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# Lessons for Modernizing Energy Access Finance, Part 1: What the Electrification Experiences of Seven Countries Tell Us about the Future of Connection Costs, Subsidies, and Integrated Planning

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## Summary

Countries facing electricity access challenges today have more options and potential electrification pathways than ever before. Technology developments in distributed renewable electricity systems, monitoring and payment systems, and end-use equipment efficiency have made off-grid electricity systems the lowest-cost and most expedient option for the majority of unconnected rural populations. However, the initial cost of connecting new rural customers remains an expensive proposition, and public financing that addresses the affordability issue will be required for most countries to achieve universal access, just as it always has. This brief explores the successful rural electrification experiences of seven case countries—Brazil, Chile, Laos, Peru, South Africa, Thailand, and Tunisia—looking specifically at the cost of connections and how subsidies and public financing were deployed to address the affordability challenge and facilitate energy access. The analysis finds that connecting rural customers has been costly—more than $1,500 per connection on average—far more than the cost of distributed systems today. The rural electrification programs examined subsidized 70–100 percent of connection costs. Maintaining these public investments and adapting funding mechanisms to address the unique nature of the off-grid sector, will dictate the extent to which distributed systems are able to scale in the coming decade.

## EXECUTIVE SUMMARY

Low- and middle-income countries facing electricity access challenges today are dealing with a new playbook of potential solutions. While the six billion people on the planet with electricity access today gained it almost entirely via the grid, the plummeting costs of solar and batteries, the Internet of Things, and the development of ultra-efficient equipment and appliances point to a much different set of possible electrification pathways for the next billion. The IEA estimates that off-grid systems will be the low-cost solution for more than 70 percent of rural people gaining electricity access over the coming decade (IEA 2017a). Taking full advantage of off-grid technology will require countries to adapt electricity planning and financing approaches to this private sector-led space, while at the same time addressing the persistent affordability gap that has made rural electrification subsidy dependent since President Roosevelt created the first Rural Electrification Administration in 1935.

Over the last several decades, many countries have made great strides in bringing electricity to their rural populations in the face of a range of financial, geographic, and technical challenges. The electrification experiences examined in Brazil, Chile, Laos, Peru, South Africa, Thailand, and Tunisia represent a diversity of circumstances and approaches. Yet consistencies across their approaches in dealing with the challenge of affordability reveal relevant insights for countries facing access deficits today:

- **Rural electrification programs have historically been costly and public financing has been essential for raising capital.** Programs examined in the seven focus countries delivered connections at an average cost of more than $1,500 per connection.[1] As countries moved closer to universal access and focused on last mile connections, these costs grew. Governments and multilateral development banks played central roles in financing these efforts, anchored by billions of dollars in concessional loans from the World Bank and regional development banks. All the countries studied relied primarily on grid expansion, with some countries including limited off-grid programs. These off-grid electrification programs, while ranging in the level of service provided, were generally similar in cost or cheaper than grid expansion on a per connection basis.

- **Households paid a low proportion of electricity connection costs and relied on large government subsidies.** With connection costs surpassing the annual income of many rural households, national governments typically funded the vast majority of up-front capital costs for new electricity connections. Across the cases examined, customers paid an average of $210 per connection, or 14 percent of total connection costs. In several cases, households paid nothing to be connected. Connection subsidies ranged between 70 and 100 percent of connection costs.

- **Rate subsidies have been used frequently to stimulate increased consumption of electricity among rural households, helping derive broader benefits from access.** Rural customers typically have lower average incomes than urban customers, and initially have low demand for electricity. In order to encourage energy use for appliances and productivity gains, many countries subsidized electricity tariffs for these customers. In some cases, these households were cross subsidized through higher rates for other customer segments. While well-designed rate subsidies can help maintain the financial sustainability of the utility over the long-term by increasing the revenue base, targeting them to the poor is difficult and these subsidies have historically benefitted middle- and high-income households disproportionately.

- **Several countries made explicit decisions about prioritizing electrification investments based on broader social or economic factors, including productive uses.** Prioritizing electrification investments around socially valuable objectives—electrifying schools, clinics, etc.—and productivity drivers—irrigation, agricultural processing, etc.—was cited as effective in building political will for electrification and generating broader economic growth.

1. All dollar amounts are in 2018 dollars unless otherwise noted.

## INTRODUCTION

As countries assess strategies for expanding electricity access, the experiences of previously electrified countries can provide important lessons about what works: how to deal with high connection costs and low affordability, mobilize financial resources, design system ownership and management models, and support productive use of energy for development.

A cross-cutting driver of change over the last decade has been the emergence of cost-competitive off-grid electricity delivery platforms. With the maturation of solar and battery technologies, the rise of efficient appliances and other "smart" internet-enabled technologies, there is an expanded set of viable options for reaching unconnected populations. New options have added a layer of complexity—and importance—to systems planning, as decisions related to how and where to integrate distributed systems with grid expansion can present significant technical and institutional hurdles. Distributed systems also have different cost structures, ownership models, operations and maintenance requirements, power delivery capabilities, and equipment lifespans compared to the predominant grid expansion model, and these differences must be thoroughly considered in the planning process.

### In a Nutshell: Primary Off-Grid Platforms for Access

Solar home systems (SHS) and mini-grids are the two most widely deployed off-grid platforms for providing rural access. SHSs are household-level solutions that can be as simple as a basic kit with a 10-watt solar panel, lights and phone charging, or can cost $600 or more for larger systems that include televisions and other devices. They are frequently offered on a credit basis, with customers using mobile money to make regular payments over time and operators having the ability to disconnect service remotely in the event of non-payment. Microgrids offer a village-level power solution that can support grid-like energy services, with connection costs of $1,000 per connection and lower, depending on the size and location (AMDA 2018, 2).

What has not changed over time, however, is the economics of delivering electricity to poor, dispersed populations. From the experience of the United States in the 1930–50s, China in the 1960s–80s, to the cases examined here, countries have used public funds to subsidize electricity access for their rural populations. In fact, it is often said that no country in the world has achieved full electrification without substantially subsidizing connections for last-mile households (PowerGen 2018, Guay 2018). While it is not the intent of this paper to verify this statement, one of the goals is to examine the extent to which subsidies have been used in the recent past to facilitate rural connections.

