



Getting Electricity

Understanding the benefits of wiring regulation

An extensive fire broke out in one of Bamako's largest markets, the Marché Rose, in December 2017. Business owners watched as their investments were destroyed.¹ After the fire was extinguished, the extent of the damage was clear—hundreds of stalls had been burnt down at a cost of more than 1 billion CFA francs (approximately \$1.7 million), most of which was shouldered by small firms. An investigation by the utility later found that faulty installation of electrical wiring caused the fire.

Such incidents act as a reminder that electricity is inherently hazardous. However, electrification is crucial for economic development—its impact on education, labor and income is well documented. Household electrification is estimated to result in an average rise of around 7% in school enrollment, 25% in employment and 30% in income.² Where electricity services are deficient, firm performance is negatively impacted. World Bank Enterprise Survey data for 2017 indicate that business owners in developing economies perceive a lack of reliable electricity supply as the biggest obstacle to the operation of their businesses, behind only access to finance, the informal sector and political instability.³

There are myriad supply-side impediments to gaining access to electricity. A complicated connection process, for example, can make obtaining a new electricity connection difficult for a newly-incorporated startup.⁴ Furthermore, once connected to the grid, firms may face blackouts that force them to halt production⁵ or hikes in electricity tariffs that undermine their productivity.⁶

Safety is often absent from the discussion on access to electricity. Faulty wiring can cause direct harm or indirect injury due to fires or explosions. To adequately mitigate safety risks, electricians must be well qualified. However, without a proper accreditation system, asymmetry of information arises—the seller of a good (or service, in this case), has greater knowledge than the buyer.⁷ The public is unable to differentiate a good electrician from a bad one. Regulation is also necessary to offset negative market externalities that arise when a firm is not liable for the full cost of an economic decision.⁸ Ultimately, the hiring decision will vary depending on the perspective of the consumer—one individual may be willing to hire an unqualified professional while the neighboring community may not (as it would bear the full cost associated with faulty wiring in the case of a fire).

THE HUMAN AND ECONOMIC COST OF FAULTY WIRING

Between 2011 and 2015, fire departments in the United States responded to

- A robust regulatory framework governing the electricity sector and accrediting the electrician profession protects public safety by helping the market overcome asymmetry of information and moral hazards.
- *Doing Business* data show that approximately three-quarters of economies have an electrical code or regulation setting forth standards for electrical installations.
- Requirements for qualifications and skill development in the electrical profession can prevent electrical system failure incidents. Barely two-thirds of the economies covered by *Doing Business* require electricians to have accreditations guaranteeing their qualifications to carry out a building's internal wiring.
- Mandatory inspections and liability regimes introduce accountability vis-à-vis the party undertaking the internal wiring works of a building. Inspections can be carried out by utilities, certified electrical engineers or third-party inspection bodies. Such inspections are required in about 70% of economies.
- *Doing Business* data indicate that effective regulatory regimes that protect the public from electrical system failure incidents also tend to have an efficient grid connection process.



nearly 200,000 fires at manufacturing or industrial properties. These fires caused the largest share of civilian deaths and direct property damage, averaging \$1.2 billion annually.⁹ Most industrial property fires are the result of incidents associated with “electrical distribution and lighting equipment” (figure 4.1). The types of equipment most typically involved in a fire’s ignition are the wiring installation or transformer and power supply. Moreover, the leading cause of ignition is electrical failure (for example, a short circuit or an arc from a broken conductor).

Deadly fires involving electrical failure are common, particularly in developing economies. In South Africa, for example, electrical fires accounted for 80% of the economic loss caused by the 46,000 fires that were attended to in 2015.¹⁰ Improper equipment often causes such fires. In 2012, a fire destroyed a shoe factory in Lahore; investigators later confirmed that a faulty electrical generator was to blame. Incorrect wiring installation is another major cause of electrical fires. Peru’s National Institute of Quality (INACAL) has reported that the main causes of fires in that country

are (i) electricians not conforming with wiring codes and standards, and (ii) non-certified electrical engineers performing wiring installation and connection works. Unsurprisingly, data indicate that seven of every 10 fires in urban areas in Peru are the result of defective electricity installations, such as faulty wiring or equipment that does not comply with the norms of the National Electric Code and Norm NTP 370.304 Electrical Installations of Buildings.¹¹

