an elevator shaft after the doors opened for an elevator that hadn't arrived.[17] A representative from Kone told investigators in Paris in 2010 that France's elevator stock, particularly in social housing, was in bad shape compared to the rest of the world, and that "Kone has a list of [social housing] landlords whose requests for offers it no longer responds to, which is added to regularly."[18]

A cabinet minister named Gilles de Robien took up the cause of modernizing France's elevator fleet, introducing the first of a series of bills that would revolutionize France's elevator safety rules by requiring modernizations of older elevators and instituting a system of regular independent inspections.[19] Because the new laws required more work to be done on the nation's elevators, it also foresaw the need for a larger workforce, with provisions for state-sponsored education to supplement traditional apprenticeships in an industry that was already struggling with labor shortages.[20] Offerings now include programs extending

15 "Hvordan bli heismontør."

16 "Solidarity Works – Orona Elevator Workers in Norway Conclude Agreement."

17 Berthault, "Rapport relatif aux difficultés rencontrées dans l'entretien, la maintenance, la réparation et la mise aux normes des ascenseurs à Paris et dans l'application des dispositions de la loi « urbanisme et habitat » du 2 juillet 2003 dite « de Robien »," 10; Ceccaglini and Tomasovitch, "Bilal, 4 ans, mort à cause d'un ascenseur défectueux."

18 Berthault, "Rapport relatif aux difficultés rencontrées dans l'entretien, la maintenance, la réparation et la mise aux normes des ascenseurs à Paris et dans l'application des dispositions de la loi « urbanisme et habitat » du 2 juillet 2003 dite « de Robien »," 32.

19 Leboucq, "Ascenseurs : la loi Robien va dynamiser le marché."

20 Gournac, "Proposition de loi relative aux pénuries de main d'oeuvre."

for one or two years after the typical high school graduation, combining classroom learning with on-the-job training.[21]

Beyond encouraging more French students to study to become elevator mechanics, new immigration pathways have also fed the industry's growing need for labor. The accession of Eastern European countries into the European Union led almost immediately to workers from the new member countries entering the French elevator industry. Despite some controversy and opposition from unions, firms using temporary migrant labor from Eastern Europe now compete for subcontracts for new installations, leaving resident French workers to concentrate on more technically skilled work like service, repairs, and modernizations.[22] Elevator technicians were also added to a list of occupations where labor is in short supply, for which employers can hire workers from outside of member countries and affiliates of the European Union, with proposals now to also offer legalization of undocumented immigrants working in the field.[23]

The elevator industry in France has made strides in the two decades since the passage of Robien's laws. The number of elevator deaths fell gradually from eight in 2001, seven in 2002, and six in 2003 to just one in total between 2009 and 2013.[24] Bolstered by new planning laws forcing municipalities to accept more infill development, France has gone from being a country that mostly built single-family homes in the 2000s to one that now builds mostly multifamily dwellings, with annual new elevator installations up around 20 percent from the early 2000s.[25] Finally, French accessibility law was strengthened a few years ago, with elevators now required in four-story apartment buildings, intended to improve accessibility in new social housing in particular (covered in 2.1.1, "Walk-ups and elevator buildings").

4.2 United States

The United States (along with Canada in many ways, although due to a lack of detailed information this section will focus on the U.S. alone) has a significantly tighter labor market for elevator workers than Europe. The United States has a weaker system of technical education than most countries in Europe, and is more of a nation of office workers who sit at desks than people who work with their hands, contributing to a shortage of young people with the skills and inclination to enter the trade. The United States is, like many other wealthy countries, heavily reliant on immigrants in the construction industry generally, which poses a problem for the American elevator sector since it has one of the lowest shares of foreign-born workers of any trade.[26] It is almost completely closed to undocumented immigrants due to licensure and union rules, and the country lacks essentially any legal immigration pathway for construction workers.

Contrary to stereotypes about organized labor in the United States as compared to Europe, the elevator sector in the U.S. is heavily unionized,

21 "Les Formations du technicien."

22 Bissuel, "Le recours croissant des ascensoristes aux sous-traitants inquiète les syndicats."

23 "Arrêté du 1er avril 2021 relatif à la délivrance, sans opposition de la situation de l'emploi, des autorisations de travail aux étrangers non ressortissants d'un Etat membre de l'Union européenne, d'un autre Etat partie à l'Espace économique européen ou de la Confédération suisse"; "Loi immigration : quels sont les métiers en tension ?"; Vignal, "Régularisation des sans-papiers dans les métiers en tension : que dit l'amendement de compromis entre LR et centristes ?"

24 "Situation économique du secteur."

25 Freemark, "Doubling Housing Production in the Paris Region"; Institut national de la statistique et des études économiques, "Logements mis en chantier"; "Les pratiques de marquage CE des ascenseurs en France"; "Les ascensoristes et élévatoristes s'engagent dans la formation des jeunes et recrutent près de 1 500 nouveaux techniciens en 2020"; "Les ascenseurs en France."

26 Siniavskaia, "Immigrant Workers in the Construction Labor Force."

and organized labor exerts much greater power over the process of installing and maintaining elevators. The binational International Union of Elevator Constructors (IUEC) represents most workers in the field in the United States and Canada. The union handles recruitment into the industry, makes a strong and successful effort to limit entry into the field, and limits the ability of firms to use new technology and factory production to streamline the installation and maintenance of elevators in North America. The result is higher compensation, more work for citizens and little opportunity for immigrants, and less efficient work overall, contributing to high final costs. The labor shortage is, paradoxically, somewhat of a self-reinforcing mechanism, strengthening the hand of the IUEC at the bargaining table to create more work through prohibitions on efficiencies in the installation process in particular.

4.2.1 Training

In the United States, state-supported technical education is far weaker than in Europe. Training for workers in the elevator sector has little to no state support at almost any level, and takes place almost entirely within the confines of private companies. Training and entry into the industry is mostly mediated through the International Union of Elevator Constructors, the craft union that represents most workers in elevator construction, maintenance, repairs, and modernization in the United States and Canada. Like other craft unions, the IUEC uses apprenticeships to restrict entry into the field, as a way to maintain worker bargaining power over employers, supporting high wages, strong benefits, and protections against technological innovation and efficiencies that might threaten jobs.[27] Securing a union apprenticeship in the elevator industry can be a difficult task often requiring knowledge that is not widely available, and training can begin up to a decade later than in Europe, with the high costs being almost entirely borne by private industry.

The vast majority of the North American elevator companies – including Otis, Kone, Schindler, TK Elevator, Mitsubishi Electric, Fujitec, and many of the smaller regional firms – are signatories to a master labor agreement with the International Union of Elevator Constructors. The IUEC (or simply, “the union” in this report) is a traditional American craft union, a form of labor organization that evolved from the feudal guild system. It sorts workers along the lines of their craft (otherwise known as their trade) rather than along the lines of an industry or a whole company, as is more common with unions who represent elevator workers in Europe. Only elevator field workers – those who work on new elevator installations and modernizations, or in service, repairs, or maintenance – are members of the union. Sales representatives, factory workers, supervisors, consultants, and other North American elevator industry workers, even within the major firms, are not represented by the IUEC.

27 Barbash, “Union Interests in Apprenticeship and Other Training Forms”; Meeks, “A Primer on the Different Types of Labor Unions.”

4.2.1 IUEC applications and recruitment

The International Union of Elevator Constructors limits access to the industry – or at least the majority that it represents – through its apprenticeship program, organized through the joint labor-management National Elevator Industry Educational Program (NEIEP). The process of joining the trade can take many years, and successful attempts often involve already having a career in another union trade (for example, as an electrician or welder) before even beginning the recruitment process. The elevator trade is, as in Europe, quite niche and obscure even within the construction industry, but unlike in Europe, there is almost no effort by the unionized majority of the sector to actively recruit, since demand for jobs at the negotiated wage usually outsrips available opportunities for work. Due to the difficult recruitment process, entry into union firms is nowadays significantly delayed compared to Europe. In this sense, the pathway to a job in the elevator industry in the United States is not unlike that of the medical education process, where American doctors must go through significantly more schooling than their European counterparts, with barriers to entry into the workforce proliferating throughout the industry to drive up costs.[28]

Unlike in Europe, where job seekers apply directly to elevator firms, would-be entrants into the union elevator industry in the United States are all funneled through the common National Elevator Industry Educational Program. Elevator firms control the pace of hiring (which is limited by available work and wages and benefits that must be paid), but the IUEC, through its close relationship with NEIEP, controls access to the hiring pool. Each union "local," which represents workers within a metropolitan area, holds periodic recruitment drives organized by NEIEP. The recruitment and application process involves filling out an online application, taking an aptitude test, and then standing for an interview. Successful applicants are then ranked, and called up by companies to begin apprenticeships in order of their ranking. Within these general steps, there are a number of unusual and opaque processes, which, especially in locals in older and larger metropolitan areas like New York City, Chicago, and Los Angeles, can be difficult to successfully navigate using only the information provided on official websites. In the past, the finer details of successfully joining the union were only available through word-of-mouth, strongly favoring those with family or friends in the trade. Nowadays, the internet and forums like Reddit's r/elevators "subreddit" have demystified the process for those adept at doing online research, so nepotism is less of a necessity (although large numbers of apprentices do still have family connections to the trade).

The first hurdle involved in the recruitment and application process is understanding the process at all, and timing entry correctly. The very general steps are laid out on the NEIEP's website, but with critical details omitted about timing and steps that must be taken to maximize success (an out-of-date and inaccurate median wage is also listed).[29] Recruitment periods open up once every roughly two years, though

28 Orr and Jain, "The Case for Shortening Medical Education."

29 "NEIEP Help Center."

they can be canceled or postponed, so it's not unusual to go longer between recruitments. Open recruitment periods are listed in advance by quarter, with the exact dates appearing a few weeks before opening.[30] When recruitment periods are posted on NEIEP's online calendar, they are listed as starting either at midnight or in the morning on a particular day, and then remaining open for a few weeks. Unmentioned, though, is that applications for competitive locals in major metropolitan areas may only be accepted for a few hours before the application limit is reached and the opportunity is closed for the next few years.

A key reason for the long periods between recruitments and uncertain timelines is that the union contract stipulates that no inexperienced workers may be hired until all union members in the area have work – that is, in the language of the industry, "the bench is cleared." Companies are free to lay off workers or decline to hire a "benched," or out-of-work, union member at their discretion, but they may not train new workers or hire experienced union members from outside of the area until all willing union members within the local are employed. If a union member is continuously rejected by a company looking to hire, the matter is eventually sent to arbitration, where a neutral arbitrator decides whether the rejection is warranted (in which case the worker is excluded from the out-of-work list for a time, allowing companies to train new apprentices), or not (in which case the company may lose its right to reject union members for hiring for a period of time).[31]

Following the application and an aptitude and tool test, those who scored above a certain threshold are invited for an interview. The interview includes a series of generic hiring questions (for example, asking applicants to describe a conflict they've had in the past and how they resolved it), followed by an open-ended opportunity for applicants to describe things like their past work experiences, qualifications, and motivation for joining the union. The interviewees are judged by one representative from employers and one representative from the union, and the score can reflect how an applicant carried themself, how extensive their work experience is, or simple nepotism and bias. In competitive IUEC locals, it is difficult to score highly unless an applicant has extensive work experience, and it is not uncommon for successful candidates to have already worked their way through a different union's apprenticeship program (costing the employer in that other trade quite a bit of money paid for training, and an experienced worker). In many cases, given the extensive work experience ranked applicants already have, workers have to take a temporary pay cut to start training, since even though the starting salary is high by global standards (for example, apprentices in Local 25 in Denver started at $23.27 per hour in cash, plus benefits, in 2020, half the rate of journeyman elevator mechanics), the work experience necessary to enter the union can be even higher.[32]

Applicants are then ranked and given a number, starting with 1 for the best applicants. When companies are looking to hire and the bench has been cleared of all trained mechanics, helpers, and apprentices,

30 "Apprenticeship Opportunities."

31 "NEBA Agreement with IUEC, 2022-2027," Article XXII, Par. 1, (b).

32 International Union of Elevator Constructors, "Wage Rates, IUEC Local Nº 25, Denver, CO," January 1, 2020.

4.2.1 new, untrained workers are referred to start internships at signatory companies in the order of their ranking. Ranked applicants must follow hiring closely to have an idea of how likely it is that – and when – they'll be called up before the next recruitment (at which point unhired applicants, regardless of their ranking, are put through the process again if they want to continue to try to pursue a career in the union). Many locals post hiring progress on their websites, and others require applicants to call the union hall or glean information on social media.

Being ranked is no guarantee that an applicant will be called up before the list is restarted a few years later. As an example of how imbalanced supply of and demand for jobs can be, IUEC Local 1 – the largest and one of the most highly paid and desirable locals, covering New York City and its suburbs – accepted 1,500 applications in 2021 for the current recruitment cycle, and was stuck at number 94 for well over a year, with the next recruitment scheduled to accept applications in the fall of 2024.[33] The recruitment that started before the current cycle started in 2018.

Once a ranked applicant's number is up, they are called by the union and told to report to work within a few days. If they do not answer the phone and have not alerted the union hall that they will be temporarily unavailable, they are given a certain amount of time – usually measured in hours – to call back, and if they do not, they are skipped over and in many cases must restart the years-long process. When called, they must quit their job immediately, without giving any notice to their employer, unless they had a good enough relationship with their employer that they were able to notify them months or years in advance that they may abruptly leave at some point, without fear of being replaced before then.

The barriers to joining the union deter many applicants on an individual level, but at a higher level, the barriers are reflective of a wage far above the market-clearing level – that is, the level at which there are about as many qualified applicants as there are available positions – and do not drive it. With wages and benefits above those found in most other construction industry positions, there will always be far more applicants than available jobs. One of the union's most important roles is to square that circle, which they do with a combination of very high standards (for example, by making prior experience in other trades a de facto requirement), obscuring information about the process, and giving outright preference to those with connections to the union, all of which bias successful hires towards those with pre-existing social connections to union members.

Apprenticeships

Once an applicant is called to begin work, they start the typically four-year apprenticeship program. The vast majority of training occurs on the job, as a helper working under a full mechanic. NEIEP began the union's apprenticeship program in 1967, which at the time consisted of

33 "Apprenticeship."