The group of countries examined here—Brazil, Chile, Laos, Peru, South Africa, Thailand, and Tunisia—have experienced rapid growth in electrifying rural households during some period of their recent history. Each was broadly successful in mobilizing investment to expand grid access and, in more limited and recent examples, the roll out off-grid technologies. In this brief we examine how they went about it, looking specifically at the underlying connection costs, subsidies, and complementary programs associated with those initiatives. We also compare these historic cases against countries facing energy access challenges today, looking at what similarities and differences across certain indicators—namely population density and average income—may imply for electrification costs and subsidies in these markets.

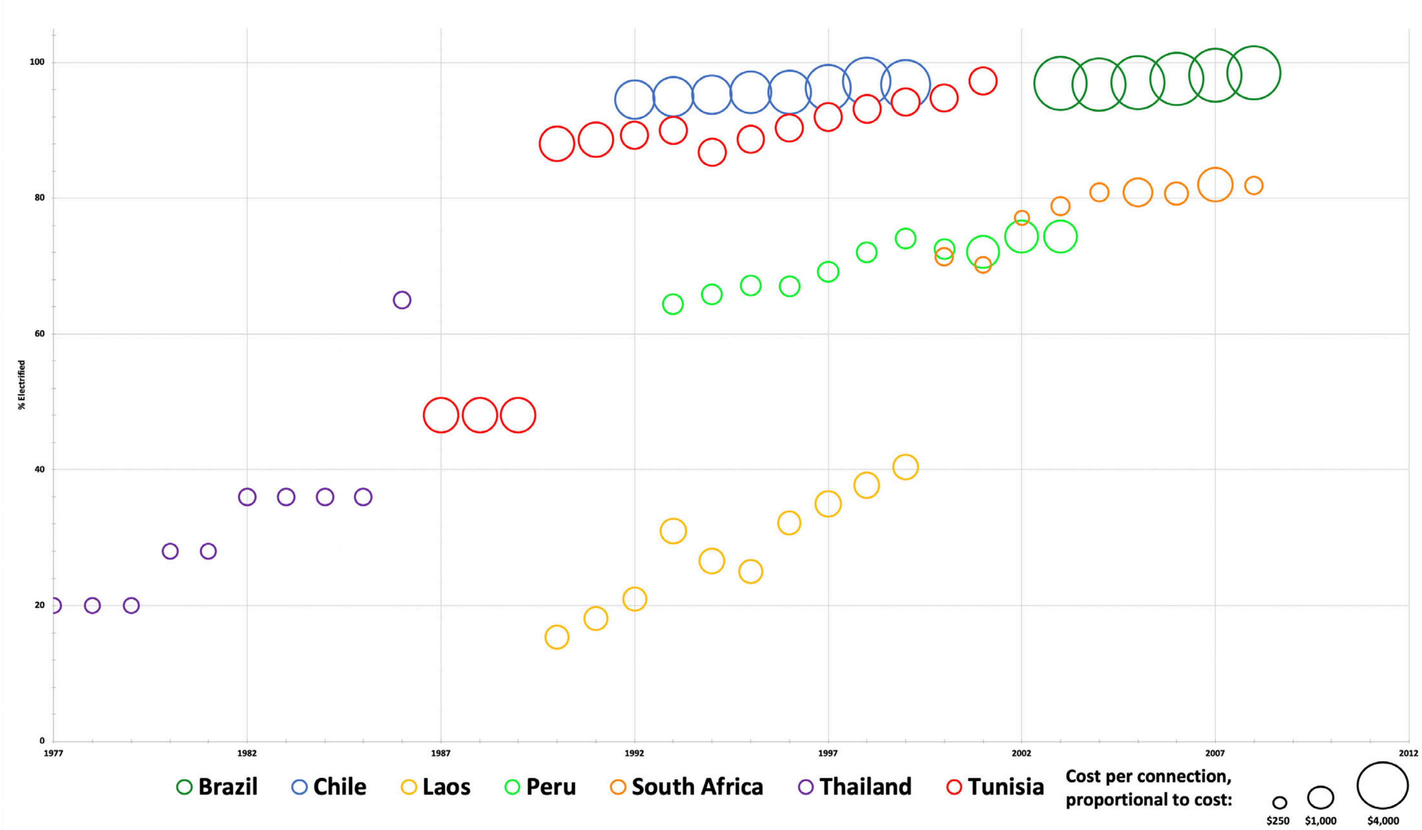
## Common Power Sector Subsidy Mechanisms

Subsidies supporting electricity access can take many forms. The most common outlined in the focus countries in this paper include:

- **Subsidies for connection costs**. Many low-income households cannot afford, or are unwilling to pay, the steep cost of connecting to the distribution system and wiring the inside of the house, the cost of which commonly surpasses the annual income of many rural households. Subsidy schemes can be constructed as outright free connections for households, percentage-based or matching programs, or amortizing the cost of the connection—or a reduced portion of it—over time via the customer's monthly bill.
- **Subsidies for transmission and distribution**. These are typically covered through dedicated funds and frequently supported by donors through concessional loans and, to a lesser extent, grants. These can be substantial, covering the full investment cost in some cases or allowing for repayment terms of 30 years or more at interest rates deeply discounted below market rate.
- **Rate subsidies**, including cross-subsidies within the tariff system. Expanding the electrical network is costly, but first-time electricity users typically have low incomes, few appliances, and consume little electricity. Low consumption makes the economics of electrifying rural users challenging in the short-term. Several case countries applied lower tariffs to low-consuming or poorer households, which can spur experimentation with different appliances and jump-start a habit of electricity consumption. Sometimes referred to as lifeline tariffs, these subsidies typically reduce the cost of the first block of power sufficient to cover basic needs and increase to a commercial rate after a specified consumption level. Tariff rates favoring more geographically remote or lower-income customers may be cross-subsidized through commercial, industrial, or large residential users that pay higher tariffs.

The seven case countries examined were also in different stages of their electrification journeys. As illustrated in Figure 1 some countries were addressing truly last mile connections for the final 5–10 percent of their populations, which represented the most remote and expensive to reach. Other countries, however, were examined at an earlier stage of expansion. Cost per connection ranged from $554 to $4,363, which is comparable to current figures for connection costs both for grid expansion and off grid expansion (Kojima & Trimble 2016). As a point of reference, Ethiopia's 2015 rural electrification program cost $245 million and connected 65,000 new customers, resulting in a cost per connection of $3,770 (Trimble et al. 2016).

## Figure 1. Rural Electrification Rate and Cost per Connection




Source: Multiple. See Works Cited—Graphs.