ENSURING SAFE ACCESS TO ELECTRICITY MAKES ECONOMIC SENSE

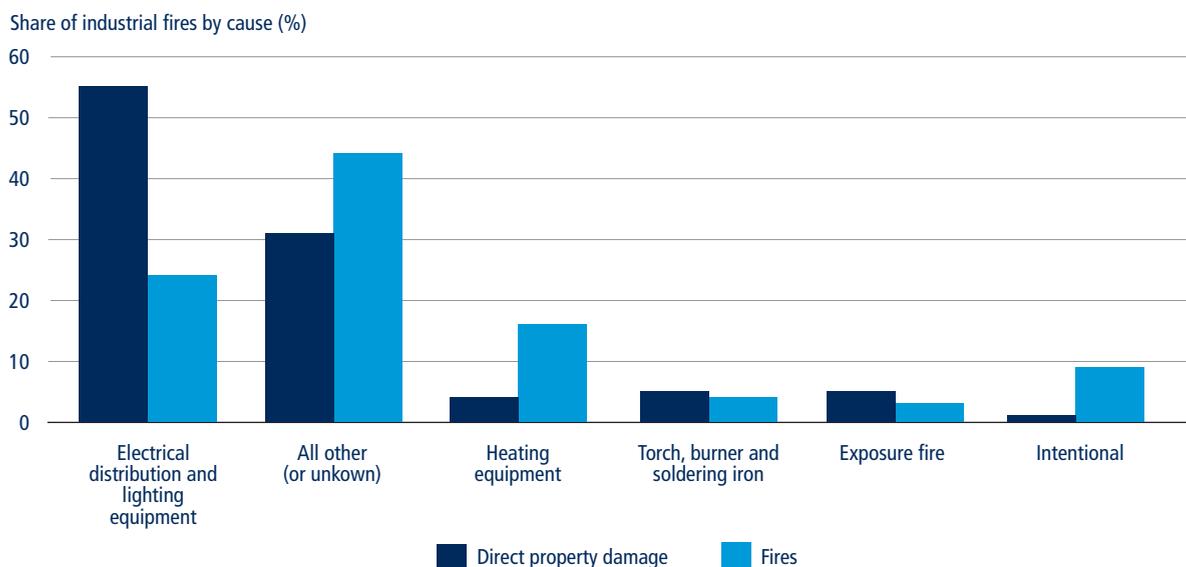
The risks associated with electrical failures undermine firms. At the same time, access to the electrical grid is a key driver of firm production. A casual relationship has been established between electricity consumption and economic growth in India, Indonesia, the Philippines and Thailand.¹² Across Sub-Saharan Africa, it is estimated that the economic growth drag of a weak power infrastructure is about 2 percentage points annually.¹³ In Nigeria, increases in

energy consumption have been found to spur economic expansion.¹⁴

Small and medium-size enterprises (SMEs) are especially dependent on grid access as they often lack the resources to rely on captive power solutions. Doe and Asamoah (2014) find that without reliable energy supply, SMEs in Ghana struggle to boost output, resulting in low profitability.¹⁵ Similarly, research on electricity provision in India shows that the expansion of the electricity network boosts industrial development and increases the performance of smaller firms.¹⁶

Given the importance of electricity, managing the risks associated with its use is imperative. The lack of professional certification requirements and quality controls that characterize an inadequately regulated electricity sector reinforce the asymmetry of information individuals face when assessing the qualifications of electricians and engineers. Analogous to Akerlof’s “lemons problem,”¹⁷ unqualified electricians may drive their qualified counterparts out of the market since the latter group will

FIGURE 4.1 Electrical failure is the leading cause of industrial property fires in the United States



Sources: Campbell 2018; National Fire Protection Association.
Note: Data are annual averages for the period 2011–15.

be reluctant to lower their prices if they cannot make a return on their educational investment. In turn, the quality of electrician services will suffer.