4.2.1 around 80 hours of formal training each year, plus 1,800 hours of work experience.[34] Over time, the formal training component has expanded to 144 or 150 hours a year, but the majority of an apprentice's time is still spent on paid jobs.[35]

The union's apprenticeship program used to be largely informal, but has been formalized over the years, in part to qualify it for licensure regimes. Licensure has raised the stakes for what can be considered a registered apprenticeship, and the union takes an active role in opposing the registration of apprenticeship programs that it does not control. When the Associated Builders and Contractors (a non-union, or "merit shop" trade group) tried to register an elevator apprenticeship program in New York State, both the elevator constructors' international and local based in Albany wrote to ask the Department of Labor to not approve the program.[36] In some cases, non-union apprenticeship programs must be recognized by the state elevator safety review board, where IUEC leadership is well represented.[37] Many states have few or no registered apprenticeships that are not affiliated with the union, in contrast to apprenticeships in other trades where non-union programs have more of a presence.[38]

Licensure

In the past, as in many smaller skilled trades, there was no special license required to work on elevators, either as a contractor or as a mechanic doing new instalions, modernizations, or service and repairs. Over the past few decades, however, licensure has spread across the vertical transportation industry, as major manufacturers and the IUEC have lobbied together for laws that regulate licensure in the industry (see "Cooperation between labor and manufacturers" in 4.2.2 for more on this political collaboration). As of mid-2022, about half of all U.S. states required specific licenses to work on elevators.[39]

Licensure can create barriers to movement by elevator mechanics and contractors across state lines, supporting restrictions within the IUEC's contract on movement between locals.[40] Connecticut was an early adopter of licensure, and is viewed by non-signatory firms as a particularly hostile state to work in.[41] The state's elevator board, in the words of its 2018 acting chairman (and IUEC Local 91 business manager), "has always been hesitant to approve [journeyman license] applications for those who have not completed their [on-the-job] training or apprenticeship in Connecticut," or to approve licenses for contractors who have not worked in the state as journeymen for at least two years.[42]

Connecticut Governor Ned Lamont has introduced bills to, among other things, make it easier for workers in a range of professions licensed in other states to work in Connecticut.[43] The governor's office, in their 2021 push to recognize out-of-state licenses, wrote that licensed workers were 24 percent less likely to move between states than unlicensed

34 *2005 Ct. Sup. 844.*

35 Devlin, "Re: Proposed Rule: Apprenticeship Programs, Labor Standards for Registration, Amendment of Regulations," October 24, 2019.

36 Christensen, "Re: Associated Builders and Contractors Empire State Chapter Elevator/Escalator Constructor & Modernizer Program Pending Approval," October 16, 2020; Hagerty, "Re: Associated Builders and Contractors Empire State Chapter Elevator/Escalator Constructor & Modernizer Program Pending Approval," October 12, 2020.

37 "Office of the Illinois State Fire Marshal Elevator Safety Review Board Meeting," July 14, 2011, 58–85.

38 "DOL-Registered Apprenticeship Programs in Texas as of 8.28.19"; "Period Covered: 7/1/2017 - 1/1/2023 (Connecticut Registered Apprenticeships)"; Public Sector Consultants Inc., "Benefits of Michigan Apprenticeship Programs"; Argyres and Moir, "Building Trades Apprenticeship Training in Massachusetts: An Analysis of Union and Non-Union Programs, 1997-2007."

39 Blankenbiller, "Get With the Program!"

40 "NEBA Agreement with IUEC, 2022-2027," Article XXII.

41 International Union, El. v. State El., 11822.

42 Layman, "Minutes: Elevator Installation, Repair and Maintenance Work Examining Board."

43 Looney et al., An Act Expanding Economic Opportunity in Licensed Occupations; Lamont, An Act Expanding Economic Opportunity in Occupations Licensed by the Department of Consumer Protection.

workers, despite having comparable rates of intrastate mobility.[44] The bill never passed, and attracted the strong opposition of construction unions.[45] A representative of IUEC Local 91 wrote that "related instruction in other states may not meet Connecticut's standards," while the owner of a small firm whose "family began [e]levator manufacturing and contracting in 1895" wrote in opposition as well.[46] A bill did eventually pass recognizing out-of-state licenses in Connecticut, but it did not apply to elevator mechanics, and most other licensed building trades were stripped out. The governor's office did ultimately find an administrative pathway to license elevator mechanics who completed apprenticeships in other states and who can prove that they completed the on-the-job training and instruction hours equal to what Connecticut now requires for new licensees.[47]

Connecticut is not the only state that has restricted entry of out-of-state mechanics into the market. Massachusetts's Office of Public Safety and Inspections requires that applicants for an elevator mechanic's license be currently registered as an apprentice, and have completed "not less than 6,000 on-the-job-training hours over a period of not less than 3 years as an elevator constructor apprentice, under the direct and immediate field supervision of a licensed elevator mechanic in [Massachusetts]."[48] Full mechanics from other states must therefore accept a demotion and potentially a pay cut for three years in order to rack up the necessary hours in Massachusetts in order to obtain a license to work in the state.

4.2.2 **Labor relations**

The International Union of Elevator Constructors is fairly unique among construction unions in signing a contract with a national bargaining unit composed of all of the major elevator companies. The agreement covers matters like wages (which are different for each union local), benefits (which are standardized across the United States), work conditions, strikes, procedures for hiring and laying off workers, and – importantly – designating what work must be carried out by union members. The latest agreement, in effect from 2022 to 2027, runs 82 pages, but there are many other side agreements that govern relations between the union and employers, and conflict between the two parties over details of the relationship is not uncommon.

Compensation

International Union of Elevator Constructors officials are fond of saying that elevators are the best trade in the country, and pay statistics bear that out. The U.S. Bureau of Labor Statistics (BLS) keeps data on wages for over 50 "construction and extraction occupations," and what they classify as "elevator and escalator installers and repairers" have the highest median wage of any of them. At $47.60 per hour (or $99,000

44 "House Bills 6445, 6449, An Act Concerning Economic Opportunity in Occupations Licensed by the Departments of Consumer Protection and Public Health."

45 "Testimony For Bill Number HB-06445 In All Committees."

46 DeRosa, "Testimony of the International Union of Elevator Constructors Local 91," February 23, 2021; Farnsworth, "Public Hearing Testimony," February 23, 2021.

47 Comey et al., An Act Expanding Economic Opportunity In Occupations Licensed By The Departments Of Public Health And Consumer Protection And Requiring A Report From Certain Executive Branch Agencies Regarding Background Checks And The Feasibility Of Establishing Preclearance Assessments Of Criminal History; "Elevator Journeyperson - Equivalent Out of State License."

48 General Laws, Part I, Title XX, Chapter 143, Section 71C.

4.2.2 per year, though this may not reflect the reality of overtime, and does not includes benefits), the median elevator mechanic makes more than the median "construction and building inspector" ($31 per hour) or the median "first-line supervisor of construction trades and extraction workers" ($35.62 per hour).[49] According to BLS data, full-time elevator mechanics make more than twice the median U.S. worker's hourly wage ($22.26 in May 2021).[50]

Because the vast majority of mechanics belong to the same union, specific wage rates are easy to determine. These are not published openly, but can often be found online through searching, or guessed based on local government prevailing wage publications. These documents back up what Bureau of Labor Statistics data shows. While the industry's master collective bargaining agreement is the same nationwide, individual union locals have their own wage rates, which generally rise with latitude. The New York City (currently $77.49 per hour for installers, or $60.89 for modernization, service, and repair mechanics) and San Francisco locals ($69.78 per hour for all mechanics in 2020) have some of the highest rates in the United States, and locals in the southeastern U.S. have some of the lowest ($41.90 per hour for mechanics in Charlotte in 2020). Union elevator mechanics receive strong supplemental benefits on top of wages. In 2020, benefits contributions by employers totaled $35.25 per hour, including healthcare, pension, 401(k) contributions, and contributions to union funds.[51]

Labor conflict

Conflict between workers and employers is an inevitable feature of labor relations, but the amount of acrimony between unionized elevator constructors and their employers (that is, firms like Kone, Schindler, etc.) stands out in the United States construction industry. Most disputes do not make it into the public record, but those that do offer a hint at stormy relationships, and a balance of power within the industry that tends to favor the union, with employers far more often alleging breaches in the collective bargaining agreement than employees.

The early 2000s were a particularly turbulent time for labor relations in the American elevator industry, in some cases related to global technological innovations and the introduction of new machine room less electric traction elevator designs. In a 2006 court filing, a judge noted that IUEC Local 4 (based in Boston, which at the time had around 1,000 members) "had violated no-strike clauses at least six times in the last four years with respect to other employers."[52] The collective bargaining agreement states that employees are not allowed to withhold their work – that is, they are not allowed to strike – as long as the agreement is in effect. Disputes around the finer points of work jurisdiction must be taken to a neutral arbitrator, with employees to follow orders of the employer until a decision has been reached, with compensation paid by the employer to the union if the arbitrator determines that it

49 United States Bureau of Labor Statistics, "Occupational Employment and Wages, May 2022: 47-0000 Construction and Extraction Occupations (Major Group)."

50 United States Bureau of Labor Statistics, "May 2022 National Occupational Employment and Wage Estimates: United States."

51 International Union of Elevator Constructors, "Wage Rates, IUEC Local Nº 8, San Francisco, CA," January 1, 2020; International Union of Elevator Constructors, "Wage Rates, IUEC Local Nº 135, Charlotte, NC," January 1, 2020.

52 Woodlock, Kone v. Local 4, IUEC.

was the company that was in the wrong.[53] The case was typical of such disputes, with an employer (in this case Kone) alleging that the union illegally walked off the job over some issue or another, rather than going through the grievance process outlined in the contract.

Employers have repeatedly alleged in court filings that the union uses illegal strikes during time-sensitive work to pressure the companies into agreeing to terms favorable to the union. In a 2018 case again involving Boston's Local 4, Fujitec alleged that, after a dispute over whether an hour of overtime pay was required after a short phone call outside of work hours, the union called an illegal work stoppage instead of going through the prescribed grievance process. The supposed work stoppage involved on-call mechanics ignoring text messages from an answering service over malfunctioning equipment, instead waiting for Fujitec supervisors to call the mechanic directly – a hassle and disruption intended to pressure the company into giving in to the union regarding the original overtime dispute. These service calls often involve highly time-sensitive entrapments, where riders are stuck in elevators, and Fujitec provided an example of an entrapment call at 7:29 p.m. on a Wednesday at Tufts University that was delayed by over 15 minutes, causing the Boston Fire Department to be dispatched instead – a less-than-ideal outcome given firefighters' lack of knowledge about elevators and penchant for damaging the device during rescue attempts, rendering it inoperable without an expensive repair.[54]

The 2018 dispute wasn't the only time that an elevator manufacturer claimed that a union local ordered its members to refuse to free people stuck in elevators in order to push its position on an issue that, according to the contract, should have gone through the arbitration process. In 2004, Otis alleged that Local 91 orchestrated a sick-out strike by its members in Connecticut over a dispute relating to an old elevator dismantled without paying the union or its members (see the "Other work jurisdiction disputes" subsection of 4.2.2 for more), leading to at least two entrapment calls going unanswered.[55]

Beyond entrapments, companies have alleged that the union uses illegal work stoppages during time-sensitive construction work to pressure them into agreeing to terms that should go through the formal arbitration process. In a 2003 complaint against the IUEC and its Indianapolis Local 34, Otis alleged that the union declined or put off offers over a few years to discuss the design of its new Gen2 machine room less elevator system and some preassembly of parts (discussed in further detail in the "Preassembly and prefabrication" subsection), so that the dispute would have to be resolved when Otis was in a tight spot, with its client housing tenants in temporary facilities and breathing down Otis's neck to finish the job. "The Unions have clearly timed their objections to arise when Otis, its customers and the public are most vulnerable," wrote Otis's attorneys, "when Otis is under time pressure to complete installations without costly and destructive delay that could impact the reputation and marketability of Gen2."[56]

53 "NEBA Agreement with IUEC, 2022-2027," Article XIV, Par. 1; Article IV, Par. 11; Article XV.

54 NEBA, Fujitec v. IUEC, Local 4.

55 Otis v. Local 91, IUEC.

56 Otis v. IUEC, Local 34.

4.2.2 In 2012, Schindler and the major manufacturers' national bargaining unit wrote in a court brief that the union had used spurious safety complaints to claim more work for its members. At a hospital parking garage in Buffalo, NY, the general contractor had built scaffolding within the elevator hoistway, which elevator constructors could have used to stand on while they installed equipment. The Local 14 business representative looked at the scaffolding that had already been erected and said, "that's our work," and that the local had "several guys on the bench" – that is, without work. Schinder and the national bargaining unit claimed that there was no contract provision promising the work of erecting scaffolding within the shaft to union members. They said that after pointing out that refusing to work on the site unless they were given the work (presumably having the contractor dismantle the scaffolding and then paying Local 14 members to reassemble it) would constitute an illegal work stoppage, the local's business representative changed tactics and said, "it's not a [contract] breach if it's a safety issue."

The general contractor then had a certified scaffolding inspector look at the work and certify it as compliant with federal Occupational Safety and Health Administration (OSHA) rules, with the local's business manager then replying that OSHA certification was "just a piece of paper, and unless we erect it, we can't guarantee safety." The business manager soon followed this up with a text reading, "Let me correct myself. Schindler employees" – that is, Local 14 union members – "can deem a situation or area unsafe to work in." In a later conversation, a Local 14 business representative then returned back to the economic argument, with plaintiff's attorneys claiming the local's representative said that "if Schindler continues to 'give away our work, there won't be anything for our guys to do.'" Later, the IUEC's regional director said that the dispute could be resolved if Schindler made payments to the union equal to 12 hours of wages for a two-person crew. The plaintiffs also claim that the elevator mechanic-in-charge on the site explicitly denied that he had any safety concerns, and "admitted it would be an insult [to the tradespeople who installed it] to suggest the platforms were unsafe."[57]

In other cases, elevator companies have claimed that union locals have put work and job preservation above safety, and have engaged in illegal work stoppages. In 2021, attorneys for Schindler alleged that, after a Local 5 member was fired for using an expired piece of equipment during an elevator installation without checking whether its certification was still valid, the local's business representative said to a Schindler manager, "I have a feeling that morale is going to drastically decline immediately," after which 42 union members walked off construction sites around the Philadelphia area, including at least two public elementary schools and a healthcare facility.[58] In a 2004 case, Local 4 in Boston insisted that a piece of equipment in a hydraulic elevator that had already been delivered be removed so that union members could disassemble and reassemble the part, presenting what Otis claimed would be "serious and unnecessary physical safety concerns" over creating unnecessary work with heavy equipment (the judge agreed that

57 NEBA and Schindler v. IUEC, Local 14.

58 NEBA and Schindler v. Local 5, IUEC.

4.2.2 the dispute was arbitrable, and ordered the union to let its members return to work and resolve the issue in arbitration).[59] And in at least two instances, employers have alleged that union locals, in Boston and New York, pulled workers off of a job in retribution for employers suspending or terminating mechanics for engaging in physical fights at work.[60]

In most cases, the work stoppages that made their way into court were settled out of court before a judge could decide on the merits of the case (usually when cases advanced this far, they were decided in favor of employers, and the union was enjoined from illegal strikes). But the legal record suggests that the union often feels that it has enough market power to withhold labor in order to win more work for its members.

Preassembly and prefabrication

A common and recurring tension between the International Union of Elevator Constructors and major employers is over the issue of preassembly and prefabrication of elevator parts. To a greater extent than anywhere else on earth, the IUEC has succeeded in thwarting the adoption of more productive, faster, and lower-cost methods of elevator construction in the United States, by preserving work for its members and keeping it out of globalized factories. The IUEC has even won the right to undo some work already performed in factories in order to have its members redo it themselves on the job site. From the drive machine and support structure at the top of the shaft to the wiring of electronics to door mechanisms to the construction of cabins themselves, the union has fought and won the right to perform work in most elevator installations in the United States in a uniquely unproductive manner. Labor is the largest cost in any elevator installation, and wages and benefits for IUEC members in the United States are the highest on earth, so this preservation of work for the union has ramifications for developers and, ultimately, anybody who lives or works in buildings with elevators, or who might benefit from one.