These cases were selected with the aim of including a diversity of geographies, domestic economic situations, population densities, and income levels, as well as based on the availability of English-language information about their electrification programs. Data for this study were collected from a range of sources, primarily development bank documents. They have been standardized in 2018 U.S. dollars unless otherwise noted (the value from the source document is included in parentheses). Cost per connection was calculated by dividing electrification program costs by the number of households electrified by the program. Program costs typically include transmission and distribution infrastructure capital costs, solar home system capital costs (where relevant), as well as project implementation costs, such as the cost of administering surveys of unelectrified regions. Unless otherwise noted, subsidies discussed in the report are connection subsidies to the customer and were calculated by subtracting the connection fee (price customers were charged for the connection) from the total program cost per connection. References for these figures have been included at the end of the document.

## KEY FINDINGS AND ANALYSIS

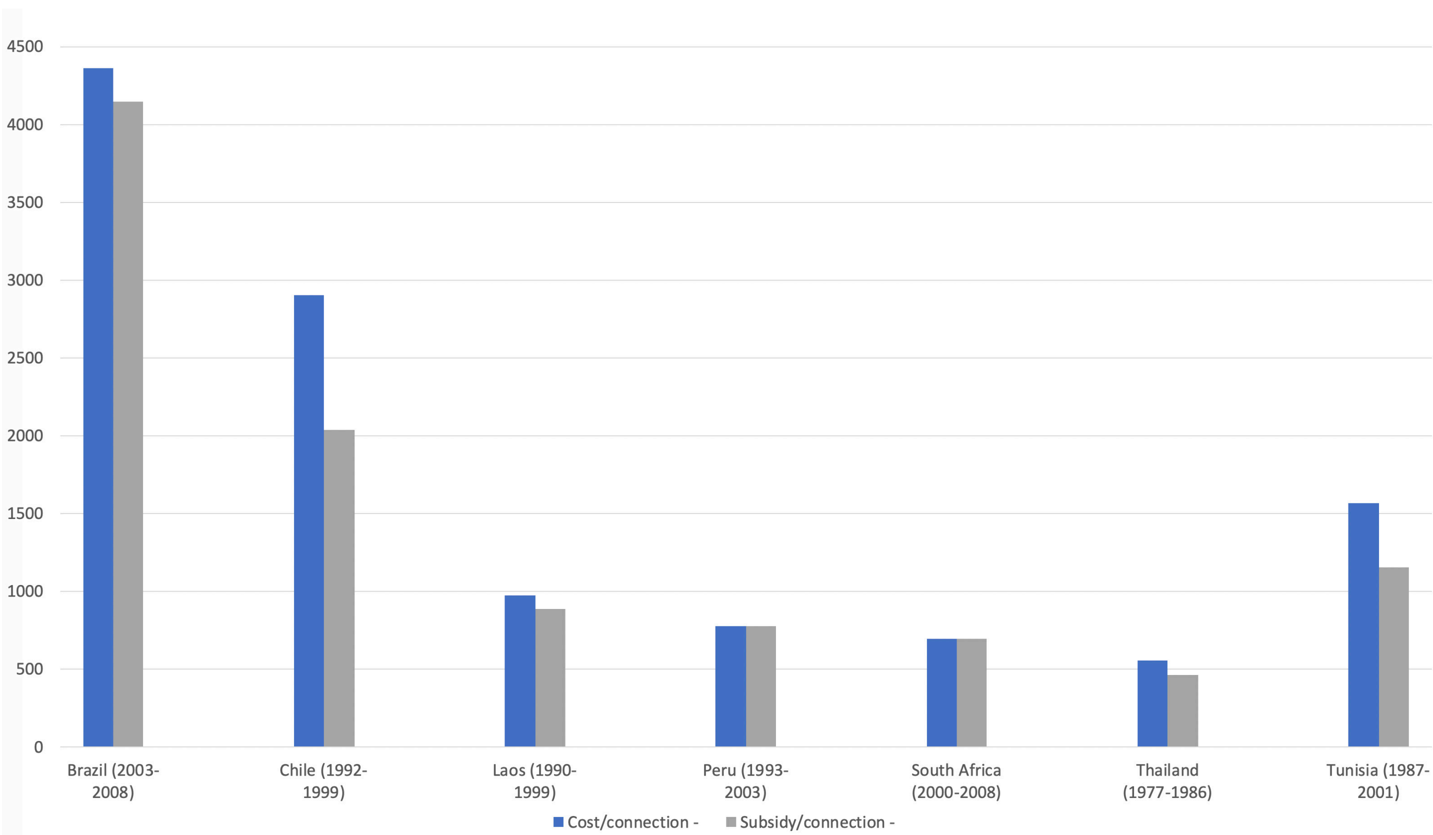
### *Using Subsidies to Manage the High Cost to the Consumer*

Across all seven cases examined, **rural electrification programs were costly on a per connection basis and public financing was essential for raising capital**. Programs examined in these countries achieved connections at an average cost of more than $1,500 per connection. As countries got closer to universal access and focused on last mile connections that were more isolated and further from existing infrastructure, those costs grew (Fig. 1).

These high rural connection costs commonly surpass the annual income of many rural households, leading to a relatively low ability to pay for connections. As a result, customers in the case countries bore a lower share of total connection costs. Across the cases examined, customers paid an average of $210 per connection, or 14 percent of total connection costs. In several cases, households paid nothing to be connected. The governments of Peru and Brazil, under strong social policy mandates, fully funded new connections during the period. Across all case countries, connection subsidies ranged between 70 and 100 percent of cost per connection (Fig. 2).

These findings are consistent with other research that has found national utility connection costs often exceed $2,000 in rural areas (Blimpo & Cosgrove-Davies 2019, Trimble et al. 2016). When connection fees surpass household willingness to pay for them, households develop creative ways of accessing the system, including illegally connecting—often at a great risk to safety—and sharing electricity meters. These workarounds can undermine the financial sustainability of the system and make it more challenging to target rate subsidies to low-income users (Kojima & Trimble 2016).

**Figure 2. Cost per Connection and Subsidy per Connection**




Source: Multiple. See Works Cited—Graphs.

## Demand Stimulation and Integrated Sector Planning to support Productive Use

The seven case countries had to make decisions with significant implications for the financial health of the utility companies, including how to stimulate electricity demand and target subsidies for rural customers that typically have lower average incomes and lower demand for electricity than urban customers. **Rate subsidies were used to stimulate demand and** increased adoption of appliances and productivity-improving equipment among rural households in Thailand, Tunisia and Brazil. In the case of Tunisia, these households were cross-subsidized through higher rates for other customer segments. While well-designed rate subsidies can help support the financial health of the utility by boosting demand and increasing the revenue base over the long-term, targeting them to the poor can be difficult in practice. These types of quantity-based consumption subsidies are politically popular and can be useful for introducing electricity to first-time users. However, in practice, they are difficult to target, and the vast majority of benefits are not captured by the poor (Komives et al. 2005, 70).