Furthermore, in the event that a wiring defect causes a fire, the societal costs can extend beyond the private parties onto neighboring communities. Because private companies do not assume all damages, their decisions may stand in contrast to societal interests. In short, if the electricity market is unregulated, the hiring party may find it economically justifiable to use an unqualified electrician rather than a well-qualified (but more expensive) technician.

A robust regulatory framework governing the electricity sector is necessary to maintain public safety. Regulation must be transparent and cover a broad range of areas. Examples of good practice in electricity sector regulation are highlighted below, as are key findings from a *Doing Business* cross-economy comparison of electrical wiring safety provisions.

CLEAR REGULATION: THE FIRST STEP TOWARD ENSURING PUBLIC SAFETY

A regulatory foundation establishes qualification requirements and electrical installation norms. In nearly all economies private contractors carry out the internal wiring *within* buildings. And in about one-half of the economies covered by *Doing Business*, private firms undertake the connection works *outside* the building, from the switchboard to the network. It is, therefore, important that commercial interests not be placed ahead of public safety.

Regulation should provide clear rules on (i) norming electrotechnical equipment, (ii) stipulating professional requirements in relation to electricians and installers, and (iii) establishing an inspection regime to ensure wiring works are up to code. *Doing Business* data show that,

When electricians are certified and licensed, the public has proof of their professional qualification and an informed hiring decision can be made.

across 190 economies, approximately three-quarters of economies have an electricity code or comprehensive legislative text that covers some or all of these areas. Having clear regulation in place establishes a foundation for regulating the electrical profession. The National Electric Code of Barbados, for example, sets forth requirements for professional qualifications to carry out electrical wiring, conditions for inspections of electrical wiring and prerequisites for the professional qualifications necessary to inspect electrical wiring.

Independent regulatory agencies contribute to the design of regulation governing electrical installation safety in good practice economies. An independent regulator can ensure clarity and transparency and form the basis of a system that encourages accountability.¹⁸ In South Africa, for example, the statutory Bureau of Standards (SABS) has an explicit mandate to promote quality in products and services in several sectors, including engineering certifications and electrical appliances.

Common standards and rules encourage shared manufacturing facilities across economies.¹⁹ It is indeed easier for private firms to operate beyond their borders in economies where regulation is similar. The European Committee for Electrotechnical Standardization (CENELEC) has strengthened regulatory coherence by aligning the electrical installation standards of the members of the European Union through standard HD 384 on Electrical Installations of Buildings. These standards provide clear guidelines on electrical installations for new buildings. Similarly, the African Electrotechnical Standardization Commission (AFSEC), established in 2008, promotes the harmonization of

standards across Africa and aims to incorporate international good practices. It currently has 11 statutory members.

Communication is just as important as regulation—market players must be informed of the rules. A first step, therefore, is to make the laws that stipulate the required professional qualifications for electricians—as well as norms on electrical equipment and installation—available to the public. In most economies, electricity codes and regulations are not publicly available online and only half of economies measured by *Doing Business* provide a list of steps online which customers must complete to obtain a new connection.

In the event of a legislative change to electricity sector regulation, market participants—including employees of the distribution utility and private contractors—must be informed swiftly. While modes of communicating such changes vary from one economy to another, two-thirds of distribution utilities report organizing training workshops for engineers, technicians and inspectors involved in the connection process when a change in regulation occurs. The majority of economies, however, do not provide public funds for such programs.

ENSURING ELECTRICIANS HAVE THE RIGHT SKILLS

When electricians are certified and licensed, the public has proof of their professional qualification and an informed hiring decision can be made. Certification and licensing mechanisms can incentivize qualified professionals to offer their services, as their credential will allow them to stand out from their uncertified counterparts.