Modern construction is always a mix of work performed in factories and work performed on site, and the global trend has been towards performing more work in factories. Factories are climate-controlled facilities with more room for precision machine tools, and they allow for more labor specialization. They are generally more productive than construction sites, and moving work out of the field and into these more controlled settings has been a long-running goal of builders, with examples of off-site construction dating as far back as 6,000 years ago, to the construction of an early Neolithic road in England.[61]

Moving work into factories is also a major goal of elevator companies. Hoistways are tight spaces that are difficult to work in, their heights present safety challenges, the structures surrounding them are not designed as construction staging sites, and new construction tends to be driven by strong local economies with high wages. The elevator

59 Otis v. Local 4, IUEC, D. Mass. May 26, 2004 at 4; Otis v. Local 4, IUEC, D. Mass. June 10, 2005 at 4.

60 Otis v. Local 1, IUEC; Otis v. Local 4, IUEC, D. Mass. November 24, 2004.

61 Coles, "The World's Oldest Road."

4.2.2 sector is largely a global one, and the Big Four and other major firms prefer to shift as much production as possible to lower-wage countries like China and India in order to bring down prices. In the most extreme cases, they are working towards removing humans from the process of on-site elevator construction entirely, pressing forward with modular shafts and robots drilling holes and setting anchor bolts in demonstration projects in Europe, Asia, and the Middle East.[62]

North America's International Union of Elevator Constructors, on the other hand, fiercely resists labor-saving innovations in preassembly and prefabrication. "We can't afford to sit back and see our trade dumbed down through factory prefabrication and preassembly to a point where all our members will have to do on the job is simply uncrate the elevator, set it, and plug it in," wrote IUEC's General President Dana Brigham in 2011. The union is the strongest fighter among the trades against efficiency, with Brigham writing that elevator and escalator companies "look around and ask why, when no other trade is fighting over prefab, they have to allow our members to take sheaves off and put them back on, or to take a complete escalator apart on the job. And, believe me, it's not an easy task convincing an impartial arbitrator, who may be more familiar with other industries where that kind of thing never occurs, to allow us [to] do it."[63]

The mention of "tak[ing] sheaves off and put[ting] them back on," and "tak[ing] a complete escalator apart on the job" is a reference to the most inefficient practices within the American vertical transportation industry, where parts that ship from global factories already assembled are, as the general president wrote, taken apart and then put back together, to make work for the IUEC's members. An arbitrator summed it up in a 2010 decision over a dispute between Kone and IUEC Local 35:

> In the elevator industry, it has become routine that when work is performed in a factory – that is, determined to be within the jurisdiction of workers in the field – the company may, instead of modifying its production process, continue to use the production process that was found to be impermissible, so long as the field workers are permitted to disassemble the work in question and reassemble it in the field. By proceeding in this manner, the companies can manufacture and ship their equipment in today's global market without having to make changes for certain geographic areas, and the Union can apply its contract rights by continuing to perform bargaining unit work.

The process of disassembling and reassembling parts is unnoticeable in the final product, so witnesses from the union testified to the arbitrator that "[t]hey also signed their names, or initials, on the sheave when it was disassembled to prove that it had actually been disassembled."[64]

62 "Modular Construction in the Lift Sector"; "Fast and Innovative: Modular Design Lifts"; "The Urban Future Is Pre-Fabricated – Why Modular Construction Is on the Rise"; "Step into the Future with Schindler R.I.S.E."

63 Brigham, "General President's Report."

64 Grossman, "IUEC, Local 35 v. Kone, Gr: Nº 4-112 – Reassembling Crosshead Sheaves."

4.2.2 The rules are hammered out in a complex dance of contracts, settlement agreements, arbitration decisions, and occasionally work stoppages and injunctions – few of which are supposed to be visible to the public – and are constantly in flux as technologies change, economic conditions strengthen and deteriorate, and union officials come and go. The practice is somewhat of a dirty secret within the industry, not talked about in *Elevator World* or any other publicly available source, and the specifics are hard to nail down in interviews, given the level of detail and shifts over time. But occasionally, documents surface, both in and out of the public record, that offer a window into the practice and, sometimes, even its exact costs.

Perhaps the most high-profile example of the practice of undoing completed work to create billable hours for the union comes in the installation of escalators, referenced in the general president's 2011 letter. While "tak[ing] a complete escalator apart on the job" might be a slight exaggeration, the design of escalators and low tolerance for failure given the public's close interaction with moving parts means that there is a substantial amount of necessary preassembly, with parts later disassembled and reassembled on site. The biggest source of acrimony between the union and manufacturers involves the balustrade, or the side of the escalator that extends above the steps and supports the handrail, and how much alignment can be done before shipment, and then how much can be undone and then redone on site by IUEC members. IUEC General President Brigham described this "alignment work as the 'bedrock' of the industry," and described the alignment work at installation as a sort of training, ensuring that "the skills of the bargaining unit employees [can] be maintained so that maintenance, repair and modernization can be properly and efficiently accomplished."[65]

Kone's development of the ECO-3000 escalator in the early 2000s kicked off a grievance by the company against the union regarding disassembly and reassembly, specifically regarding the work aligning the "balustrade brackets," which hold the balustrade in place and are "important to the safety and operation of the escalator," in the arbitrator's words. The escalator was designed, primarily in Germany, to meet "new tighter tolerance safety standards," redesigning an older model to "[reduce] the likelihood that items and/or people might be caught" between the elevator skirt and the step – a common issue with escalators, which are responsible for far more injuries per device than elevators.[66] This design involved some alignment in the factory, which the union believed was in contravention of their agreement with the company, and which the union directed its employees to remove and reinstall. The arbitrator ultimately sided with the union, concluding that "[t]he Company's design and factory alignment may well promote efficiency and safety," but the contract nevertheless forbade it and the contract terms needed to be changed if the company wanted to continue with its preassembly practices.[67]

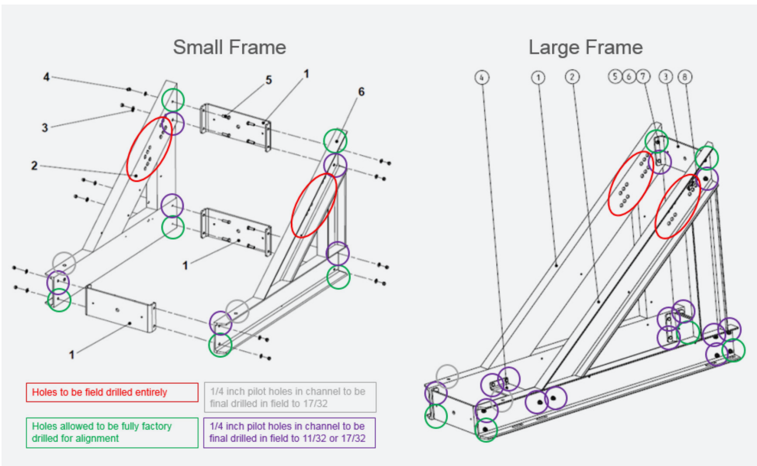
65 Vaughn, "Kone v. IUEC, Work Jurisdiction, Installation of Balustrade Brackets Grievance, AAA Case Nº 33 300 00336 02."

66 McCann, "Deaths and Injuries Involving Elevators and Escalators."

67 Vaughn, "Kone v. IUEC, Work Jurisdiction, Installation of Balustrade Brackets Grievance, AAA Case Nº 33 300 00336 02."

4.2.2 Over the next decade and a half, Schindler and the IUEC would also sign a series of agreements related to Schindler's own escalator models released around the turn of the millennium. As with Kone's escalators, Schindler's agreements instructed mechanics to remove or loosen – only to immediately reinstall or retighten – components including balustrade clamps and brackets, comb plates, and skirts.[68]

The settlement agreements and arbitrators' decisions were often part of a system called "obey and grieve," where, when faced with disputes, the union carried out the employer's orders, and then was sometimes compensated if the orders were later determined to violate the contract. Settlement agreements therefore sometimes include dollar amounts that employers must unions in compensation for work that was already done, which the union was later determined to have been entitled to. In 2010, for example, the IUEC and ThyssenKrupp Elevator signed a settlement agreement resolving some (but not all) grievances around various aspects of the firm's Synergy L – a machine room less elevator model developed and sold in the late 2000s – which allowed for car and counterweight sheaves to be "drilled, installed then shipped from the Factory to the job site, [and then] removed and reinstalled by IUEC members in the field." TKE was to give the union's benefit plan $80,343.39 in compensation for lost work associated with 130 Synergy L units that were already (or soon-to-be) sold.[69]



Source: Settlement Agreement: FMM/6400 Product

More recently, the IUEC's Assistant General President signed an agreement with Schindler's Director of Labor and Employee Relations – suggesting the importance of these negotiations to both parties – over the FMM/6400, a model sold for modernizations of older election traction elevators in low- and mid-rise buildings. The 2019 agreement concerned a particular point of contention between the union and employers: the drilling of holes. The manufacturers prefer to drill holes in parts before they arrive on site, to take advantage of the cheaper labor and more controlled conditions in factories. For global products, sold primarily in Europe and Asia, the Big Four have free rein to drill as many holes as they'd like in factories, before parts arrive on construction sites. But in the United States, the IUEC keeps as many holes as it can for its members, since they are a crucial source of work hours. The agreement therefore lays out in exacting detail which holes required for the installation of the drive machine support structure can be drilled in the factory ("for alignment," the agreement specifies, hinting at the superior accuracy and quality control of factory work), which can be drilled in the field, and which can be a mix of both – a smaller "pilot hole" drilled in the factory to ensure proper placement, to be enlarged on site by a union elevator constructor.

68 "Settlement Agreement Regarding 9300 Escalator"; Bender and Van Winkle, "Settlement Agreement Regarding 9700 Escalator."

69 "Settlement Agreement, TKE and IUEC (Synergy L MRL)."

4.2.2 The cost of the work was pegged at a total of $180,253.42 for 349 machines with mostly large frames requiring more holes. The agreement came with a list of elevators installed across the country, showing the range of buildings saddled with higher costs – everything from an Air Force base in Louisiana to a low-cost condo complex in Honolulu, along with lots of hotels, offices, and rental and condo buildings across the country. At $132.80 per hour for a team of two in 2017 (a mechanic at full salary and a helper at 55% salary, presumably a composite figure representing average compensation across the country, with both wages and benefits), the work owed to the union comes out to four hours of drilling holes per team of two, or eight total hours of labor.[70]

Schindler signed similar agreements for its new construction 3300 and 5500 MRL models (some of its most popular to this day), as did presumably other manufacturers coming out with new models around that time.[71] The issue of drilling holes has become so contentious – and, by implication, lucrative for the union and costly for employers and elevator buyers – that a union leader in a 2011 issue of *The Elevator Constructor* breathlessly relayed a story about Otis trying to come up with an end-run around the issue of drilling holes by using a different method of connecting pieces entirely: “They had slotted the beams. One more time, you heard it right; the beams had been slotted, not drilled with a hole!”[72]

Beyond holes, wiring comes up as a recurrent topic of dispute between the union and its employers. The International Union of Elevator Constructors prides itself on the diverse skills needed to perform the trade, with elevators being complex electromechanical devices requiring both brawn and welding, mechanical, and electrical skills to install, with more intellectual skills to troubleshoot problems in routine service. But over the years, elevator manufacturers have simplified the electrical work required in the field by developing plug-and-play electrical connections between components. The United States stands out in resisting these trends, with the IUEC’s latest contract specifying that “[a]ll wiring, conduit, and raceways from main line feeder terminals on the controller to other elevator apparatus and operating circuits” lie within the work jurisdiction of union elevator constructors, and that “controllers are not to be shipped from the factory with extended wiring attached thereto.”[73]

The exact line between allowed and disallowed prewiring has been contested over the years. Schindler’s 2014 settlement agreement over its popular 3300 MRL model, for example, specifies that the company “will modify the extended wiring from the machine not to exceed the length of a six foot pigtail,” while extended wiring associated with the elevator doors “will be removed and replaced in the field by Elevator Constructors.”[74] In 2017, an arbitrator found in favor of the union in its dispute with ThyssenKrupp Elevator over wiring installed in a factory in its Endura model, a hydraulic MRL elevator. He ordered the company to “cease and desist shipping Endura MRL elevators with the junction box pre-installed and pre-attached,” and to make whole “those employees who installed Endura MRL elevators for the time each lost” – that is,

70 Bender and Dzierzawiec, “Settlement Agreement: FMM/6400 Product.”

71 Bender and Dzierzawiec, “Settlement Agreement: 5500 MRL Rear Counterweight.”

72 Local 18, “Local Roundup.”

73 “NEBA Agreement with IUEC, 2022-2027,” Article IV.

74 Shields and Bender, “Settlement Agreement (Schindler 3300).”

4.2.2 time they did not work and were not paid for – "as a result of not wiring the junction box," along with some related complaints over brackets.[75]

Other work jurisdiction disputes

Beyond the above issues around preassembly and prefabrication – drive machines and their support structures, prewiring, and escalator balustrades – there are a number of other disputes around work jurisdiction that come up from time to time in the public record. Dismantling of old equipment, hoisting of equipment, finishing work in high-end and historic cabin interiors, and, with new technological innovations, remote interaction have all been matters of contention between the union and its employers.

Before a new elevator is installed, the demolition of an older unit sometimes becomes an issue. Article IV of the latest contract states that "[t]he wrecking or dismantling of elevator plants" – including escalators and other related equipment – "shall be performed by [union members]," and "the Union reserves the right to refuse to install any new elevators" in a building where they were not paid to dismantle the old equipment.[76] In 2004, Otis was hired to install three hydraulic elevators at a Connecticut Public Television facility in Hartford. Local 91's business manager pulled two workers off of the job, since the old equipment had been removed by non-union employees, and demanded that Otis pay "one week of labor per team per elevator," Otis alleged in a court filing. Otis refused to pay for work they did not perform (they were not involved in removing the old equipment), and over the next few days the issue escalated to a statewide strike by the union.

Hoisting equipment has also come up as a point of contention in the past. In 2005, a federal judge heard a case that Otis brought against Boston's Local 4, which started with an aforementioned incident where the union walked off the job over Otis's "use of cranes to hoist and put in place elevator plunger/cylinder units" in a hydraulic elevator installation. Local 4 contended that these units should have been hoisted manually, while Otis claimed that it used cranes to install plunger/cylinder units for 50 to 60 elevators in the past, without strong objections from the union.[77]

There has also been conflict over high-end elevator cabin interior work. In 2015, Otis was contracted to modernize three passenger elevators in a historic St. Louis hotel. The interior work had to be done by a "professional metals refinishing contractor." In the Bay Area, with its large stock of historic high-rise buildings, there are IUEC-signatory firms specializing in refinishing work, but that did not appear to be the case in St. Louis.[78] Otis therefore subcontracted the refinishing work to a non-union specialist firm. IUEC Local 3's business manager claimed jurisdiction over the refinishing work, first saying it was a safety issue, but then changing tack and making a purely jurisdictional claim. The business manager said "the issue could be resolved if Otis paid a Union-represented employee to 'stand by,' i.e., watch but not work," which Otis

75 Clarke, "ThyssenKrupp Elevator v. IUEC, Grievance: Work Jurisdiction."76 "NEBA Agreement with IUEC, 2022-2027," Article IV.

77 Otis Elevator Co. v. Union, Elevator, Local 4, 408 F. 3d.

78 "Contractors."