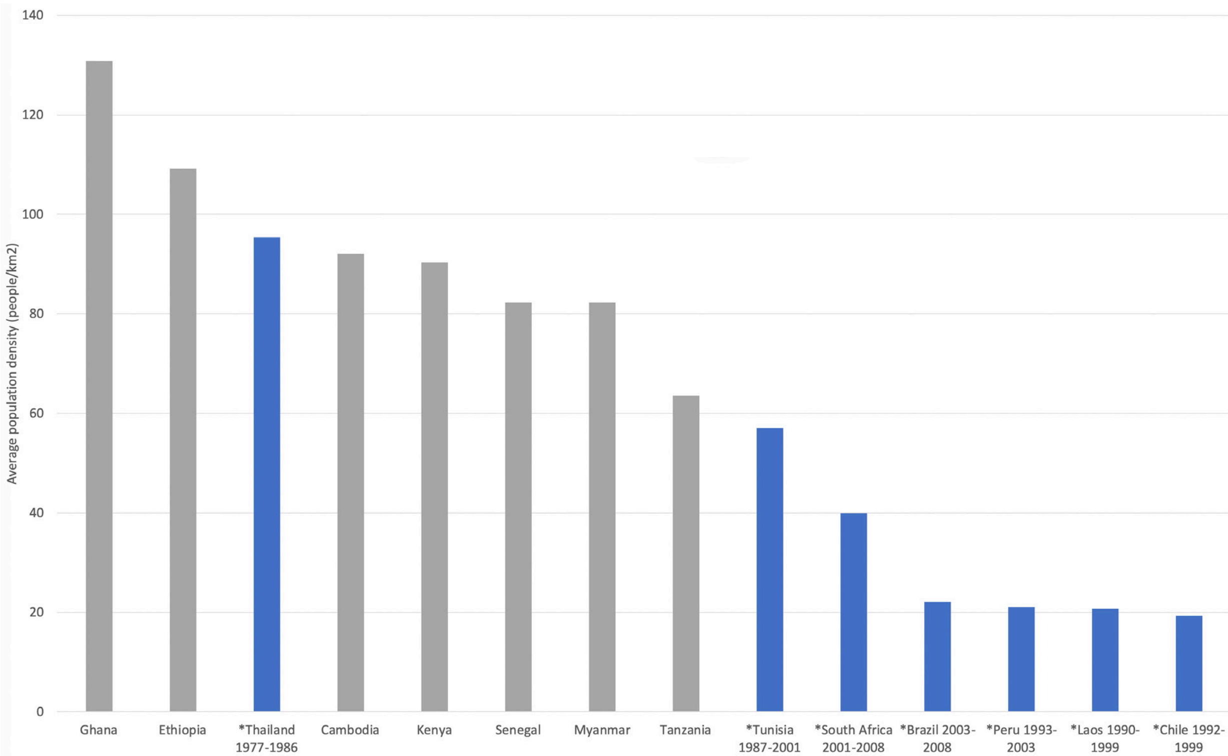
Some countries also **prioritized social or productive electricity uses** in order to improve returns on investment—both social and financial—and align politics. Prioritizing electrification investments around socially valuable objectives like electrifying schools, clinics, and public lighting, as well as productivity drivers like irrigation and agricultural processing, was cited as effective in building political will and generating broader economic growth. Laos and Tunisia explicitly prioritized areas with health clinics. Tunisia's program also included a focus on access that enabled water pumping to support agriculture. Brazil's Luz para Todos program also placed priority on connections that would service agriculture or other productive uses (Slough, Urpelainen, and Yang 2015). Other case countries **targeted their spending based on efficiency**—where a unit of subsidy could enable the most connections. For instance, Chile opted for an arrangement wherein communities competed with each other for subsidies, with both social and financial costs and benefits considered in ranking potential projects. Similarly, Thailand focused resources on villages willing to pay a portion of interconnection costs, as well as considering demand and income in prioritizing electrification.

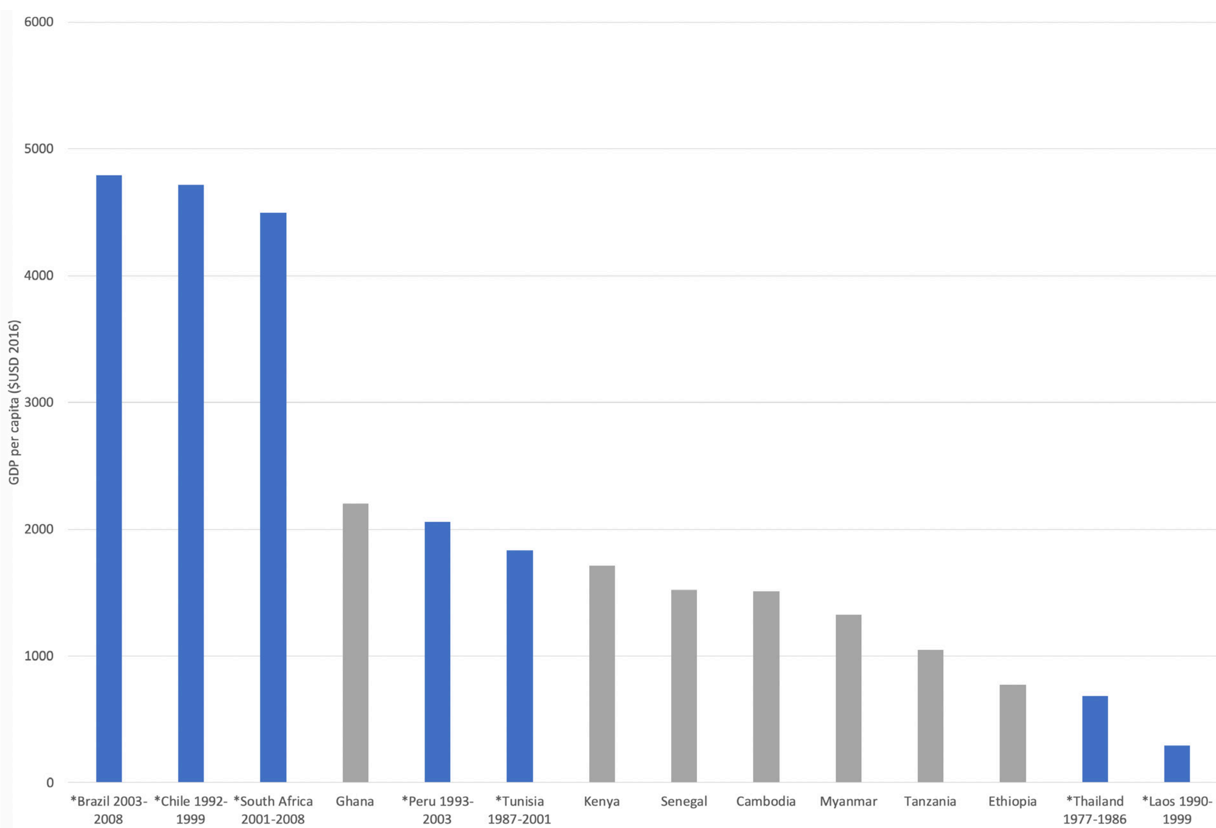
## Relevance for Countries Facing Access Deficits Today