Proof of professional experience and education is commonly required for professionals to carry out electrical installation works. Different approaches exist across economies, however, with regards to licensing. Licenses can be issued by a dedicated public authority—for example, the Electrical and Mechanical Services Department in Jamaica—or the national regulatory body, as in the case of Uganda’s Electricity Regulatory Authority. Other economies rely on professional organizations or academic institutions to issue licenses. In Pakistan, electricians performing internal installations are required to be a member of the board of engineers, a professional body that regulates the engineering profession. In the Dominican Republic, licenses are issued by the Colegio Dominicano de Ingenieros Arquitectos y Agrimensores (CODIA, a national engineering association). In other economies, including Brunei Darussalam and Singapore, the utility is responsible for issuing certifications. Such cases are usually confined to smaller economies where the utility is vertically integrated and has broad national coverage.

The requirements to be certified as an electrician also vary widely across economies. In Malaysia, to carry out internal wiring works, one must be registered as a professional engineer and have at least three years of professional experience, have successfully completed the required courses as determined by the Board of Engineers Malaysia and have either undergone a professional assessment examination or be a member of the Institution of Engineers Malaysia.²⁰ In Germany, electrical contractors require a certification which they can only obtain through an *Ausbildung*, a program that combines an apprenticeship and education. While most economies measured by *Doing Business* mandate a minimum level of education to undertake internal wiring installations, about 30% of economies have no requirements at all—and many

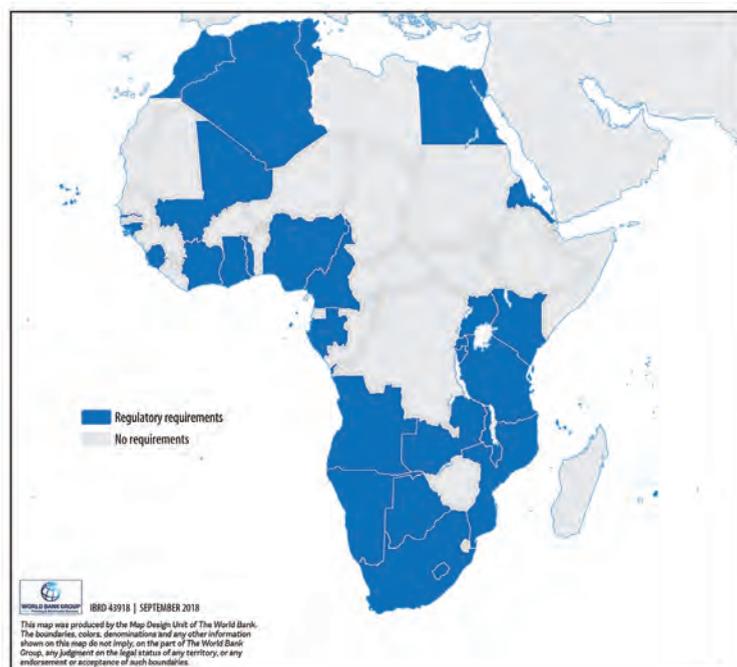
of these economies are in Sub-Saharan Africa (figure 4.2).

While entry into the electrical trade requires regulation, emphasis should also be placed on continuing participation. Many electricians are self-employed and are not associated with a professional body at the time they receive their trade license. As such, keeping them up to date on new regulation or technological changes can be challenging. Most companies lack the financial resources to offer formal training to their employees. In some economies, therefore, the onus is put on electricians to remain active to retain their license.

Hong Kong SAR, China, offers an extensive professional training program—the Continuing Professional Development (CPD) Scheme—in which all Registered

Electrical Workers (REWs) must participate to renew their registration. The training consists of two modules: (i) statutory requirements in electricity ordinance, wiring regulations and safety protocols; and (ii) dissemination of information on the design, maintenance and testing of electrical installations. The CPD Scheme requires REWs to complete the training, which is provided by various organizations and agencies, within the three years prior to the expiration of their registration.²¹ Similarly, in the United States, all licensed professional engineers in the state of California are required to obtain 32 hours of continuing education at an approved trainee school—or any federate or state apprenticeship program—every three years prior to the renewal of their license. Elsewhere, the private sector has taken an active role in organizing training programs to improve the qualifications of all construction professionals. The Korea

FIGURE 4.2 Many African economies lack professional norms to undertake internal wire works



Source: *Doing Business* database.