4.2.2 would not agree to. Finding that the union's apprenticeship program did not include any training for refinishing work and that the union's business manager "conceded that Union-represented employees might not have the training or skills to do the work," the National Labor Relations Board found in favor of Otis in the dispute.[79]

Moving from the historic to the modern, elevator companies and the union have also butted heads on the topic of remote monitoring and interaction, going back to at least the 1980s.[80] One of the latest trends in vertical transportation is the "internet of things," or internet connections to monitor and manage elevator performance. Devices attached to elevators and connected to the internet can monitor elevators and alert owners and maintenance companies of problems that have occurred or might occur in the future, and, more controversially, devices can change settings or parameters.

This remote interaction was the topic of a 2016 settlement signed between the IUEC and Otis, triggered by a 2013 arbitration opinion, over the company's so-called "Otis Elite Service" remote monitoring and interaction system. The agreement allowed "Otis Elite Experts and Specialists" – that is, office employees who work at computers at Otis facilities and are not represented by the IUEC – to "continue to perform remote monitoring and diagnostic functions," but it designated remote software resets (essentially rebooting the elevator as one would a computer to see if it will fix a problem) and changing parameters (like restricting access to a floor, shutting down elevators, or changing how long doors stay open) as remote interaction that Otis may not perform without the involvement of a union member. Otis is also not allowed to use remote interaction to free a trapped passenger from an elevator. This means that certain services that Otis advertises in other countries in its marketing materials – remotely disabling access to a floor under construction, or rescuing riders from stalled elevators remotely before a mechanic arrives – are unavailable in the United States, and Otis had to pay the union's scholarship fund $85,000 in compensation for services it provided its clients in contravention of its contract with the union. The agreement also stipulated that Otis must supply the union with logs of all Elite Services remote activities performed on a semiannual basis, to ensure compliance with the agreement going forward.[81]

Cooperation between labor and manufacturers

Despite the acrimony, the IUEC and the multinational and other unionized elevator firms are bound together within North America, and share an important interest in industry consolidation. Field employees at Otis, Kone, Schindler, TK Elevator, Mitsubishi Electric, and Fujitec America are unionized and their field workers are represented by the IUEC. While there are many smaller firms that are also union signatories, there are many that are not. These firms might not be held to any union agreement at all, or, in the New York City market in particular, might have workforces

79 International Union of Elevator Constructors, Local 3 (Otis Elevator Company), 364 NLRB.

80 Elevator Constructors Local 91 (Otis Elevator), 281 NLRB.

81 "Sistema MPD (Multi Pantalla Digital)"; "Settlement Agreement: Otis Elite Services."

4.2.2

that are represented by other unions with less strict contract terms. The labor flexibility that these non-IUEC firms have can put large unionized firms in the North American market at a disadvantage.

Meanwhile, for the union, small- and mid-sized non-IUEC firms threaten their hold on labor to the elevator industry, and weaken their bargaining hand. In a strike, the union cannot withhold its labor from firms that do not hire their workforce, and in ordinary contract negotiations the union's ability to dictate terms is weakened if signatory employers have to compete against firms not bound by the IUEC's contract. As such, the union often works alongside the multinational and other signatory firms in opposition to small- and mid-sized non-IUEC firms, to support the oligopolistic market structure dominated by firms that are signatories to the union contract.

The most explicit form of cooperation between the IUEC and its signatory companies takes the form of direct subsidy by the union of some bids for jobs by its employers, in cases where non-union firms might otherwise undercut union bidders. As one correspondent from Cleveland's Local 17 explained it, "The [Industry Advancement Program] is a fund offered through the Elevator Industry Work Preservation Fund (EIWPF) that pays a signatory company a fee to help offset the difference between what an unorganized [i.e., non-union] company can charge versus a signatory company."[82] Non-union Oracle Elevator has alleged that its Big Four competitors have used subsidies from the IUEC's Work Preservation Fund to outbid them for government maintenance and repair service contracts, including once at the University of South Carolina's Columbia campus to subsidize a bid by Otis in 2014, and more recently at Miami International Airport to subsidize Schindler's bid for the work.[83] Funding for the Elevator Industry Work Preservation Fund (which does more than just subsidize bids by signatory firms) is set to increase significantly over the life of the current contract, rising from $0.60 per hour of work at the start of the contract in 2022 to $2.20 per hour in 2027, leapfrogging over hourly contributions to the National Elevator Industry Education Program, which started at $0.65 and will rise to $0.90 in 2027.[84]

The IUEC and its signatory firms also share an interest in promoting licensure for elevator mechanics. The union and National Elevator Industry, Inc. (NEII), which represents large, mostly unionized, manufacturers, have worked together on what they call the Model Elevator Law (MEL), which lays out a licensure regime for mechanics and contractors, and manufacturers and labor advocate together for states to adopt it.[85] The MEL and similar adopted regimes are in theory neutral on union and non-union apprenticeship programs, but the union and its owners of non-signatory companies that compete against union labor both tend to view the licensure regimes and associated apprenticeship programs as favoring the union and its signatory companies (see the "Licensure" subsection in 4.2.1).

82 Knapik.

83 Oracle Elevator v. University of South Carolina, Best Value Bid Nº USC-BVB-2485MR; Pipitone, "Contract Controversy at MIA Escalates Into Court Fight."

84 "NEBA Agreement with IUEC, 2022-2027," Article XX.

85 "Model Elevator Law"; Blankenbiller, "Get With the Program!"

Elevators are highly complex electromechanical systems, and beyond the basic dimensional requirements found in building codes and accessibility standards, there are a series of different technical codes and standards, or norms, which govern their construction and operation (the terms “code” and “standard” have specific and slightly different meanings, but are often confused even within industries, and the exact differences are not important). These codes and standards tend to be written by nonprofit organizations affiliated with but sometimes independent from governments, and form a web of regulation that consists of various different documents which are adopted by governments and which reference each other. The organizations that produce these codes and standards are constantly learning from each other and incorporating common approaches to regulation of new technology, and occasionally effectively harmonizing with each other to create common ways of regulating equipment, installations, and practices.

The world of elevators is currently divided into two major webs of regulation: one based in Europe and centered around the EN 81 family of elevator safety codes, and one based in North America, centered around the A17 family of elevator safety codes. Each of the elevator safety codes is referenced by a building code, and in turn references other technical standards for specifics on things like safety of electrical components. For example, the model building code used in the United States is called the International Building Code, and this references the major North American elevator safety code called A17.1/B44 (written by the nonprofit American Society for Mechanical Engineers and Canada's CSA Group), which in turn references the Massachusetts-based National Fire Protection Association's National Electrical Code, otherwise known as NFPA 70, with reference to electrical equipment within the elevator shaft. In Europe, on the other hand, national or subnational building codes reference the EN 81 family of elevator safety norms written by the European Committee for Standardization, and these elevator safety norms in turn reference a different electrical installation standard known as IEC 60364, published by the Geneva-based International Electrotechnical Commission.

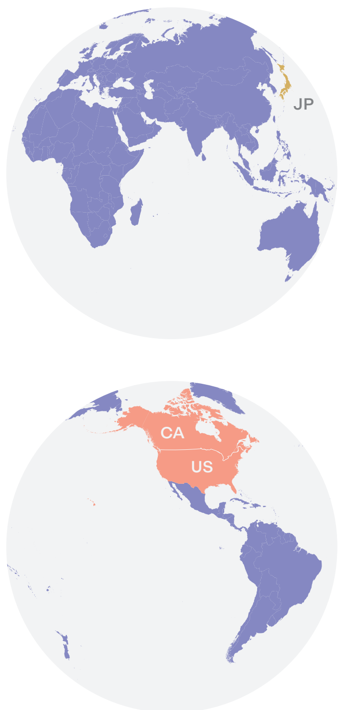
The global trend in elevator regulation has been for countries outside of Europe to adopt European elevator safety norms – a trend which North America has so far resisted. There are not significant differences between the European and North American elevator safety rules (and in fact as far back as the 1980s, before a lot of global harmonization had occurred, more than three-quarters of the rules in national standards were already the same), but the mere existence of separate codes and standards, which are not interchangeable when it comes to manufacturer certification, drives up costs.[1] The cost consequences of these variations in codes and standards come in two forms: costs driven by different certification processes and separate markets for parts, and costs driven by actual differences in products. In the first category, divergences in North America from global, European-based norms lead to a much smaller North American market for parts. This small North American elevator component market can be very profitable for those who manage to enter it, but entry is difficult for small- and mid-sized foreign firms given the greatly increased cost of and headaches involved in certifying parts to a unique set of rules that only apply to the United States and Canada, which make up a small share of the global elevator market. More stringent standards in North America can also drive up material and manufacturing costs, although interviews with industry professionals suggest that these material differences in products are not significant.

Beyond the differences between North American and global standards, there is an unusual amount of intra-country variation in technical rules in the United States compared to nations abroad. This variation between U.S. states can lead to requirements and complexity that drive costs up even further.

5.1 ASME A17.1/CSA B44: North America's standard

The elevator safety code with the longest history of continuous use is what is now known as the ASME A17.1/CSA B44-2016 code, or A17.1/B44 for short. *A Code of Safety Standards for the Construction, Operation, and Maintenance of Elevators, Dumbwaiters and Escalators* was first published by the nonprofit American Society of Mechanical Engineers in 1921, and serves as a code for jurisdictions to adopt in regulation of vertical transportation devices. Elevator regulation in North America started out as voluntary guidelines and inspections by elevator manufacturers in the 19th century. These were then codified into binding local laws in the 1910s in cities like New York, Boston, and San Francisco with many high-rise buildings, and these local laws were then harmonized into a single U.S. national standard a decade later.[2] In the 1990s, manufacturers' associations in the United States and Canada advocated for harmonization between the U.S. ASME A17.1 and Canadian B44 codes, and in 2007, the first binational A17.1/B44 standard was published.[3]

The North American standard has, in keeping with North American regulatory philosophy generally, been more of what is known as a "prescriptive" code. This means that specific ways of building, maintaining, and inspecting elevators are spelled out in the code, with local or state government inspectors verifying that the requirements are met, without much room for interpretation or creative innovation from either party. As machinery and construction advances and devices become more complex, there has been more of a trend towards more of a "performance-based" approach to regulation, where broad goals and outcomes are stated in regulation, but with more creativity allowed in achieving them. In the same year that the A17.1 and B44 codes were



Elevator standards around the world

EN 81/ISO 8100
ASME A17.1/CSA B44
Building Standards Law

merged, the A17.7/B44.7 *Performance-Based Safety Code for Elevators and Escalators* was released, although actual adoption by cities and states has been spotty (see 5.3.6, "Alternative testing," for more on the practical ramifications).[4]

5.2 EN 81/ISO 8100: Europe's global standard

Up until about a decade ago, Europe was the undisputed champion of the global elevator industry, home to the majority of the world's installations and most of the world's largest elevator manufacturers.[5] As such, its elevator safety code and related rules have effectively become global standards, and they govern the installation and maintenance of elevators in every major country on earth, with the exception of the United States, Canada, and Japan. These standards are enshrined in the EN 81 (EN for *Europäische Norm*, or European norm) and related family of standards, with EN 81 standards more recently adopted globally under the title ISO 8100.

Some European elevator safety standards were originally based on those in the United States, likely owing to American cities' early embrace of the skyscraper.[6] After World War II, two trends – urban concentration and European political and economic integration – shifted the locus of elevator regulation away from the United States and to Europe.

Europe, like the United States, underwent a massive post-World War II building boom. The continent, and especially southern European countries like Spain, Italy, and Greece, leaned heavily on dense mid-rise urban housing blocks rather than single-family houses, creating a massive internal market for elevators that would come to exert huge influence on the global industry through technical and regulatory prowess and sheer number of elevators installed across Europe.

The unified European regulation was borne out of two goals: rational regulation of safety and free trade. At a 1957 meeting in Milan, "[i]t was learned that differing opinions concerning safety existed, though risks connected to elevators should be the same in all countries," wrote a Finnish representative to European elevator safety committees, spelling out the logic for what would eventually become the global safety standard. If humans and the physics of elevators were the same everywhere, why should the safety rules governing them be different? Further motivating a single European standard was the longstanding European project to remove trade barriers between member countries to stimulate commerce and promote political unity. And so the European Economic Community began working in 1969 towards removing technical barriers to elevator and crane sales across the bloc.[7]

Cooperation in Europe over the years has given rise to the EN 81 family of elevator safety standards, and in particular EN 81-20 and EN 81-50, which together lay out safety requirements for the construction

1 *The A17.1 Code: A Century of Progress for Safety, 1921-2021*, 21.

2 *The A17.1 Code: A Century of Progress for Safety, 1921-2021*, 2–7.

3 *The A17.1 Code: A Century of Progress for Safety, 1921-2021*, 21–22.

4 *The A17.1 Code: A Century of Progress for Safety, 1921-2021*, 23; Alley, "Elevator Rules and ASME Adopted Code Year by State."

5 Dispan, "Aufzugs- und Fahrtreppenbranche in Deutschland: Entwicklungstrends und Herausforderungen - Branchenreport 2015," 24.

6 "IAEC Position Paper: Should ASME A17.1/CSA B44 'Converge' with ISO 8100"; Freeland, "Elevator Maintenance and Inspection: Recommendations, Regulations and Codes: 1880-1940"; Gray, "The 1935 Code of Practice for the Installation of Lifts and Escalators."

7 Mäntyvaara, "40 Years of Elevator-Code Standardization."

and installation of elevators. The European Union uses a system of organizations known as "notified bodies," which are private entities (e.g., Liftinstituut in the Netherlands, or the TÜV family of corporations in Germany) that have been given the right by member states to assess the conformity of products to adopted technical rules, and then give them a CE mark (standing for *conformité européenne*, or European conformity) that allows them to be sold throughout the European Union, and increasingly beyond. Often these notified bodies assess conformity based on performance-based requirements of European standards, leaving manufacturers with more flexibility to innovate and come up with new designs, but also placing more responsibility on the notified bodies to exercise good judgment in assessing conformity with elevator standards.

Over time, the EN 81 standards and the rules they reference have spread beyond Europe. For elevator manufacturers – with Kone, Schindler, and ThyssenKrupp based in Europe, and Otis doing almost half of its sales in Europe in 1998 and only a third of its sales today in the Americas – harmonization on the European standard means more efficiencies and lower product development costs.[8] For individual jurisdictions, adopting European standards means getting rid of the cost of developing, reviewing, and amending increasingly complex sets of technical rules governing elevators and the components within them. And so, around the turn of the millennium, the world went from a dizzying array of local standards and codes – one for Russia, another for China, another for India – to almost complete convergence on European standards. The Chinese adoption of European standards was quite a coup for the Euro-dominant global elevator industry, since China will by 2030 account for half of the world's total installed elevator base, and already accounts for the vast majority of new installations. The Chinese adoption of European rules as aided by copying the European standards into the International Organization for Standardization's ISO 8100 global standards, theoretically giving China a say in code development, even if in practice Europe still dominates rulemaking.[9] By 2015, global harmonization around the European family of safety codes was nearly complete, with only three code families remaining worldwide – A17.1/B44 in the U.S. and Canada, a Japanese set of codes seemingly only used there, and the EN 81 family ruling in the rest of the world.[10]

5.3 Differences between standards and consequences for North America

As a global EN 81/ISO 8100 family of elevator codes and related referenced technical standards have developed beyond the borders of the United States and Canada, elevators held to the A17.1/B44 standard and its related web of North American technical rules have diverged in design from those in the rest of the world in some different ways, both specific and general.