To help gauge the extent to which the experiences of our case countries are relevant today, we selected a geographically diverse group of seven countries that are currently facing access challenges and compared them with our case countries across two broad but important indicators, income and population density.

As illustrated in figures 3a and 3b, the seven historic case countries had a higher GDP per capita and less dense population distributions on average than the basket of countries facing access deficits today. In general, the higher the density of the population, the less expensive it is per household to expand access because of economies of scale in distribution. The case countries tended to have lower average population densities, suggesting that countries such as Ethiopia and Cambodia may be able to reach their rural populations at lower average costs during analogous periods of their electrification journey. However, the subsidy required to reach low-income populations is also driven by the ability to pay for a connection. Using GDP per capita as a very rough gauge for what rural consumers are able to pay for connections, Figure 3b illustrates how some countries currently facing access challenges have lower incomes than those included in the study. This means that even with denser, easier to reach populations, the countries facing access deficits today will require significant connection subsidies to bridge affordability gaps for last-mile customers.

## Figures 3a & 3b. Comparing the Case Countries with Countries Facing Rural Electrification Challenges Today: Income and Density Snapshot




Source: World Bank. 2019b; World Bank 2019c.
Note: Countries with an asterisk (*) are case countries, and their data is from the focus period for each case. Other countries are 2018 data from countries where rural electrification is a priority issue at present.

## CONCLUSION: ADAPTING FINANCING MODELS TO SUPPORT OFF-GRID APPROACHES

What do these findings mean for electrification programs today that aim to leverage decentralized solutions? As previously discussed, decentralized systems will likely be the most cost-effective solution for a significant majority of rural populations going forward. However, scaling these new technologies and platforms to the last mile will not be a purely commercial endeavor. The sector is attracting growing and significant private capital, but less than two percent of the $36 billion in annual investment flowing into energy access is for off-grid solutions (SEforALL 2019). **Subsidies and public financing schemes must be adapted in fundamental ways to include off-grid systems, and likely maintained at similar aggregate levels as we've seen in the past on a per customer basis to reach the last mile**.

The ownership and management structure of the national grid varies country-to-country, but the basic formula for financing grid extension has remained the same for decades: governments use low-cost capital, either through their own resources or by mobilizing concessional debt and grants from development banks and donors, to extend transmission and distribution lines to remote populations, and then subsidize connections for customers. This is the same formula used by our case countries. This existing financial plumbing is well-tailored to support electrification program implementation through a single government-owned electric utility. However, decentralized technologies are largely private-sector driven, with some markets having high numbers of companies competing. Subsidies and public financing schemes must be adapted to the sector and done so with care to minimize market disruption and crowding out of private capital.

This is easier said than done. The politics of using public dollars to fund private electricity businesses can be difficult in many places where electricity is viewed as a public good or where deep skepticism of the private sector may exist. To further complicate matters, off-grid providers use different platforms, which deliver different levels of electricity service. The desire to avoid picking winners among competing private models may lead to reluctance among governments to supply public funding. Matching the level of energy service needed to support certain productive uses or sector-specific applications adds an additional level of complexity to both financing programs and the energy planning process. But these are all solvable problems.

The large-scale subsidization needed to mainstream off-grid solutions has been largely absent, but that appears to be changing. The World Bank and the Nigerian government, for example, have committed $765 million in funding to support, among other things, the build-out of solar microgrids and standalone solar systems, aiming to provide electricity to 2.5 million people and 70,000 businesses (World Bank 2018). The U.S. Millennium Challenge Corporation is partnering with the government of Benin to provide $32 million in grant funding through a competitive facility that will fund household solar systems, microgrids, and energy efficiency measures (MCC 2018). Many other programs are emerging.

Results-based financing (RBF) schemes are increasingly popular as an incentive that provides certainty to project developers investing private capital. These policies provide a payment to off-grid providers per connection delivered (or when other goals are met), helping to close the affordability gap and incentivize private enterprises to expand into the last-mile regions. For mini-grids, that subsidy could represent approximately $400-$900 per connection (ESMAP 2019), in line with the connection subsidy levels seen in the seven case countries, or significantly less in some cases. The Nigerian program is seeing mini-grid deployments at a subsidy level of $350 per connection. RBF programs that can be deployed across markets—rather than narrow, country-specific programs—could also help to reduce bureaucracy, lower total costs, drive healthy competition, and accelerate electrification. The Rockefeller Foundation, Shell Foundation, Sustainable Energy for All and others have led the creation of the Universal Energy Facility, which aims to fill this roll (SEforALL 2020).

Whether RBF schemes, auction-type competitive procurements, or regional programs are utilized to support the large-scale deployment of off-grid solutions, robust subsidies and public financing will be a lynchpin for reaching last-mile customers, just as they have in the past.

# APPENDIX: CASE COUNTRY SUMMARIES

## *Case Country: Chile*

### Focus Time Period: 1992–1999

Chile offers a case study of a middle-income country focusing on last-mile connectivity in the wake of major policy reforms and privatization (Pollitt 2004). At the time, GDP per capita was $4,716, relatively high compared to our other case studies. The 1982 Electricity Act of Chile led to the unbundling and privatization of the state-owned electricity sector, making it one of the first countries to enact comprehensive electricity reform. In the 1990s, the government initiated the Programa de Electrificación Rural (PER) which offered capital subsidies to electrification projects to incentivize private investment. During the period between 1992 and 1999, the rural electrification rate rose from 70 percent to 87 percent as over 120,000 households were newly connected, almost entirely through privately-owned distribution companies (Barnes 2005, 234–235).

