1. Introduction

INTRODUCTION

In 2010, the History and Heritage Committee of the American Society of Civil Engineers gathered in Las Vegas, Nevada to celebrate the 75th Anniversary of the Hoover Dam. In its time, the dam was the most ambitious infrastructure project in the United States and it ushered in an age of federal megaproject development. Among most engineers and historians, Hoover Dam was a resounding success. Despite enormous technical, physical and managerial challenges, the dam was completed two years ahead of schedule and within budget. By all measures, it was a model of megaproject management. Federal financing was secured through long-term power purchase agreements. Long before the dam was in operation, all the interested parties agreed to a plan to divide the revenue and benefits, including water and power products. During construction, the private contractor and the major governmental agency involved (the Federal Bureau of Reclamation) enjoyed a mutually constructive relationship.

Yet, despite this rosy assessment, a broader evaluation of Hoover Dam calls into question just how to define success in terms of projects so large and so significant. For example, while Hoover Dam was completed two years ahead of schedule, more than 100 men lost their lives speeding its construction. The Hoover Dam provides essential flood control along the Colorado River. But it does so by impeding the natural movement of water with Lake Mead, a 247 square mile human-made reservoir in the middle of the desert. Constructing this desert oasis may have seemed a colossal feat of human ingenuity in the 1930s. But, engineers overlooked that, with such a large surface area, the desert sun evaporates about 800,000 acre-feet of water from the lake each year. Since Lake Mead’s surface is now thousands of times larger than the Colorado River, approximately 350 billion gallons of extra water evaporates each year, more than the amount of water lost to flooding before the dam was built.

Now consider another mammoth megaproject: the Panama Canal. While there is only one canal, there are two stories regarding its construction. The first, the French effort led by Ferdinand DeLesseps, was considered a colossal failure. DeLesseps never properly surveyed the
existing construction conditions, never considered alternative routes, did not adequately investigate geological conditions or tidal controls, and failed to consider how the tropical climate would impact his labor force. As a result, torrential rains turned Panama’s clay into a thick sludge that bogged down construction machinery, while the tropical salt air set about rusting it. Malaria and Yellow Fever combined to kill as many as 20,000 European workers. After a decade of work, and cost overruns in the hundreds of millions of dollars, in 1892 DeLesseps was forced to admit defeat and liquidate what was left of the project’s assets. The failure was so scandalous and the press so vitriolic that the French government, which had backed DeLesseps, was replaced within the year.

The second story is of the U.S. takeover of the Canal project in 1903. Better engineering, more employment of local labor (which was naturally immune to many of the tropical diseases that felled the French) and considerably more adroit project management led to the first ship transiting the canal on 17 January 1914. While the Americans ultimately were successful in completing the canal, they too exceeded construction costs by more than double estimates. In fact, while the project was initially expected to require $144 million in labor and materials, by 1914 the U.S. had spent more than $302 million, a total project cost of $120 billion in 2006 dollars. It is hard to imagine a project—even the scale and importance of the Panama Canal—getting the green light today with such a gargantuan budget.

Nonetheless, despite the same kinds of massive costs overruns the French encountered, the U.S. effort was seen as an economic and humanitarian success. Not only had the Americans completed a daunting engineering challenge, they had managed to forever alter the course of trade between the Atlantic and the Pacific, reducing the cost of oil and other commodities, increasing the flow of goods between West and East, and providing a vital military conduit that would prove invaluable during the World Wars soon to come. Surreptitiously, the U.S. effort also expedited the development of anti-malarial drugs and sped new public health technology to regions of Central America desperately in need of it.

What the Hoover Dam and Panama Canal projects illustrate is the central ontological problem inherent in making normative assessments about megaprojects in general: what exactly constitutes project “success” and “failure”? And, perhaps more importantly, why do most megaprojects in the energy sector seem to “fail”? European scholars Bent Flyvbjerg, Nils Bruzelius, and Werner Rothengatter collected data from hundreds of major infrastructure projects around the world, and found that costs were
underestimated in a shocking 90 percent of them. Infrastructure analyst E.W. Merrow surveyed oil and gas energy megaprojects and calculated that costs rose on average by 46 percent more than estimated. Both assessments imply a sort of economic failure.

Indeed, the pages to come show that megaproject failure can take many forms. Perhaps the easiest type of failure to identify is internal or process oriented, such as a megaproject failing to meet its own benchmarks, construction deadlines, or budget targets. Perhaps planners and advocates tend to inflate these targets and their ability to meet deadlines or, conversely, perhaps they have unrealistic expectations in the first place. Failure can be external and social—a megaproject could produce costs and externalities that clearly outweigh its benefits. Failure can be risk-based and improbable, but possible, with a megaproject breaking down catastrophically and visibly through accidents, explosions, and other unexpected (or overlooked) risks; think of the Exxon Valdez oil spill in 1989, or the Fukushima nuclear power accident in Japan in 2011. Failure can even take the form of wealth inequality: a megaproject can produce benefits exceeding costs, but unfairly concentrate and distribute benefits among a few elite stakeholders, causing more net misery and inequality as a whole.