Note: Economies in blue have an electricity code (or set of regulations) that sets forth the professional qualifications (education and professional experience, for example) required to legally carry out a building’s internal wiring installation. Economies in grey have no such requirements.

Electric Association, for example, which is comprised of corporations that are engaged in electricity-related businesses, provides regular training programs taught by leading experts in the industry.

ENSURING THAT INTERNAL INSTALLATIONS ARE SAFE THROUGH MANDATED INSPECTIONS OR LIABILITY REGIMES

Regulatory compliance is as essential as the rules themselves. In 2009, a fire caused by ineffective grounding and aging cables destroyed the building of the Ministry of Foreign Affairs in Accra, Ghana. As is often the case in economies where there is a shortage of qualified engineers and a large informal sector, although regulation existed—Ghana’s National Wiring Code—it had not been observed. In Kenya, the informal sector, also known as *jua kali*, is extensively involved in the manufacturing sector. A study of electrical safety management in Kenya’s informal sector shows that most *jua kali* operators do not follow electrical safety regulations

and lack the appropriate equipment for electrical services.²²

Despite the information prescribed in electrical codes and other regulation, technical audits often reveal faults in design, installation and maintenance. Inspections provide an incentive to comply with regulation. Initial inspections—carried out before the facility becomes operational—can help identify and fix any nonconformity of the installation.²³ In economies where private sector electricians make the external connection to the network, nearly all require that the utility inspect the connection works ahead of the electricity turn-on. Similarly, in about 70% of economies covered by *Doing Business* inspections of a new building’s electrical wiring are compulsory.

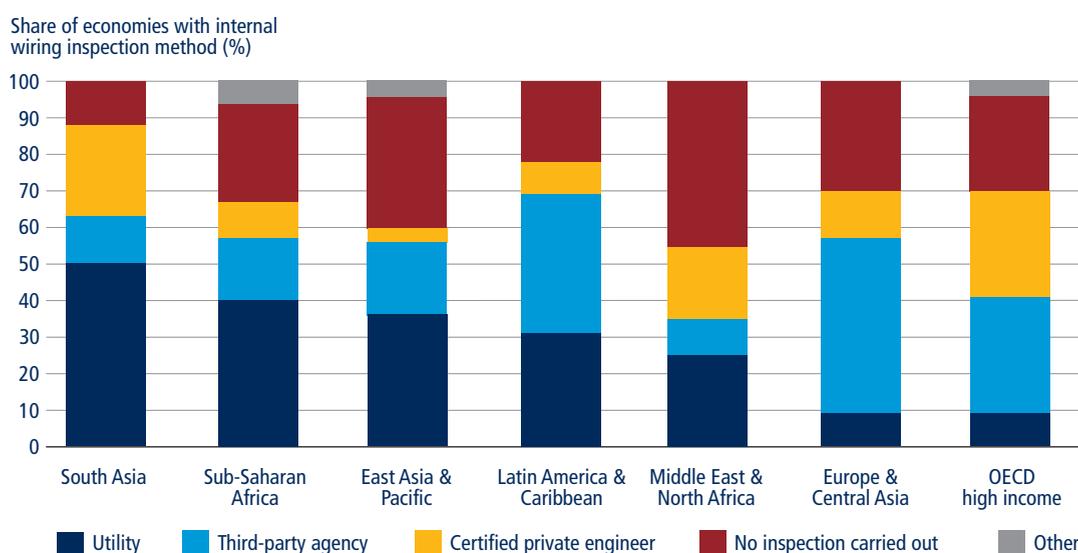
Inspections are typically carried out by the utility, a third-party agency or a certified electrical engineer (figure 4.3). Utilities perform this function in nearly 40% of economies where internal wiring inspections are required. In the United Arab Emirates, the Dubai Electricity and Water Authority (DEWA) checks the

internal wiring of the building to ensure compliance with the approved plans. Inspections approval is communicated internally within the utility, allowing DEWA to carry out the external electrical works immediately without the need for the customer to be present.