### Programs

The main electrification initiative during this period, the PER program, ran from 1994–2004. In order to get private utilities to invest in electrification, the program sought a novel way to allocate subsidies. Communities and distribution companies would propose electrification projects that were then evaluated by a regional planning agency for their social and financial costs and benefits. Those projects that had positive net social benefits but negative private financial returns could apply for competitively awarded subsidies that ensured a 10 percent rate of return for the company (Jadresic 2000a, Jadresic 2000b). By the time Chile was admitted to the OECD in 2010, more than 99 percent of the population had access, including 96 percent of rural households.

### Costs

From 1992–1999, the total cost of investment was $378 million ($(1995)211 million), $219 million ($(1995)133 million) of which was provided by Chile's National Development Fund (FNDR) (Barnes 2005, 234–5). Cost per connection ranged from $2,442–$3,789 per household, approximately 70 percent of which was subsidized by FNDR (Barnes 2005, 237). The remainder of those costs was taken on by the private utility companies, municipalities and customers.

### Key Results

- Last-mile connections to the final 5–10% of the population cost this middle-income nation more than $2,900 per connection.
- Consistent and transparent policy facilitated healthy competition for federal electrification funding, with private utilities working in partnership with municipalities to develop effective projects.
- Systems for allocating public funds allowed for subsidization of privately owned power systems with reasonable rates of return.

## *Case Country: Lao People's Democratic Republic*

### Focus Time Period: 1990–1999

Laos is an example of a country with low average household incomes and a population that is spread out across a mountainous geography. During this time period, Laos made great progress on electrification through blending an array of diverse programs and channeling profits from hydropower exports to finance electrification. The government managed to balance keeping connection fees low with strengthening the financial health of its national utility, Electricité du Laos (World Bank 2012b, 15).

The government recognized from the start that state subsidies would be required to ensure that retail tariffs and connection fees would be affordable for poorer segments of the population, especially as the grid expanded into more rural areas with lower incomes. Rural electrification was financed through a mix of the profits from state-owned hydropower exports and large concessional loans from multilateral development banks. From 1987–2009 approximately $660 million ($(2012)600 million) was invested in Laos' rural electrification programs (World Bank 2012b, 15). From 1990–1999 seven programs were running simultaneously, expanding rural electrification rates from less than 1 percent in 1990 to over 25 percent in 1999. This was at a time when the average GDP per capita was only $291.43.

### Programs

During this period, seven programs were expanding electricity access: Nam Ngum-Luang Prabang Power Transmission Project (ADB), the Power Transmission and Distribution Project (ADB), the Northern Area Rural Power Distribution Project (ADB), the Southern Providence Electrification Project (WB), the Provincial Grid Integration Project (WB), the Southern Project Rural Electrification Project (WB), the Rural Electrification Project I (WB) and the national LAO PDR program (World Bank 2012b, 35).

Laos focused its rural electrification strategy around broad-based development impact. The electrification planning process considered the financial and economic viability of power sector investments, so it looked for village clusters that were close to roads and had a high density of households. The suite of programs also aimed to maximize social impact by prioritizing villages with clinics, schools, and temples, as well as potential productive power loads like irrigation, sawmills, rice mills, and other small industries. (World Bank 2012b, 10).

### Costs

Between 1990 and 1999, the Asian Development Bank and the World Bank injected over $495 million ($(2012)450 million) into electrification programs in Laos (World Bank 2012b, Appendix E). The scale and scope of those projects has led to varied costs per connection, from as low as $836 (Southern Province Rural Electrification Project, 1998–2004) to $4,567 (Nam Ngum-Luang Prabang Power Transmission Project, 1989–1998). Customers paid an average of approximately $87 across all the programs to get connected, although only the Rural Electrification Project II and the ongoing Lao PDR grid expansion project expected customers to pay for a portion of the connection cost. In the case of the Rural Electrification Project II, those costs were relatively small ($25) and were funded by local communities in some instances. The ongoing Laos PDR grid expansion program, the largest of the different initiatives, required customers to contribute for connection and house wiring. However, only costs from later iterations of the program are available, which suggest that consumers paid approximately $117 per connection.

## Key Results

- Engaging with major multilateral and bilateral lenders at the outset of the process, and fostering productive partnerships through an open exchange gave the country access to extensive capital (World Bank 2012b).
- The electrification strategy aimed for positive social impacts and broader development improvements, and so it prioritized productive uses and public facilities like schools, health clinics, and temples.

## *Case Country: Peru*

### Focus Time Period: 1993–2003

Peru aggressively expanded access in the 1990s while simultaneously privatizing its electricity sector. Over the course of a decade, Peru's rural electrification rate jumped from 2 percent to 30 percent (World Bank 2006, Feron and Cordero 2018). This jump occurred after the power sector reforms of 1992 unbundled the vertically integrated state utility into its generation, transmission and distribution components, creating private concessions for each sector and an independent regulator (ESMAP 2012). As private utilities entered the sector, however, there was less incentive for the utility to expand electrification in poorer and harder to reach areas, so the Government of Peru stepped into a larger role in rural electrification (Haanyika 2005; World Bank 2006, 1).

### Programs

In 1993, the Government of Peru initiated its Rural Electrification Plan along with the formation of an organization tasked with overseeing implementation of the projects at the core of the Rural Electrification Plan. The electrification program was financed primarily through the Social Development and Compensation Fund. The program was part of a broader social mandate, which emphasized social benefits over community willingness-to-pay and private sector investment (World Bank 2006, 1).

Rural electrification proposals were based on technical criteria (project design status, existing electricity infrastructure, and provincial electrification index), economic criteria (economic net present value, required investment per capita), and social criteria (poverty index, geographic location) (Dasso and Fernandez 2015). It was only after this period that new laws were introduced to invite private sector participation and greater decentralization for rural electrification (World Bank 2006, 1).

### Costs

The cost per connection at this time was initially an average of $690 but reached a high of $1,739. During this period, new connections were averaging at 64,000 per year (Peru Ministry of Energy and Mines 2004, 52). Customers were not required to pay a connection fee.

## Key Results

- In the wake of energy sector reforms and large-scale privatization, Peru opted to centralize rural electrification policy and implementation within the government to ensure rural and low-income populations were served.
- Rural electrification proposals were selected, prioritized, and funded by the central government.
- Social criteria of electrification projects, although considered alongside economic and technical criteria, were weighted more highly.
- The government footed the full cost of rural electrification and households were not required to pay a connection fee.