8 "Otis Overhaul to Cut 2,000?"; Lotze, "Esfandiar Gharibaan: Harmonised Standards Reduce Costs."

9 Kukhnin et al., "Global Elevators & Escalators."

10 "IAEC Position Paper: Should ASME A17.1/CSA B44 'Converge' with ISO 8100."

5.3 The safety standards and other standards referenced by them are incredibly complex, but we will highlight a few substantive differences between North American elevators and those in the rest of the world. As discussed in section 2.4, “Safety outcomes,” the below differences have no measurable impact on consumer or worker safety.

Beyond these specific differences in standards, the widespread adoption in almost every country in the world of the European web of rules has left North America on an island when it comes to product certification. The testing process to ensure compliance with either standard is expensive, so the ability for a manufacturer to produce a product that complies with the applicable rules does not guarantee that the product will actually be certified for use in all markets. Successfully obtaining certification for a component in Europe more easily allows its use across nearly the entire world, in countries with well over 10 million installed elevators, including the massive Chinese market. Obtaining certification in North America, on the other hand, only opens up a market of a little more than 1 million installed units – about the size of the Italian market, as one person who specializes in codes and standards put it.

Because of the vastly larger size of the elevator market that is governed by European rules, there are also vastly more parts available for countries adopting European rules than for the U.S. and Canadian markets. The unique North American standard makes it difficult for distributors of elevator kits designed in Europe or Asia by mid-sized firms like Orona (from Spain’s Basque Country) or Kleemann (from Greece) to enter the market and compete with the largest multinationals. The lower availability of parts for the North American market likely also contributes to delays in procuring parts for repairs in the United States and Canada, leading to less reliability for users.

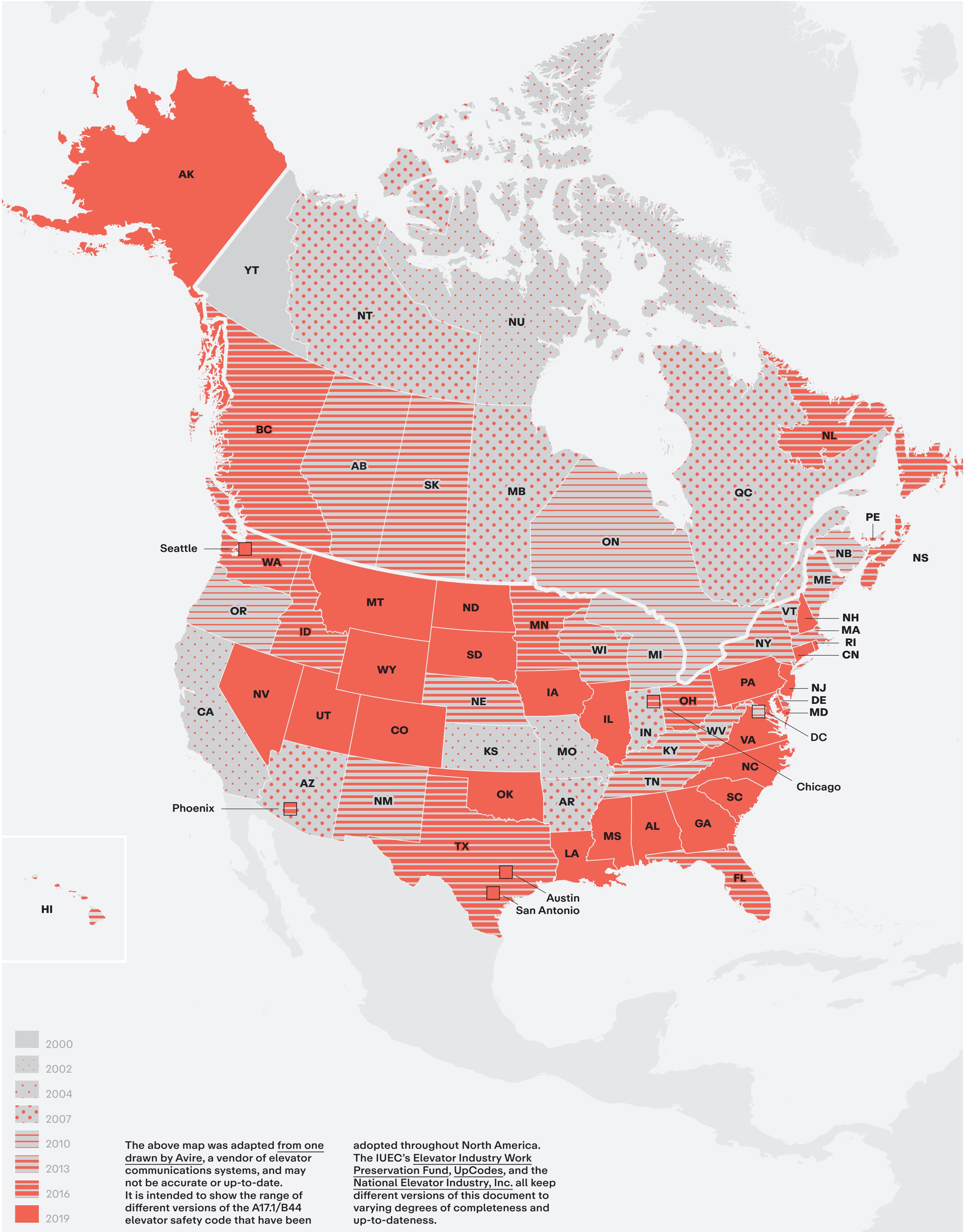
While the United States and Canada have worked towards regulatory harmonization, full harmonization of codes across jurisdictions within the two countries remains elusive. A new version of A17.1/B44 is published every three years, but only a few of the nearly 100 jurisdictions that regulate elevator safety (a mix of cities, states, provinces, and special authorities) automatically adopt the latest version.

The majority of North American jurisdictions adopt new versions of A17.1/B44 at their own pace, leading to 20 years’ worth of different versions of the standard in use across North America. Beyond adopting versions of the standard from different years, many jurisdictions also amend the model code, adding or removing specific language that changes the way elevators can be built, maintained, and inspected. An extreme example is California, where in theory the 2004 version is adopted. That code however predates many standard features of new elevators, like the machine room less configuration and the use of belts rather than ropes to hold up the car.[11] As a result, new elevators in the state must go through a theoretically discretionary process, making the adopted code text somewhat irrelevant to actual installations.

11 8 CCR § 3141, Conveyances Covered by ASME A17.1-2004.

Figure 6

ASME A17.1/CSA B44 elevator safety code adoption



The above map was adapted from one drawn by Avire, a vendor of elevator communications systems, and may not be accurate or up-to-date. It is intended to show the range of different versions of the A17.1/B44 elevator safety code that have been adopted throughout North America. The IUEC's Elevator Industry Work Preservation Fund, UpCodes, and the National Elevator Industry, Inc. all keep different versions of this document to varying degrees of completeness and up-to-dateness.

The process for adopting and amending the A17.1/B44 standard into code can also be messy and unprofessional. In November 2020, the director of Illinois's Elevator Safety Review Board chastised board members after failing nine consecutive times to set up a meeting that could meet quorum since the prior meeting two years earlier. "I have individuals that will not even respond to numerous emails that are sent out," he told those in attendance. "I am not the babysitter of this board."[12] Because there is a separate board for Chicago, the Illinois board has jurisdiction over the state only outside of the City of Chicago (the Illinois board attracted controversy years earlier over the questionable appointment of a number of IUEC officials after the Chicago local made a $10,000 donation to Governor Rod Blagojevich, which prosecutors allege was bundled by Tony Rezko).[13] Carve-outs for large cities from statewide codes (of all kinds, not just for elevators) are common in the United States, a practice which increases the complexity and inconsistency of rules and vests powers in Swiss cheese-like jurisdictions, depriving them of the scale, care, and oversight that comes with consistent rulemaking across large geographic areas.

5.3.1 Machine room less elevators

The most significant innovation in elevator technology over the past few decades has been the advent of the machine room less elevator, or MRL. Electric traction elevators have important components – the machine, governors, and controller – that historically sat above the shaft, in a dedicated room. This room usually has to be housed in a small mechanical penthouse on the roof of the building, as the shaft must extend high enough to accommodate a landing on the top floor of the building and the machine room must sit above that. This machine room penthouse is expensive to build, and to avoid it, hydraulic elevators were often used for low-rise buildings, since the machine room for a hydraulic elevator has more flexible placement options.

Beginning around the 1980s, engineers in Europe and then later Japan began experimenting with linear induction motors, which allowed manufacturers to shrink some parts and move others. Components that previously had to sit in large machine rooms above the shaft could be moved to within or near the shaft itself with an electrical MRL model – in particular the machine, but also the controller, which can even be placed inside of a landing door jamb – saving space and also lowering energy consumption.

The resulting new MRL elevators did not work well with existing safety codes that assumed the presence of a machine room, but codes in Europe and Asia – which were at the time being harmonized into what is now today the EN81/ISO 8100 family of codes – quickly adapted, and the major manufacturers all introduced MRL models to the European market in the 1990s.[14] In North America, however, regulators were much more cautious. New York City launched a pilot program to consider MRL

12 "Office of the Illinois State Fire Marshal Elevator Safety Review Board Meeting," November 5, 2020.

13 Rushton, "Fire Marshal, Governor's Offices Have Questionable Track Records as to Elevators"; O'Connor, "Quinn Renames Board Chairman despite Alleged Rezko Ties."

14 Gray, "Early Machine-Room-Less Elevators."

elevators in 2001, and the ASME A17.1 standard did not include rules that accommodated MRLs until a supplement was published in 2005.[15]

A number of American jurisdictions resisted the trend towards MRLs, but the industry mostly prevailed and the MRL is now the most common type of elevator installed in new low- and mid-rise buildings, even if it has not achieved the same market penetration as in Europe and Asia. A few states are still ambivalent towards the technology, with California being the most resistant. The state has been trying for years to update its rules to reference a more recent standard than the current 20-year-old A17.1 standard it theoretically adopts, but even these proposed changes would include significant variations from the North American standard.[16] Much of the discussion revolves around the placement of machinery and controllers, with California regulators taking the position that current industry practices are not safe (though no data has been presented to show that California has better safety outcomes than the rest of the country, or Europe).[17] The location of controllers remains an issue even in more liberal U.S. jurisdictions, which often still require separate controller rooms while abroad smaller controller spaces are standard practice.

5.3.2 Landing doors

Doors are an essential safety component of a modern elevator, keeping people from outside the elevator from falling into the shaft, and keeping those inside an elevator from being exposed to the shaft itself. Both EN 81-20 and A17.1/B44 have prescriptive requirements for landing door strength. The North American A17.1/B44 requires that a 100-square centimeter compact area near the center of a door panel be able to withstand a force of 2,500 newtons, while EN 81/ISO 8100 requires the same area to resist a force of 1,000 newtons.[18] The A17.1 requirement used to require about the same strength as today's EN 81-20 requirement, but was made stricter in the 1993 version of the A17.1 code.[19]

Beyond the strength of the landing door, European and North American codes also differ in terms of fire testing – one of many examples of differences in rules that are referenced by but not contained within the main safety standard. The American A17.1/B44 code references UL 10B (or an equivalent standard), which requires that, after 90 minutes of being heated to over 1,800°F, the lobby side of the entrance has to be able to withstand being sprayed for 20 minutes in a specific way, without showing any openings beyond a certain size, in order to simulate a fire burning for 90 minutes without intervention, followed by a hose attack by firefighters.[20] In Europe, on the other hand, EN 81-20 references EN 81-58, and most manufacturers target a longer burn time of 120 minutes, but without the subsequent hose test that the American standards impose afterwards.[21]

The specific differences in requirements have never, as far as we know, made any life safety impact in the real world, but they do make a big

15 LiMandri, "Promulgation Details for 1 RCNY 3610-02"; Karin, "New Elevator Technology: The Machine Room-Less Elevator"; "MRL Elevators on the Rise."

16 Blaska, "California Proposed Elevator Code Changes."

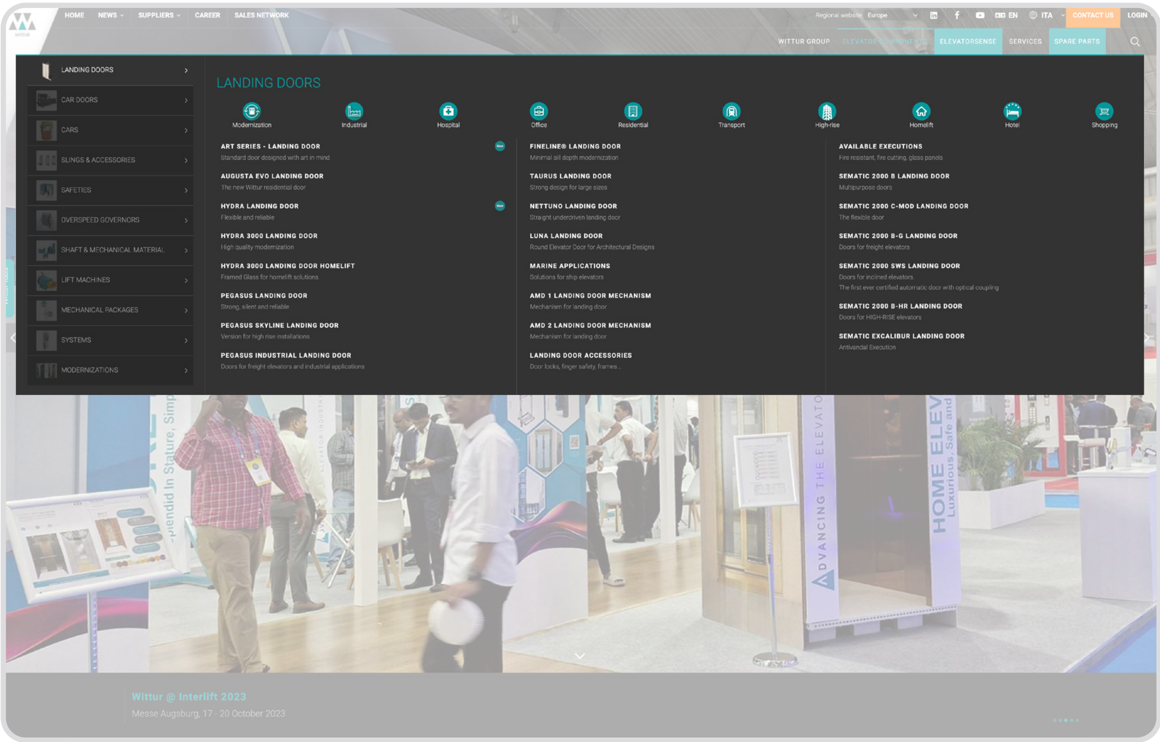
17 "NEII Comments on DOSH Presentation."

18 "ASME 17.1-2016/CSA B44-16," 2.11.11.5.7; "BS EN 81-20:2020," 5.3.5.3.1(b).