Third-party bodies carry out inspections in about one-third of economies with internal wiring inspection requirements. In Côte d’Ivoire, a public works institution, the Laboratoire du Bâtiment et des Travaux Publics (LBTP), is tasked with ensuring that all internal electrical installations comply with safety standards. To this end, an inspector examines various points on the installation—the grounding, the electrical panel, and so on. Clients can only apply for a new connection once the installation has been approved and a certificate of conformity has been issued.

In some economies, private certified electrical engineers provide internal wiring inspections. In Croatia, an internal wiring certificate must be submitted before the utility, Hrvatska Elektroprivreda (HEP), installs the meter. This certificate, which

FIGURE 4.3 Who conducts the inspection of the internal wiring installation prior to the electrification of a commercial building?



Source: *Doing Business* database.

proves that the electrical installation has been tested, can be prepared by the client's electrician, provided they have the required accreditation, or—in most cases—by a third-party firm if the electrician lacks the required accreditation. The utility issues a final connection approval once this documentation is deemed satisfactory.

Because the circumstances surrounding electrical failures vary significantly, blanket recommendations on internal wiring inspection schemes are unhelpful. Mandatory inspections may be advisable in economies with a history of faulty wiring incidents; however, a risk-based approach may be more applicable in economies where the electricity profession is well-regulated and qualification standards are enforced. Despite varied practices, one recommendation holds true across all economies: inspectors should receive adequate training and have relevant qualifications.

Beyond inspections, another way to ensure the safety of internal installations is to implement clear liability regimes, placing an added responsibility on electricians by holding them legally responsible when incidents occur. In the Philippines, for example, the Board of Electrical Engineers can suspend electrical engineers for unprofessional or dishonorable conduct. The law specifies the circumstances under which an electrical engineer can be suspended from professional practice (for example in the case of fraudulent documents). Also, in cases of wiring regulation violations, the law gives any person, firm or association the right to file charges resulting in the revocation of the electrical engineer's license.

The choice of whether to employ internal wiring inspections or liability regimes (or both) varies from economy to economy as it depends on myriad factors (such as existing regulation, the size of the informal sector or history of wiring incidents). In economies where the

electrician profession is well regulated, norms are respected and the informal sector is small, liability regimes may be sufficient to ensure public safety, provided there is an efficient court system to foster accountability. Internal wiring inspections for lower risk constructions may not be necessary, as is current practice in OECD high-income economies such as Germany and Sweden. These economies do not require internal wiring checks as all electricians (i) must undergo a rigorous professional certification process and (ii) are held legally responsible that the installations they carry out are up to code.

The reality in other economies, however, stands in stark contrast to that of the OECD high-income economies. Many economies lack the qualified professionals needed to impose strict qualification requirements, making the implementation of liability regimes more challenging. Even where the electrician profession is well regulated, unqualified professionals may still offer their services if the informal sector is large and law enforcement is weak. Many economies with these characteristics (rightfully) require that all internal wiring installations be inspected to avoid incidents.