## *Case Country: South Africa*

### Focus Time Period: 2001–2008

Post-apartheid, a key objective of South Africa's infrastructure policies has been to eradicate historical inequalities based on race (Niez 2010, 81). In 1996, 97 percent of rural white households were electrified, as opposed to only 25 percent of rural black households (Marquard et al. 2007, 7). At the beginning of our focus period, the government had just recommitted to a universal electricity plan while also enacting reforms toward the unbundling of the power sector, which influenced the role that Eskom, the public utility, would play in rural electrification (Niez 2010, 83; Marquard et al. 2007, 20).

### Programs

The Integrated National Electrification Program (INEP) was planned to run from 1994–2012. In the first phase, the National Energy Regulator oversaw rural electrification with a central role for Eskom in implementation (Niez 2010, 83–84). In 2001, Eskom took on the structure of a government-owned corporation in anticipation of power sector reform. The impact was that Eskom, now a tax-paying entity with increased shareholder obligations, was less willing to finance the program (Marquard et al. 2007, 20). As was the case in Peru, the central government stepped in to fund the full cost of connections under the INEP and oversight of rural electrification shifted to the Department of Energy (Bekker et al 2008).

With the most cost-effective connections already achieved, additions became slower and more expensive (Eskom 2019). However, the off-grid component of the INEP picked up in this period, from zero off-grid connections at the beginning of the program to 84,000 in 2007–2008 (Niez 2010, 88). Off grid solutions would be provided where the expanding the grid either cost significantly more than average or where the grid would not reach within three years. These were expected to be temporary solar home systems, and that the grid would reach these customers eventually (Niez 2010, 88–91).

### Costs

Between 2001 and 2008, the average cost per connection was $694, ranging from a low of $476 to a high of $1,872 per connection. Cost varied significantly by geography, primarily due to differing infrastructure needs. The cost for the off-grid program was on average approximately 10 percent of the cost per grid connection, although the level of access was considerably lower (Niez 2010, 88). Throughout this period, the Government of South Africa covered 100 percent of the cost of connecting rural customers.

### Key Results

- South Africa's apartheid experience created a gross disparity in electricity access heading into the 1990s, and so themes of social equity largely drove the conversation around electricity access.
- Eskom's corporatization reduced its appetite to fund loss-making rural electrification efforts. The Government of South Africa stepped in to subsidize the full cost of rural electricity connections.
- Off-grid connections were approximately 10% the cost of grid connections on average, although levels of access were lower and they were intended as temporary measures.

## *Case Country: Tunisia*

### Focus Time Period: 1987–2001

Tunisia created an innovative approach to financing that leveraged what consumers could pay, contributing to Tunisia's low connection subsidy rate. Rural electrification became a priority for the Government of Tunisia with the introduction of its five-year plan in 1972, which emphasized education, health, and rural electrification. Electricity access became a fundamental part of Tunisia's social equality agenda (Cecelski et al. 2005, 9). Beginning in 1987, large scale financing from the African Development Bank, Kuwait Fund, the French Development Agency, and other international sources accelerated electrification efforts, leading to an increase in rural access from 48 percent in 1987 to 93 percent in 2001 (Cecelski et al. 2005, 6; World Bank 2019a).

### Programs

This period covers Tunisia's VII, VIII, and IX Five-Year Plans. These plans largely expanded electricity access via the grid, though an off-grid solar program was also included in the VIII and IX Five-Year Plans. Illustrating the commitment to providing at least minimal levels of electricity service to even its most remote rural households, the National Agency for Renewable Energy targeted 70,000 households and other community buildings that could not be readily connected to the grid through off-grid solar. The program provided solar panels with a minimum power of 100 watts, batteries, a charge/discharge regulator, three fluorescent light bulbs, a radio, and a television outlet (Cecelski et al. 2005, 53).

The electrification approach balanced the financial sustainability of the utility with broader rural development objectives. Although customers were expected to pay a significant portion of their connection cost, payments were spread out over three years, allowing poorer customers pay in smaller increments. Close coordination with regional government focused on integrating electrification with key public-service provision like schools, clinics, roads, and public lighting systems. Low-consuming households and agricultural consumers also benefited from tariff rate subsidies (Cecelski et al. 2005, 2).

### Costs

From 1987–2001, $610 million (TD$(2001)369 million) was invested in the rural electrification program, which connected 429,000 new customers. Costs per connection ranged from $1,260 to $1,920. For grid-connection projects, customers were expected to pay $370 (TD$(2001)200), which could be spread out as 36 bimonthly payments, with the aim of lowering the financial barrier to connection for households. The Tunisian state-owned utility financed an additional $370 (TD$(2001)200) per connection. Where connections were greater than $740 (TD$(2001)400), the central government subsidized the remaining balance, so that the utility never paid more than $370 (TD$(2001)) per connection.

For the off-grid solar program, beneficiaries paid $185 (TD$(2001)100), regional government funds covered $370 (TD$(2001)200) and the remaining $2,960 (TD$(2001)1,600) of the costs per connection were funded by the central government (Cecelski et al., 2004, 31–32). During this period, around 8,000 households, 200 schools, and some clinics and border posts received off-grid solar PV connections at an average connection cost of $3,510 (TD$(2001)1,900) per connection. This falls within the range for the cost of grid-connections, which was $2,770–$4,065 (TD$(2001)1,500–2,200). (Cecelski et al. 2004, 4). The utility also contributed $460 (TD$(2001)250) to connect agricultural pumps, which encouraged the productive use of electricity (Cecelski et al. 2004, 20–21).

## Key Results

- Investments from multilateral and bilateral banks enabled the Government of Tunisia to support scaled-up electrification efforts beginning in 1987.
- Balance between state, utility, and beneficiary financing supported rapid growth in access without undermining the viability of the public utility. Consumer financing for the household share of connection costs increased willingness to connect.
- Cross-sector planning, a strong social mandate, incorporation of off-grid systems, and complementary subsidies for agricultural pumping provided by the utility enabled an integrated electrification approach that supported broader growth in rural regions.
- Even in the 1990s, stand-alone off-grid solar systems provided connections that were cost competitive with the grid, although capacity and quality may have differed.