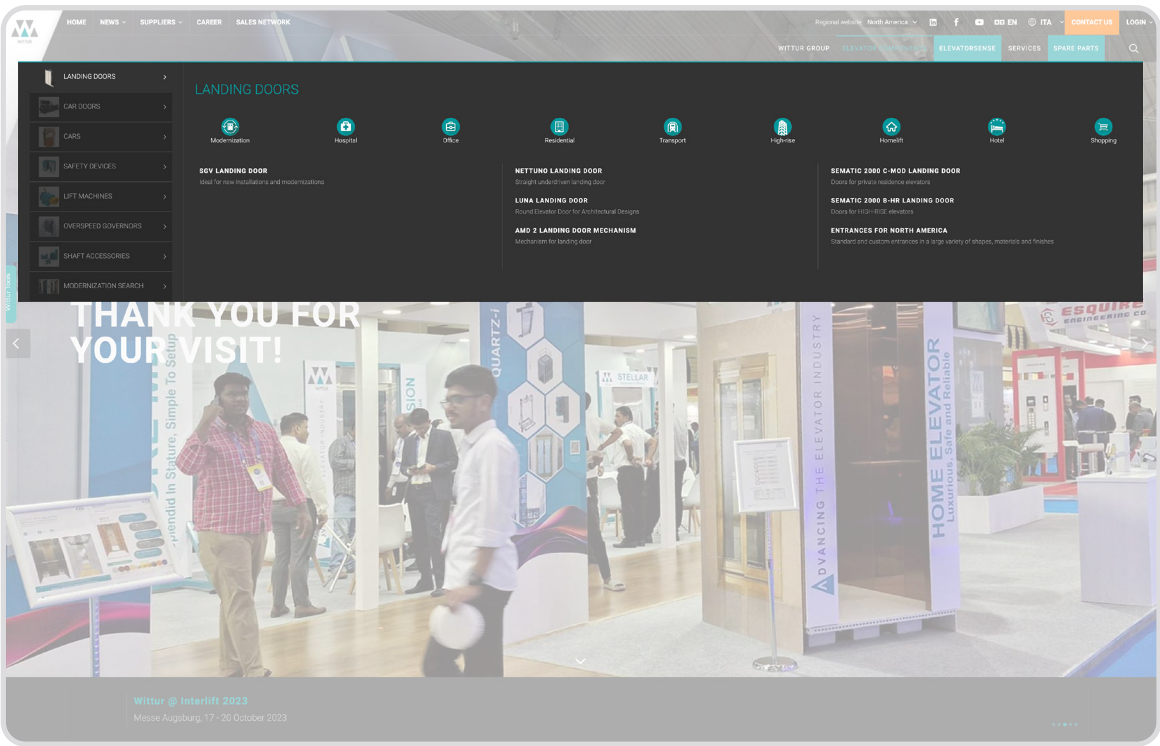
19 Koshak, "Elevator Hoistway Doors."

20 "ASME 17.1-2016/CSA B44-16," 8.3.4.

21 "BS EN 81-58:2018"; Gizicki et al., "The Investigation of Efficacy and Fire Resistance Characteristics of Fire Barrier in the Lift Industry Applications"; "BS EN 81-20:2020," 5.3.5.2.



Wittur landing door part availability in Europe.



Wittur landing door part availability in North America.

Source: wittur.com

difference in parts availability and the competitive landscape of the elevator door industry. The German non-proprietary elevator component manufacturer Wittur offers a concrete example of the narrower range of parts available on the North American market. On Wittur's European, Chinese, Eurasian, and Indian websites, would-be buyers are offered the choice of over 20 landing doors or related items and a similar number of car doors, with similar offerings across these regions. On the North American version of the website, however, at least two-thirds of the options disappear. The same pattern of more limited product availability for the North American market can be found with lift machines, safety devices, and other component categories in their catalog.[22]

5.3.3 Two-way audiovisual communication

By one estimate, the chance of getting trapped in an elevator during a ride – an entrapment, in industry parlance – is 1 in 100,000.[23] While on an individual level this is quite low, elevators are heavily used devices, so entrapments are an everyday occurrence across a large enough area. Codes have evolved over the years to require better communication for people trapped in elevators, starting with alarm bells that alert anybody within earshot of the shaft that somebody is stuck in a car, and eventually evolving into today's global standard contained in EN 81-28 of a hands-free phone line in the elevator cab. The line is continuously monitored by a rescue service that can reach the site within no more than one hour, with backup power and the ability for the rescue service to communicate verbally back to within the cabin, and attempt to verify that the emergency was real and not an accidental push of the button.[24]

This was the American approach as well, contained in A17.1/B44, up until a 2018 change to the model International Building Code, which then triggered a change in the A17.1/B44 safety code. In the leadup to the 2018 edition of the International Building Code (only in use in the United States), one unaffiliated individual won a code change to require two-way communication in both audio and visual form, to accommodate deaf and hard-of-hearing elevator riders. An example of the problem to be solved with the code change was noted in a parallel code change proposal, with the proponent writing about an incident that occurred one year earlier in Virginia where two deaf people were trapped in an elevator when the power failed, and were rescued by the fire department after they texted a friend, who in turn alerted hotel management (the ubiquity of cell phones has added an additional communications layer to elevators, and in Europe, most cabins now have a sticker with a phone number for riders to call for disentrapments, in addition to built-in equipment).[25] We could not find any more serious incidents involving deaf or hard-of-hearing individuals trapped in elevators.

In the code change request, the proponent, responding to the International Code Council's prompt for the cost impact, stated that it would not increase the cost of construction – and would in fact

22 "Wittur."

23 Pelikan, "Stuck in an Elevator? Here's What to Do (and Not Do)."

24 "BS EN 81-28:2018."

25 "2015 Group A Proposed Changes to the I-Codes Memphis Committee Action Hearings," April 19, 2015, EB 94-15.

5.3.3 decrease it, by clarifying an uncertain regulatory situation – since "the code already requires conformance with these standards" (which was not in any meaningful way true, since the system was not in practice provided in or requested by jurisdictions).[26] In a separate proposal for essentially the same requirement, the code change request proponent stated that the cost of the equipment would be $2,500 for an existing building and $5,000 for a new installation. This cost was written off by the code change proponent as "negligible or minimal to the building owner/operator," since there are "various incentives such as tax write-offs" available (which is not true for the equipment in question), and that for new construction, there will "be no significant additional costs involved because it will be built into the design/build" (which is a misunderstanding of how costs accumulate for construction).[27] The reasoning around the cost is typical of changes to model and adopted codes and standards in the United States, where small cost increases are each written off as individually negligible, and the negative accessibility, life safety, or other consequences of higher costs leading to fewer new elevators or new buildings generally are never considered.

After tweaking code language across multiple overlapping codes over the years, the two-way audiovisual communications requirement is finally making its way into new elevators in North America. The code change has been one of the most significant in elevator regulation in North America in recent years, and has, according to interviews with elevator manufacturers, indeed driven up costs for new elevators by roughly $5,000, as the code change proponent predicted in one of the code change proposals. One smaller manufacturer put the wholesale price of the device at around $2,000 (which does not include labor or a profit margin for the elevator manufacturer), while one proposal from a Big Four manufacturer noted that there would be a $6,500 change order to comply with the new code. The requirement necessitates the installation of a number of pieces of equipment – cameras and displays in cars (and the ability to use existing buttons to communicate), a four-hour battery backup for the modem and router in case of power failure, equipment in the machine room, and a traveling cable that can withstand the constant movement of an elevator cabin to connect it all together.[28]

Beyond the installation cost, there is also significant ongoing operational cost for both monitoring and for the new internet line that must be provided to enable video communication, which went unmentioned in the code change proposal to require these systems. Elevator monitoring is part of a broader market for round-the-clock active monitoring services that is growing in the U.S. and Canada, propelled by unique building code requirements not found at the same scale as in other countries. One company serving this market quoted the video monitoring and data connection needed to comply with this new requirement at $50 per month plus tax, on top of the $65 per month plus tax cost for audio communications and monitoring already required. The net present value of the incremental operational cost works out to a bit under $10,000 using a 7 percent discount rate – greater than the cost

26 Cid, "Complete Revision History to the 2018 I-Codes - IBC: Successful Changes and Public Comments; Code Change No: G195-15."

27 "2015 Group A Proposed Changes to the I-Codes Memphis Committee Action Hearings," April 19, 2015, G 195-15.

28 "MosaicONE VMS."

of installation. Or, put another way, the 1 million elevators in the United States will, once modernized to meet the new code requirement, incur an additional monitoring and data connection cost equal to around $600 million each year, plus tax where applicable. Beyond the simple cost, the additional ongoing monitoring relationship adds to the growing problem of vendor lock-in, making it more difficult to switch away from the original equipment manufacturer, hampering competition for service, maintenance, and modernizations (which make up the majority of elevator companies' sales).

The requirement also introduces another point of failure into elevators. The requirement is new and adoption is slow and uneven, so the author has only seen one elevator with the required device installed, at a New York City Subway station which recently had an elevator installed for the first time. During the first visit, the device appeared to be working properly. But on the second, "Out of Service" was displayed on the screen. Riders might reasonably assume that the entire elevator is out of service, and avoid using it to avoid the risk of getting stuck in the cabin.

Out-of-service video communication device, on a New York City Subway elevator.

There is no requirement for video monitoring or two-way visual communication in the global EN 81/ISO 8100 family of codes. Video cameras in elevators are legally fraught in Europe, given European Union privacy regulation, and are likely to be illegal in Germany and Slovenia.[29] This puts the U.S. and Canada on a technological island when it comes to video monitoring and communications, unable to benefit from economies of scale in research and development, or the more competitive market that comes from following global standards.

5.3.4 Toe guards/aprons

With the danger of elevator free fall largely eliminated, one of the major remaining risks to elevator users is falling into an unprotected hoistway. One of the ways this can happen is that riders are rescued – or attempt to rescue themselves – from stalled cars, but the car has stopped above the floor landing, leaving some distance open between the bottom of the car and the top of the floor. To protect the shaft in these cases, safety rules require the installation of what is known as a toe guard, or apron. This device hangs off the front of the car below the doors and runs the full width of the opening, protecting anybody who needs to step or jump down onto the landing floor from missing their step and falling back into an open shaft.

A complication of the toe guard is that, since it hangs below the car, it functionally requires a deeper "pit," or extension of the elevator hoistway below the bottom floor, in order to accommodate it. While this isn't a major driver of cost for the elevator itself – the toe guard is a fairly thin piece of metal, without the strength or fire rating requirements,

29 "Überwachungskamera im Aufzug: Ist das erlaubt?"; "Data Protection Laws of the World: Slovenia."

or duplication at every landing, of doors – it does increase the cost of the elevator shaft, by requiring more concrete and digging below the ground or basement floors, which can be expensive. Manufacturers in North America and abroad have developed retractable, or collapsible, toe guards to reduce the extra depth that must be accommodated, but not every jurisdiction in the U.S. allows these, and in any case, a deeper, fully extended toe guard will require a deeper pit to accommodate even a retracted version.

The A17.1/B44 code requires that the fully extended toe guard reach 48 in. (or 1.22 m) in length, while EN 81-20 and its global ISO 8100 equivalent requires 75 cm of protection (or 29.5 in.).[30] Off-the-shelf collapsible versions sold by third parties that meet North American requirements can be found sold online as small as 85 cm, whereas European versions can be found to collapse down to 25 cm.[31] Partly as a consequence of these longer required toe guards, planning guides for architects in North America require deeper elevator pits than those in Europe. For example, Schindler's 3300 North American model requires 1.52 m of depth, compared to 1.06 m to 1.1 m for its 3000 model sold in Italy. Otis's North American Gen3 Core requires 1.753 m to 2.108 m, compared to 93 cm for its Gen2 Life sold in Switzerland.[32]

5.3.5 Elevator lobbies and hoistway opening protection

A uniquely American – and relatively new – expense involved in buildings with elevators is the intense requirements for protection of elevator hoistway openings from smoke spread. These requirements have been in America's model International Building Code (IBC) and some prior model codes in some form for decades, but recent clarifications have dramatically increased installation requirements in practice. Largely due to one major fire over 40 years ago, before modern sprinkler and other fire safety requirements, these hoistway protection requirements can now add tens of thousands of dollars in extra cost for developers who choose to provide elevators in even small buildings.

Elevators sit in shafts, which pose a special problem for fire safety in buildings. Shafts like stairways, elevator hoistways, waste chutes, and atria communicate between floors, and are not sealed off by horizontal elements like floors to keep smoke from a fire from traveling upwards within a building. In 1980, a fire at the MGM Grand Hotel on the Las Vegas Strip killed 85 guests and employees after breaking out in an unattended, unsprinklered restaurant on the casino level at the bottom of the building. While the fire itself didn't spread far, and the sprinklers worked well to suppress it where they were installed (and even reduced its spread in nearby unsprinklered areas), there was enough fuel and air supply on the fire's level of origin to produce heavy smoke. This smoke traveled upwards through unprotected elevator shafts and other parts of the building to reach the upper floors, and was responsible for most of the 85 deaths.[33]

30 "ASME 17.1-2016/CSA B44-16," 2.15.9; "BS EN 81-20:2020," 5.4.5.

31 "Telescopic 4 Step Apron"; "Elevator Cab Retractable Toe Guard, Car Apron."

32 "Schindler 3300: Distinctive Design. Cost-Effective Solution. Green Technology Made Easy."; "Schindler 3000: Elegante, funzionale e flessibile"; "Gen3 Elevator: Hoistway Dimensional Data"; "Gen2 Life: L'ordinaire devient extraordinaire."

33 Best and Demers, *Investigation Report on the MGM Grand Hotel Fire*.

5.3.5 After the MGM Grand Hotel fire, the Uniform Building Code – a model code that was adopted in the western half of the United States at the time of and in the two decades after the fire – was updated to require hoistway protection for high-rise buildings, defined as buildings where the floor on the top level of the building sat at least 75 feet above the level at which firefighters would enter the building. Hoistway opening protection, at least nowadays, can mean elevator lobbies with fire-rated doors between the area containing the openings to the elevator hoistways and the rest of the building, but the requirement can also be met through other means. These include smoke curtains that automatically unfurl to cover hoistways, "hold-open" doors that are left open in normal operation but slam shut to cover hoistway openings when a fire is detected, or a hoistway pressurization system that that creates a pressure differential between the shaft and the rest of the building to prevent smoke from entering the hoistway and push it out when it does manage to infiltrate the shaft.

A divide emerged between the east and west coasts on the topic of hoistway opening protection, with the west coast jurisdictions favoring the systems (perhaps due to proximity to Las Vegas), and east coast jurisdictions allowing developers to build without such systems. When America's model codes were consolidated around the turn of the millennium into the IBC by the newly formed International Code Council, hoistway opening protection rules were adopted into the new code. The first edition of the code, in 2000, waived the requirement for buildings with automatic sprinklers under six stories, and this height was gradually raised over the years, exempting even taller buildings.[34] New York City, which has always had the most distinctive building code in the United States and a very large high-rise and elevatored building stock, exempts residential buildings of any height from the requirements for hoistway opening protection.[35] For over a generation after the MGM Grand fire and up until at least the last few years, most multifamily buildings in America have been built with sprinklers and without hoistway opening protection.

The IBC contained an ambiguity though around hoistway opening protection, and a Colorado-based building code official and longtime participant in ICC code development asked the council to study the issue and clarify the code language. The ICC convened a technical committee chaired by a Chicago-based fire protection engineer and longtime committee member at both the ICC and the National Fire Protection Association to study the issue and put forth recommendations. After scientific analysis and review of historical performance, the technical committee came to the conclusion that buildings under 420 feet in height (roughly 40 stories) should not require elevator lobbies or any other hoistway opening protection, for a number of reasons. These included ease of evacuation, new requirements for automatic sprinklers to both suppress fire and cool smoke down where fire does occur to reduce the smoke's buoyancy and tendency to migrate upwards, and the insignificance of the "stack effect" in lower buildings that speeds

34 "2000 International Building Code," 707.14.1; "International Building Code," 713.14.1.