REGULATION AND EFFICIENCY ARE NOT MUTUALLY EXCLUSIVE

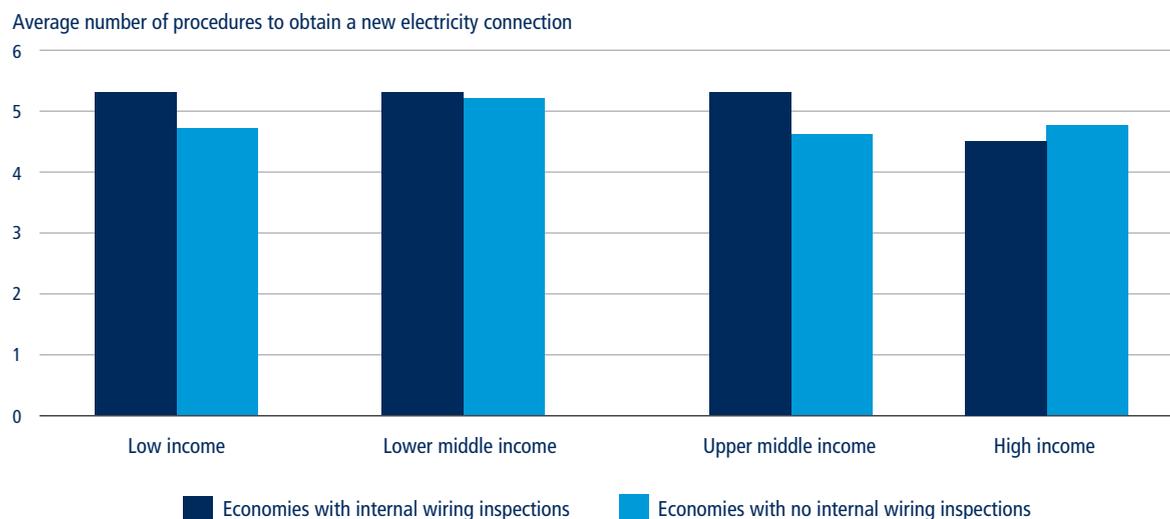
Electricity sector regulation is crucial. However, regulation should be designed to transfer the regulatory burden away from end-users. In Mauritania, the utility requires that all electrical materials bought on the private market—including the transformer—be checked by the utility before the private electrical contractor can build a sub-station; this adds time and interactions to the connection process. Alternatively, in Nigeria, materials must be purchased from accredited distributors, which sell transformers that already include a test certificate from the manufacturer.

Doing Business data reveal that economies that provide efficient grid connection services (as measured in terms of time or cost) also tend to have (i) clear legal standards stating the qualifications necessary to carry out the internal works and (ii) a requirement for an inspection of the internal installation. At the global level, those low-income economies that meet at least one of these two criteria connect businesses to the grid in about 25% less time on average. And across income groups, economies with an internal wiring inspection have, on average, lower connection times. “Smart” regulation does not need to come at the expense of an efficient connection process.

Dubai provides a good example of balancing efficiency and wiring compliance. To be certified by the Dubai Electricity and Water Authority (DEWA), practicing electrical engineers must pass the Municipality Exam for Electrical Installation. This requirement allows the utility to minimize the number of procedures needed to complete the process when the application is submitted without jeopardizing wiring safety standards. The internal wiring inspection is scheduled when the application to the utility is submitted through the utility's online portal by the customer's electrical contractor. Moreover, due to the standardization of internal wiring guidelines, the external connection works are commenced at the same time the inspection is carried out, with the results communicated internally within DEWA.

Doing Business data suggest that electricity services are in no way made worse where there is regulation that governs internal wiring inspections and qualifications. For example, there are fewer power outages, on average, in economies where an internal wiring inspection is necessary, which in turn may reduce the likelihood of faulty wiring defects. Moreover, across regions and income groups, there is no significant difference in the number of procedures—or even the connection time—in economies with internal wiring

FIGURE 4.4 The number of procedures to connect to the grid are similar across income groups whether an internal wiring inspection is required or not



Source: *Doing Business* database.

inspection requirements compared to those with none (figure 4.4).

CONCLUSION

Established standards for electrical materials, wiring installations and electricians are not only essential for public safety—they also make economic sense. Qualification requirements for professional electricians help individuals overcome the asymmetry of information they would otherwise face. Accreditation systems that focus on both experience and education are essential.

Aligning national norms with international standards can ensure regulatory coherence and facilitate the safe use of electricity. Regulation alone is not sufficient—compliance with the law is just as important. To this end, many economies have instituted inspection regimes for internal wiring installations. Other economies have put in place liability regimes so that the electricians carrying out the wiring installation are held accountable in the case of future incidents.

Doing Business data demonstrate that economies with efficient electrical connection processes tend to have clear legal standards and quality controls for new electrical connections. In other words, regulatory regimes that protect the public from electrical failure incidents also tend to deliver good services to businesses through an efficient grid connection process or a reliable network.

NOTES

This case study was written by Ahmad F. AlKhuzam, Jean Arlet, Viktoriya Ereshchenko and Silvia Carolina Lopez Rocha.

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