## *Case Country: Thailand*

### Focus Time Period: 1977–1986

At the beginning of the National Plan for Accelerated Rural Electrification (ARE), Thailand's rural electrification rate was 20 percent. By the end of the first ten years, it had jumped to 65 percent. The Provincial Electricity Authority (PEA) was in charge of rural electrification, operating and managing the distribution network in rural areas as well municipal regions out in the provinces. Managing a consumer base that incorporated higher-consuming, wealthier municipalities allowed PEA to more easily recover the costs of developing the rural distribution network. PEA also received power at a steep discount from the generating authority, which allowed it to charge lower rates to rural residential consumers (Shrestha et al. 2004, 42).

### Programs

In 1977, the Thailand PEA initiated the 25-year ARE. At that time, the PEA also established the Office of Rural Electrification, which focused on village-level distribution networks (Shrestha et al. 2004). Village electrification was prioritized based on projected demand, proximity to the grid, and income.

### Costs

During the first ten years of the ARE program the cost per connection ranged between $425 and $497 (Barnes 2005, ESMAP 1985). Customers paid an average of $93 per household connection. At the distribution level, if villages were willing to pay at least 30 percent of the grid extension and interconnection costs, the village's electrification would be prioritized. Villages willing to pay more than that share of the interconnection cost would move up the priority list (Shrestha et al. 2004, 43).

## Key Results

- A major component of the ARE's success was the availability of domestic financing and multilateral donors.
- Electricity rates for rural customers were subsidized by urban customers, and residential consumer rates more generally were subsidized by commercial and industrial customers, which improved residential and rural affordability.
- Thailand was able to lower federal government expenditures for rural electrification by prioritizing village interconnection to the grid based on factors like projected demand, proximity to the grid, and income, and by leveraging villages' willingness and ability to pay more for earlier access.

## *Case Country: Brazil*

### Focus Time Period: 2000–2008

Brazil began their universal electrification push in the early 2000s, having already reached a 75 percent rural electrification rate, but lagging behind in the less populous northeastern and northwestern regions (Slough, Urpelainen, and Yang 2015). The Brazilian constitution guarantees that the government will supply the basic needs of the people, including electricity, and so beginning in 2003 there was increased political pressure to ensure that even remote Amazonian regions were electrified (Zerriffi 2008; ESMAP 2005, 1).

In 1996, Brazil began the reform of its power sector, inviting private participation in the distribution sector through private concessions. The majority of current utilities are private companies (ESMAP 2015). The federal government, municipal governments, and utilities all played a part in financing the grid expansion (and limited off-grid provision) of the electrification programs.

### Programs

Between 2000 and 2003, approximately 600,000 new users were connected to the grid through the Luz no Campo (LnC) program, which focused on household electrification, unlike the previous program, PRODEEM, which was primarily interested in community buildings (ESMAP 2005). The execution of LnC was the responsibility of regional distribution companies, and their work was subsidized by low-interest loans from the central government (ESMAP 2005, 3). The next program, Luz para Todos (LpT) (2003–2010), placed priority on economically depressed areas and those connections that would service agriculture or other productive uses (Slough, Urpelainen, and Yang 2015). Both of these programs focused on grid extension, although the design of the later LpT program did allow for limited decentralized generation (Slough, Urpelainen, and Yang 2015).

### Costs

During 2000–2003, the average cost per connection was approximately $1,235 (ESMAP 2005, 34). In that period, Law 10604 offered subsidies to low income customers, financed by revenues from the auction of publicly generated electricity into the new power sector market. The reliance on auctions introduced significant uncertainty to this financing (ESMAP 2005, 60). The larger LpT program added over 1.8 million connections at a cost of over $8.2 billion ($(2009)7 billion), with each connection costing $4,362 (Niez 2010, 25–27). The initiative was funded primarily through federal and municipal funds, with 14 percent officially paid for by the utilities (IEA 2017b). However, the federal government subsidized the vast majority of that utility share in regions with the lowest initial rates of electrification (IEA 2017b).

Once connected, Brazil's tariff is structured so that residential and commercial users cross-subsidize rural residential customers, public lighting and low-income customers through a "social tariff" that benefits all customers using fewer than 80 kWh per month (Niez 2010, 27, 31–32).

### Key Results

- Brazilian policy made private utilities responsible for universal electrification, but leveraged generous federal funds to reach rural customers, reinforced by the constitution's claim that electricity access is a right.
- Brazil's social tariff provides reduced electricity rates to all low-consumption customers and is cross- subsidized by higher consuming residential and commercial customers.
- The speed of connections, extreme remote areas, and a lack of consumer connection fee have been cited as reasons for the Brazil's high last mile electrification costs (Slough, Urpelainen, and Yang 2015).

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**Applies to all:**

U.S. Bureau of Labor Statistics 2018; U.S. Department of the Treasury 2018; World Bank 2019a;

World Bank 2019b; World Bank 2019c

**Brazil:**

*For 1999–2003*: (ESMAP 2005, 34)

*For 2003–2008*: (Niez 2010, 25, 27)

*For subsidy amount*: (ESMAP 2005, 3, 8–9, 34); (IEA 2017b); (Brazil Ministry of Mines and Energy 2007, 1); (Brazil Ministry of Mines and Energy 2019)

**Chile:**

*For 1992–1999*: (Barnes 2005, 237)

*For subsidy amount*: (Jadresic 2000a, 81); (Jadresic 2000b, 4); (Barnes 2005, 235)

**Laos:**

*For 1989–2012*: (World Bank 2012b, 35)

*For 2012–2015*: (World Bank 2015, 13)

**Peru:**

*For 1993–2003*: (Peru Ministry of Energy and Mines 2004, 7)

*For 2004–2013*: (World Bank 2006, 65)

*For subsidy amount*: (World Bank 2006, 25, 65)

**South Africa:**

*For 1994–2003*: (Marquard et al. 2007, 28, 31-32)

*For 2004–2013*: (Niez 2010, 88)

*For subsidy amount*: (Prasad 2012)

**Thailand:**

*For 1977–1996*: (Barnes 2005, 116); (ESMAP 1985, 77)

*For subsidy amount*: (Barnes 2005, 123–24)

**Tunisia:**

*For 1977–2001*: (Cecelski et al. 2005, 6-7)

*For subsidy amount*: (Cecelski et al. 2004, 20–21); (Cecelski et al. 2005, 34)

Rate of Electrification over Years of Interest:

*For all countries, except Thailand*: (World Bank 2019a)

*For Thailand*: (Shrestha et al. 2004, 44)

Comparison During Years of Interest:

*For all countries:* (World Bank 2019b), (World Bank 2019c)

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