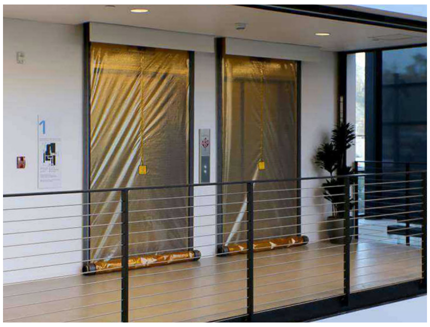
35 "2008 New York City Building Code," 403.9.1; "2022 New York City Building Code," 3006.1.1.

5.3.5 the movement of air upwards through shafts. Finally, historic performance was considered, with the technical committee writing that "code officials participating in the study group stated that lobbies have traditionally not been required in these type buildings in their jurisdictions and their experience has been good." That is to say, in the three decades between the MGM Grand fire and the study, the tragedy was not repeated, likely due to revised elevator recall operations, modified HVAC design, requirements for protecting building joints, and increased sprinkler requirements.

Another ICC committee and then the full voting membership ultimately decided against adopting the recommendations from the technical committee to forgo hoistway protection in buildings shorter than 420 feet, without much documented explanation or rebuttal of the technical committee's findings.[36] And so since the 2018 edition of the IBC, some sort of protection has been required for hoistway openings above the ground floor in virtually all multifamily buildings with an elevator.[37]

When the code change to require hoistway opening protection was proposed, the required cost impact was stated thusly:

> This will not increase the cost of construction depending upon how this issue is being interpreted. This item will only increase construction if it had not been interpreted to require protection of the hoistway opening in rated corridors. This would involve having to comply with Section 3006.3.[38]



Smoke curtain installed on an elevator. Source: smokeguard.com/gallery

While it is true that there is no additional cost if the prior codes had been interpreted by the local jurisdiction to require it all along, this was not the case in most jurisdictions (this way of avoidance of stating costs in ICC analyses is not uncommon, with the same logic used in one case to avoid putting a price tag on the two-way audiovisual elevator cabin communication requirement, in section 5.3.3). The new language has raised costs by tens of thousands of dollars in small buildings, and more as the number of floors rises. There are a few different types of hoistway protection possible (smoke curtains, hold-open doors, hoistway pressurization, and elevator lobbies), but in mid-rise buildings, smoke curtains and hold-open doors are the most popular options due to cost. One quote obtained for an installation in the Pacific Northwest put the installed cost of 20 elevator hoistway smoke curtains at around $114,000, or around $5,700 per elevator per floor (with no requirements on the ground floor). This figure does not include taxes or any markup by the general contractor, and a 10 percent upcharge is levied for wider elevator frames found in installations by two of the four major manufacturers. Another distributor of the same manufacturer's elevator smoke curtains quoted the installed cost in New York City at around double that price: $52,000 in total for installation at five landings, with upgrade options available as well – about 1 percent of the building's

36 Baldassarra, "CTC Elevator Lobbies: Study Group Report for CTC Meeting June 28-29, 2012."

37 "2018 International Building Code," 3006.2.

38 Baldassarra, "2018 Complete Revision History to the 2018 I-Codes - IBC: Successful Changes and Public Comments; Code Change No: G201-15."

total construction cost, and on par with what an entire elevator would cost for a building of such a size in Europe. As an active system, there may also be ongoing costs associated with testing and maintenance.

5.3.6 Alternative testing

Modern elevators have a number of redundant safety mechanisms to stop a cabin from falling if one or more parts malfunction, and these must be tested periodically to ensure they're in good working order. In the United States and Canada, the most important test is known as the Category 5 periodic test, performed every five years. In North America (and, in the past, abroad), this involves loading each elevator car with weights equal to or a bit over the rated capacity of the car. Various safety mechanisms are then tested and measured to ensure they perform as designed. A more modern and advanced form of testing without weights, known in North American as alternative testing, has been available for decades, but is generally not allowed in the United States by state and local elevator safety boards, in keeping with broader American industry themes of distrust of foreign technology and preservation of work for mechanics, at the expense of elevator owners and users. Where it is allowed in North America (particularly in Canada), the market for approved alternative testing equipment is less competitive than in Europe.

In Germany, the equivalent of the Category 5 test has long been required to be performed every two years, rather than every five as in the United States, which posed a few problems when using weights. Firstly, testing with load is destructive to the safety brakes, and after a handful of tests, they may have to be replaced (they are a redundant safety system and not engaged in normal operation, so they are not designed to be durable enough to withstand repeated use).[39] Secondly, the actual weights used to add load to the car are very heavy, weighing up to a few tons depending on the size of the elevator. Weights this heavy can cause damage to elevator cabins and lobby floors, and can even cause injuries to mechanics themselves. One proponent of allowing alternative testing in the United States claimed that over half of injuries to elevator mechanics are caused by hauling weights around.[40] Even when no damage is done, hauling these weights in and out of buildings takes time, and that labor must be compensated. Finally, traditional testing with load is imprecise (parts of the test involve marking distances to see how far the elevator slides down the rails before safety mechanisms engage), and the test results in a binary pass/fail grade, while weightless alternative testing uses more advanced measurements to produce greater information about system performance. All of these problems apply to the North American five-year testing intervals too, but were magnified in Germany due to the more frequent testing regime.

Due to the shortcomings of testing with load, German engineers developed an alternative method, using the output from accelerometers and rope tension measuring gauges to test components without hauling

39 Koshak, "Safety and Buffer Testing without Weights."

40 "Elevator Technical Advisory Committee Meeting, Transcript of Proceedings: February 8, 2022, Day 1," 35.

5.3.6 thousands of pounds of weights in and out of elevator cabs. Electronic devices are affixed to various parts of the elevator and the tests are run with the car empty, while a computerized testing system measures how the car reacts when various braking and traction mechanisms are triggered. These measurements are then analyzed and forces are determined, which are in turn used to determine whether the elevator would pass using the traditional testing with load. Beyond the efficiency and gentleness of using this alternative electronic testing method, the precise measurement allows finer analysis of how the elevator's systems will react to different forms of failure, including in a more typical scenario with only a few people in the car rather than the full rated weight, ensuring occupants are not injured by being flung upwards within the car as safety mechanisms engage and it stops abruptly. Alternative testing can also pick up on problems and miscalibration before they would rise to the level of failing a traditional test with load.[41]

Alternative testing has been in use in Germany since the 1990s, when multiple notified bodies, who perform tests in Germany (see section 5.2, "EN 81/ISO 8100: Europe's global standard," for more on notified bodies), introduced weightless testing systems, and it is now the standard way to test elevators.[42] This established European technology began to be demonstrated for and discussed by industry professionals in North America in the late 2000s, and in 2013, a weightless alternative testing option was added to the A17.1/B44 standard. The standard, however, leaves the use of alternative testing "subject to the approval by the authority having jurisdiction," and most AHJs in the United States – including those of all of the largest cities and states – have not granted this permission. Alternative testing also faces the additional barrier (largely theoretical, as so few jurisdictions allow it anyway) of a duplicative "baseline" test required if, like California or Pennsylvania, the jurisdiction has not adopted A17.7, the American Society of Mechanical Engineers' performance-based standard, without which the cost of the first five-year test will effectively double as the test will need to be performed with and then without weights.[43] Canadian elevator safety regulators, on the other hand, were eager to adopt provisions allowing alternative testing, and Ontario began allowing it in 2013, even before formal adoption of the 2013 edition of A17.1/B44.[44]

Minutes from elevator safety boards offer some insight into why U.S. jurisdictions have rejected alternative testing. In Illinois, one board member asked rhetorically, after a presentation where a manufacturer said that the technology is already in widespread use in Canada and Europe and has been adopted by a few U.S. states, "Does Illinois want to be a test state for the Midwest?" Another responded that Ontario's elevator safety authority "is pretty strict, so if Ontario is accepting it, we're not being the first," to which the first member replied, "We're not in Canada. We're in the U.S."[45]

Regarding the modern engineering approach, a number of people sitting on American safety boards have expressed disbelief that the

41 Ebeling and Heling, "Electronic Inspections Are Making Elevators Safer."

42 "ASIS II – Die Alternative bei der Aufzugsprüfung"; "ADIASYSTEM."

43 Alley, "Elevator Rules and ASME Adopted Code Year by State."

44 "Office of the Illinois State Fire Marshal Elevator Safety Review Board Meeting," November 5, 2020, 38.

45 "Office of the Illinois State Fire Marshal Elevator Safety Review Board Meeting," 69–72.

5.3.6 performance of an overloaded elevator car can be predicted based on the force of brakes measured with a no-load test, through use of Newton's Second Law of Motion. Based on the transcript of an advisory committee hearing in Washington State, it seems that in some cases committee members did not understand the basics of how the technology worked – that it was measuring the force of the brakes, and not simply performing the traditional manual test without weights.[46] In another forum there was confusion between electronic testing and remote testing, with no worker physically present.[47] The engineering behind elevator safety can indeed be quite complex, and this complexity is what drove the creation of model codes and standards that are vetted more intensely than individual state or city elevator safety boards are capable of. Despite attempts by the industry and many experts to harmonize codes across the U.S. and Canada, alternative testing is just one example of authorities having jurisdiction not being fully prepared to defer to the judgment of standard-writing bodies.

Finally, while adopted A17.1/B44 codes are supposed to focus solely on safety, the labor consequences of testing elevators without hauling tons of weights into cabs can nevertheless play into decisions. One speaker in Illinois brought up the fact that "union rules allow the companies to only send one guy out when there's no test weights on the job," whereas the IUEC contract requires two union members when weights are involved.[48] A union representative wrote to Pennsylvania's elevator safety board to urge them not to adopt alternative testing as they were considering adopting the 2016 edition of A17.1/B44 (so far it's a moot point, as the state remains on the 2000 code – the oldest still adopted in the U.S.), and that same representative successfully motioned to disallow it in Missouri, where he sits on the board.[49] Wurtec, an alternative testing vendor, has seemingly recognized the labor opposition to alternative testing, with a Wurtec presentation stating that "[m]ore discerning testing can create more work doing needed maintenance/repairs."[50] This stands in contrast to a testing firm in Germany that claims "significant" cost savings from weightless testing, illustrating the different attitudes towards labor-savings efficiencies in the elevator industry in Europe and the United States.[51]

In the United States, Wurtec is the only distributor of an alternative testing system, selling German manufacturer Henning's ELVI system. Henning is not the only manufacturer of these systems in Germany, where there are many competing notified bodies who do this testing with their own systems. TÜV SÜD inspects 400,000 elevators each year in Europe, or roughly one in 10 elevators, and expended resources early on trying to convince North American jurisdictions of the merits of the technology.[52] Discouraged by the slow pace of adoption, they gave up on the market, leaving Henning's system (distributed by Wurtec) as the only option in the U.S. and Canada.[53] As is common in the elevator industry, a competitive market abroad was whittled down to a far less competitive one in the U.S. and Canada.

46 "Elevator Technical Advisory Committee Meeting, Transcript of Proceedings: February 8, 2022, Day 1," 38–41.

47 "Alternative Testing – Pro and Con."

48 "Office of the Illinois State Fire Marshal Elevator Safety Review Board Meeting," November 5, 2020, 58; "NEBA Agreement with IUEC, 2022-2027," Article VIII, Par. 2.

49 Chapman, "To the Pennsylvania Elevator Safety Board," n.d.; "Elevator Safety Board Meeting Minutes: May 6, 2020"; "Elevator Plan Review and Inspection Requirements."

50 Wurtec, "2019 Video-Text-Audio & Alternative CAT5 Testing."

51 "FAQ Aufzugsprüfung: Häufig gestellte Fragen und Wissenswertes zu den Prüfungen von Aufzügen."

52 Petry, "The Germany/European Elevator Safety System and Policy"; "Office of the Illinois State Fire Marshal Elevator Safety Review Board Meeting," November 5, 2020, 38; "ADIASYSTEM."

53 "Directive: Approval of Alternative Testing for Category 5 Testing."

5.3.6 In 2015, responding to a California proposal to continue to not allow alternative testing, National Elevator Industry, Inc., the U.S. manufacturer trade group, estimated the cost of hiring the second mechanic needed to handle weights for a day for a test at $1,000 per five-year test per device (the estimate is plausible – Big Four manufacturers can charge well over $2,000 per day today in some U.S. markets for a mechanic to operate an elevator while a building is still under construction, before the manufacturer has released it to the customer for use).[54] For their legally required cost-benefit analysis, Washington State regulators nevertheless claimed that disallowing alternative testing "is unlikely to add any additional cost to affected parties," since nobody in Washington State began performing the testing during the brief window when it was legal.[55]

54 "Cost Calculations on Non MRL-Related Provisions of DOSH Elevator Code Updates."

55 Research and Data Services, "Preliminary Cost-Benefit Analysis: Chapter 296-96 WAC, Safety Regulations and Fees for All Elevators, Dumbwaiters, Escalators, and Other Conveyances," 9–10; RCW 34.05.328: Significant legislative rules, other selected rules.

As discussed in section 2, “Access,” North America has far fewer elevators than would be expected based on its population and level of wealth. The high costs of installing and operating elevators in the United States and Canada are, in part, responsible for this deficit. Parents, the elderly, people with disabilities, and multifamily residents generally would be better served by elevators if they did not cost many times what they do abroad. For prices to come down to prices seen abroad, policies must be brought in line with policies abroad. Achieving, for example, Swiss costs for new elevator installations should be possible, but would require big shifts in policy and attitudes at multiple levels of government, in ways that would go far beyond the elevator industry, and which may not be realistic. That said, the gap in elevator costs between North America and Western Europe is so large that there are many opportunities for incremental efficiencies and cost reductions, and therefore improved access to elevators. The extent of reform is limited only by North Americans’ commitment to housing affordability, quality, and accessibility.

Cost drivers can be divided into cabin size, labor, and technical codes, and this report’s recommendations for reform will be divided into those same three categories. Each influences the others, and they should be thought of not as distinct silos, but as interlocking issues that can help or hinder reform in other areas. Barriers to entry posed by technical codes, for example, can support the current labor status quo by keeping foreign firms who do not have existing agreements with the IUEC out of the North American market. Excessive cabin size requirements can reinforce labor shortages by requiring more work to install an elevator. The IUEC's labor monopoly gives it a leg up on committees tasked with choosing which technical code provisions to adopt and recommend.

Specific policy reforms are presented in the subsections below. Beyond these, however, there are a few shifts in attitudes that must take place among regulators if the United States and Canada are to ever approach the elevator abundance of other high-income countries.

Firstly, regulators should consider safety and accessibility more holistically than they have been. Cost and access to elevators are inversely related, so anything that raises cost – even if the intent is to provide greater accessibility – will come at the expense of accessibility in buildings that become uneconomical to build. Stricter safety requirements will come at the expense of the health and welfare of those who would benefit from elevators but are deprived of them due to higher costs. Regulators ought to take a bigger-picture approach to the issues of safety and accessibility, and take cost-benefit analyses more seriously.

Secondly, regulators must take international best practices more seriously. The elevator industry has become highly globalized, but regulation in North America remains parochial. Mentions of how things are done abroad are often met with eye rolling and denigration. The term "international" appears in various North American organizations that routinely ignore international best practice – the *International* Code Council, the *International* Association of Elevator Consultants, the *International* Union of Elevator Constructors. These organizations recognize the rhetorical benefits of an international outlook, but they ignore or resist global trends. In the absence of strong data on the inadequacy of international practices, deference should be given to what is tried and true in societies with far more – and far more affordable – elevators than North America.

6.1 Cabin size requirements

Currently, rules about when an elevator is required in American apartment buildings (if they are required at all) are found mostly in federal law, while requirements for the size of cars are found in both the building code and the ICC's A117.1 accessibility standard. Exact dimensional requirements for stretcher elevators are not found written into any code at all, with local authorities instead deciding whether designs meet performance-based standards. There are typically no legally binding standards at all for the number of elevator cars in larger buildings, leading to difficult situations for people dependent on elevators when cars are placed out of service for repairs or modernization.

The current rules governing when elevators must be installed in multifamily buildings and how large the cabins must be should be consolidated into a single code and clarified. Elevators should be required in multifamily buildings of a certain size, regardless of whether the ground floor is accessible, while at the same time allowing for smaller cabins for smaller buildings and implementing other technical and labor reforms to bring costs down. There should also be incentives in the code to provide more redundancy.

The current lack of any clear requirement at all in most jurisdictions to install an elevator in an apartment building (as long as the ground floor is accessible) has been workable due to a raft of unrelated and largely unintentional zoning and building code rules that make small apartment buildings functionally impossible to build. But as codes are being reformed to smooth small-lot development, developers seem to be experimenting with larger and larger walk-up buildings, and finding market acceptance. Five- and six-story walk-ups are unbecoming of one of the wealthiest countries in the world, and the model International Building Code should be revised to require an elevator at a certain height, or in buildings with a certain number of units. Based on the experience of other high-income nations, three or four stories is an appropriate maximum height for a walk-up apartment building. A limit could also be placed on the number of apartments that a multistory building can have before an elevator is required. In order to ensure that the above limits do not harm the feasibility of development overall, these new requirements should come at the same time as other measures to bring down costs.

6.1 The simplest measures to bring down cost would be to allow smaller elevator cabin sizes for smaller buildings in particular. For an elevator that accommodates a wheelchair (and not a stretcher), the required size should be fixed at that of a standard European type 2 elevator car for small buildings: 1.1 m × 1.4 m, or 3 ft., 7 in. × 4 ft., 7 in. The current ICC A117.1 Accessible and Usable Buildings and Facilities standard already acknowledges that an even smaller elevator car can accommodate a wheelchair, with 3 ft., 6 in. × 4 ft., 6 in. being the minimum required internal dimensions for an existing building.[1] The definition of a small building should be set at any building (or portion of a building served by a single elevator) where there are at most 20 units that are not on the ground floor of the building, with today's cabin size remaining in place for any building with more than 20 apartments located above or below the level of entry.

The logic behind reducing the allowed size of cabins for small buildings is twofold. Firstly, with so few apartments, an elevator user is unlikely to have to share an elevator with anybody outside of their household on any given trip. Secondly, developers have been shown to often avoid installing any elevator at all in small buildings (see 2.1.1, "Walk-ups and elevator buildings"), and even a smaller, wheelchair-accessible elevator in these buildings would be an upgrade.

Smaller elevator cars could also be used to address a problem that a number of wheelchair users brought up in interviews, which is a lack of redundancy. Currently, voluntary elevator planning guidelines for multi-family call for one cab for every 50 to 100 units. For small- or mid-sized buildings, this often means there is only one elevator car available, and when it's placed out of service for inspections, service, repair, or modernization, people who depend on the elevator have no way of getting in or out of their apartment. In order to encourage developers to increase the number of elevators, 1.1 m × 1.4 m cabins should be allowed for buildings (or segments of buildings) with at least two elevators, and a ratio of no more than 35 non-ground floor units for each elevator. So, for example, the developer of a 50-unit building would have the option to either install a single elevator meeting today's North American accessibility standards, or two elevators meeting European accessibility standards.

Beyond the wheelchair requirement, elevator cars in the United States and Canada are also larger than is typical abroad because of the requirement to accommodate a 7-ft. stretcher in a fully extended position. This requirement was not subjected to a cost-benefit analysis, and has not yielded better clinical health outcomes in North America compared to regions that do not require elevators to fit stretchers. In order to bring stretcher elevator requirements in North America more in line with those abroad, the trigger could be aligned with the definition of a high-rise building (measuring 75 feet from ground level to the top of the finished floor on the highest occupied story, or starting at around eight stories). More conservatively, the requirement could apply to buildings of at least six or seven stories. In situations where a stretcher is required

1 "A117.1: Accessible and Usable Buildings and Facilities," Table 507.4.1.

but a wheelchair turning radius is not (for example, if the building has few apartments, or the developer has opted to provide a high ratio of elevators to residential units), then a 1.1 m × 2.1 m, 1,000-kg (2,200-lb.) European stretcher elevator could suffice, rather than the current 3,500-lb. stretcher elevators found in North America that fit a stretcher diagonally.

6.2 Technical codes and standards

The United States and Canada have been left on a technological island when it comes to elevator designs and components with the ASME A17.1/CSA B44 elevator standard and related web of technical rules. This raises costs in a number of ways, the most pernicious of which is by restricting entry into the market by small and mid-sized foreign firms, both for entire elevator kits and also for specific components. Intracontinental variations in adoptions also introduce more minor but still impactful differences in regulation. These divergences have not resulted in better safety outcomes in the United States as compared to high-income countries that use the global ISO 8100 codes, and may have harmed building occupant health and safety by limiting the installation of elevators in low- and mid-rise buildings, and pushing users towards more dangerous stairs. State and local elevator safety boards who further modify the model A17.1/B44 code introduce differences without any deep analysis of the impacts, and it is not plausible that jurisdictions of a few million people (or fewer in some cases) have the capacity to do any such analysis better than much larger standards-setting bodies.

At a minimum, state and local deviation from the latest ASME A17.1/CSA B44 code should not be allowed. Going further, these North America-specific technical codes and standards should be phased out entirely, and the United States and Canada should join the rest of the world in adopting the ISO 8100 family of standards and the related global harmonized web of technical rules. As an interim step, both existing North American and global harmonized codes and standards could be equal options for compliance. The latter task – aligning not just the elevator safety codes and standards with those of the rest of the world, but also the referenced standards regulating things like electrical standards – would require the cooperation of regulators and construction sectors outside of the elevator industry.

6.3 Labor

On-site labor is the largest single driver of cost for every element of installing and maintaining a functioning elevator, and the issues around it are some of the most intractable. Unlike elevator car sizes and technical codes and standards, the labor issues affecting the industry are often not directly legislated, but rather hammered out privately between

6.3 the IUEC and elevator manufacturers. Nevertheless, government policy plays a role in shaping these negotiations, and there are a number of measures that governments could take to reduce labor costs.

To ease the chronic labor shortage within the highly skilled and licensed construction trades generally, governments should take a more active role in educating workers, through state-sponsored technical and vocational training. The exact contours that this might take are beyond the scope of this report, but Central Europe in particular offers good models.

Following the European model, the field of new installations should also be opened up to foreign labor. New installations are the most physically demanding and least intellectually challenging elevator subsector, and tend to be less desirable assignments among mechanics. Unlike inspections, service, repairs, and modernizations, where work is steady regardless of economic conditions, demand for new installations rises and falls with the real estate cycle. More labor is needed during boom times, and less is needed during recessions and troughs in the business cycle. A labor force that aims to eliminate unemployment among its members, as the IUEC does, is not able to both ramp up and down new installations while at the same time providing reliable service for existing devices – the goals are simply not compatible. Either the labor force must be sized to provide an adequate number of workers during boom times and substantial unemployment must be accepted during quieter periods, or the labor force must be sized to provide full employment during recessions and some level of work during busier times must be turned away (likely through what economists term "demand destruction," or prices so high that developers and building owners forgo new installations, service, and modernizations). The use of foreign labor for new installations is how this circle is squared in Europe, and it is worth considering in North America.

Currently, both immigration policy and licensure stand in the way of foreign labor in the elevator industry. In the United States, there is no legal pathway for construction workers to enter the country. Huge numbers of undocumented immigrants work in construction generally, but not in the elevator sector, where licensure and the consolidated nature of the industry make employing undocumented immigrants untenable – Schindler or Otis, for example, cannot employ the same labor practices as a small framing or roofing subcontractor. Skilled construction workers cannot enter the country on H-1B visas, since the program is only open to workers whose fields require at least a bachelor's degree. New legal immigration pathways should therefore be created for skilled construction workers, including elevator mechanics.

Licensure is an increasingly common feature of the elevator industry in both North America and Europe, and is appropriate given the greater technical demands placed on mechanics. However, the American practice of requiring licensure for mechanics working on new installations complicates labor mobility. In Europe, licensure is usually limited to mechanics working on service and maintenance. New installation work can be performed underneath somebody with a license or some certification, who checks the work and signs off on the installation during the commissioning process. This allows foreign workers, who have experience but cannot reasonably obtain licensure in dozens of different countries or subnational jurisdictions, to work in the field, and could be emulated in the United States and Canada.

Beyond reforming licensure laws to accommodate foreign workers, the state-by-state system of licensure in the United States should also be reformed. There are not significant enough differences in elevator design between states to justify individual regimes in each state.

Finally, bringing technical codes and standards in line with those of other countries would make it easier for foreign small- and mid-sized manufacturers with more efficient labor practices to enter the market, unencumbered by the IUEC's master contract and settlement agreements about things like which holes belong to whom.

6.4 U.S. federal government role

In the United States, regulation of elevators and construction generally is left up to states, counties, municipalities, or even other types of authorities, justified by the national tradition of federalism. The industry, however, has become so complex that it is questionable whether subnational jurisdictions have the capacity to properly regulate the industry. At a minimum, the system of roughly 100 different North American jurisdictions reviewing and adopting different editions of the A17.1/B44 model code, with slight amendments, is duplicative, inefficient, and introduces opportunities for rent-seeking and error. There are no differences in conditions between cities and states to justify separate codes. The federal government is in a better position to do research and decide on standards than jurisdictions that represent and are funded by small numbers of people.

Constitutionally, there are many issues related to elevators that could put regulation well within the federal government's purview. The federal government should develop reforms for the issues discussed in this report and force their adoption by states and other jurisdictions by making housing or transportation funding contingent on adopting nationally harmonized regulations, in the same way that the U.S. federal government has imposed a uniform minimum drinking age across the country.[2] The issue of codes and standards – both for elevator safety and the various standards referenced by the main elevator safety code – is especially ripe for intervention by a large bureaucracy like the United States Department of Housing and Urban Development or the Department of Commerce, through the National Institute of Standards and Technology.

2 "The 1984 National Minimum Drinking Age Act."

7 AREAS FOR FURTHER RESEARCH

This report is the first to ever examine the North American elevator industry from a global perspective, and there are many opportunities for further research to refine ideas and apply them to other areas.

This report focused on mid-rise elevators, since they are the most common in any country larger than a city-state, and the heterogeneity of high-rise installations makes them difficult to compare to each other. However there are many themes that are worth exploring in more depth, from cost to ratios provided in new buildings.

American architects and developers have cited various accessibility requirements that only apply when an elevator is provided as a disincentive to provide elevators in the first place. While an elevator is not required in many multifamily buildings, voluntarily installing one may trigger accessibility requirements, particularly within units, that may not otherwise apply. This disincentive to provide elevators could be fixed in a number of ways, but before deciding on a path, a better understanding of the costs and benefits of accessibility is needed.

Elevators are a critical accessibility tool, but are only effective insofar as they work. Many American wheelchair users said they would not consider living in a building with only a single elevator, due to the risk of downtime trapping them in or out of their apartment. Global elevator firms have data on reliability and uptime on different continents, but this data was not made available for this report. There are many peculiarities of the North American market that might influence reliability one way or another – the greater use placed on individual elevators due to the greater number of apartments served by each device, the larger size of cabins, the more limited market for parts, and the unique labor market. More research is necessary to determine whether any of these differences affect reliability in any significant way.

The technical codes and standards referenced by the main elevator safety rules deserve hundreds of pages of research and analysis. The issue pervades not only the elevator industry but also the broader construction sector, and drives market differences in everything from gypsum board to heat pumps. Significant differences in regulation should be analyzed for usefulness, but even more pernicious might be the insignificant ones – separating markets for parts and materials, without any meaningful physical differences in allowed materials. Electrical standards – with America using the National Electrical Code (NEC, or NFPA 70), and Europe and much of the rest of the world using IEC 60364 – were singled out by one interviewee as impactful in the field of elevator components, and are worthy of more study.

One topic that was not covered at all in this report is freight elevators. Deindustrialization has been a major theme of American urbanism and politics throughout the second half of the 20th century and into the 21st, as vertical urban warehouses and factories gave way to sprawling, single-story facilities in the suburbs and exurbs. Reindustrialization has been on the minds of many policymakers in America, with the energy transition, supply chain security, and growing demand for logistics facilities driving increased interest in industrial real estate. Freight elevators were in heavy use in multistory industrial buildings in U.S. cities in the 19th and early 20th centuries, and are still common in East Asia and, to a lesser degree, Europe. And possible reindustrialization of North America's urban cores will have to involve freight elevators – modern multistory warehouses in U.S. cities are built with truck ramps, but the amount of land needed limits their development. There may also be smaller-scale freight applications that could smooth out the bumps of urban logistics. One person with experience developing grocery stores in Germany, for example, said that freight elevators are often installed in urban format stores there. They are rarely seen in New York City, on the other hand, which has problems with breaks in the cold chain when perishable food needs to be hauled by hand into basement storage. Freight elevators likely see the same cost premium in North America as passenger elevators, and their cost could impede broader efforts to bring denser industry back to North American cities. More research is needed to confirm this, and to identify any issues that are separate from those of passenger elevators.

This report was not able to cover the elevator industry in depth in high-income Asian countries like Japan and South Korea, due to linguistic gaps. While our preliminary research shows that East Asian costs are likely similar to those in Europe, the details of how the industry functions are still opaque to this author. The relatively low-immigration environment of South Korea, for example, or Japan's unique safety code (it is the only major country in the world outside of North America that has not harmonized to the dominant European standard) may provide insights into how North America can bring down costs without fully adapting to the European paradigm.

Due to the greater rate of unionization, nonexistence of subcontracting, and higher salaries in Norway's elevator sector, further research there would be valuable to understand how these factors influence price in an environment where, unlike in North America, elevator car sizes are more modest, equipment is held to global harmonized standards, and there are no union contract provisions against preassembly and prefabrication. We were not able to obtain any quotes for new installations in Norway, but doing so would help disaggregate the price effects of similar policies in North America.

While we tried to integrate Canadian perspectives into this report as much as possible, the smaller size of the market made research difficult. There are some hints that Canadian new installation prices might be slightly lower than in the U.S., and also that some of the issues identified in the United States might be somewhat less of a factor in Canada – greater acceptance of new technology within the confines of the A17.1/B44 standard, and perhaps somewhat more flexible labor in terms of contract provisions and immigration law.[1]

1 Singer, "How To Immigrate To Canada As An Elevator Constructor Or Mechanic."

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