This book explores the complicated forces driving investment in massive energy projects. It investigates their largest benefits, in essence detailing “who wins”; and, as a result also documents their largest constraints, essentially unveiling “who loses”. It focuses on the nexus between energy megaprojects and frameworks of governance, national energy and climate change planning, and community resilience. To do so, it tests five key propositions:

- Proposition 1: Stakeholder involvement can fragment megaproject design and implementation.
- Proposition 2: Megaprojects will suffer from their complexity, coupling, and costliness.
- Proposition 3: Megaprojects will externalize costs as much as possible.
- Proposition 4: Megaprojects can reinforce corruption and erode democracy.
- Proposition 5: Project sponsors will oversell megaproject benefits.

In testing these propositions, the book also provides up-to-date analysis of pressing energy security concerns facing major economies that are considering energy megaprojects, including those in the European Union, United States, China, Japan, South Korea, Indonesia, and Turkey.
Beyond demonstrating success and failure, it is salient to study energy megaprojects, in part, simply because of their size. Megaprojects invite government and corporate commitment because they break new ground or expand new heights; think of the tallest building in the world the Burj Dubai, which nearly bankrupted its financiers and required a massive, last-minute bailout by its oil-rich neighbor Abu Dhabi (with the condition that the tower be renamed the Burj Khalifa). Because of the massive investment megaprojects require, their failures have greater relative impacts on markets. For the same reason, their failure also produces greater opportunity costs. Had the American effort in Panama failed, for example, to what better use could $120 billion have been put?

Besides scale, however, studying the success and failure of megaprojects is important for improving their outcomes. If it is true that public and private interests are seduced into loving megaprojects despite their many challenges and despite their high likelihood of failure, perhaps understanding why they fail will improve outcomes, even if it does not turn marginal failures into true successes. Our book has the ability to apprise the builders and operators of existing and future energy megaprojects, those responsible for working and designing technology, about the obstacles they will likely encounter. It can enlighten users of energy megaprojects about unknown or previously hidden risks. It can educate citizens, since many energy megaprojects utilize public money and are subsidized by taxpayer dollars or public service mandates, about the influence megaprojects have on regulation and corruption. It can also instruct scholars and researchers to not view a megaproject as a “black box”, instead reminding us that values and cultural norms get built into large-scale technologies in ways that often become invisible after the fact. Deciphering who to hold accountable when megaprojects fail may have value independent of its ability to ensure future megaproject success; accountability may be valuable for its own sake.

In the end, studying megaprojects has utility because of the paucity of ex ante evaluations of most megaprojects. Given the scale and expense of these endeavors, it is surprising that so little is systematically evaluated when they collapse into heaps of organizational mess. Despite their magnitude and growing frequency, megaprojects are an understudied entity in the literature on both energy and policy. Even though we live in a world in which daily life is becoming more tightly coupled to multilayered infrastructural systems, few books and studies investigate megaprojects and none, to our knowledge, exclusively focus on energy megaprojects. Berkeley political scientist Todd R. La Porte suggests that this obscurity of scholarship might be connected in part to the complexity of megaprojects themselves. As he writes:
The number, scale, complexity, and range of large technical systems . . . confound engineers, social scientists, historians, economists, policy planners, and political leaders. Social and organizational theories falter in the face of complex, interdependent relationships. Nor do historical or economics-based models of technological change give policymakers a firm theoretical basis for their decisions.19

Because only “mega” theories are thought to explain “mega” projects, most scholars and analysts have shied away from them towards safer, and less complicated, ground. Our book fills that void. If anything, it addresses knowledge gaps by raising many tough questions about the wisdom and utility of energy megaprojects, and perhaps even answering a few.

KEY TERMS AND CONCEPTS

A sample of the literature on megaproject management reveals numerous past “things” called megaprojects, cutting across a variety of sectors shown in Table 1.1. Some of them are quite old, such as the system that built the pyramids in Egypt, the ancient irrigation canals in the Middle East, and the gothic cathedrals in Europe. What is also revealed is that historians and analysts have described these projects with a variety of terms, from “megaprojects” and “large engineering projects” to “big technology”, “large technical systems”, “large-scale technological networks”, even Kampfbegriff.20 The late historian and sociologist Lewis Mumford coined the term “megamachine” to describe a system of both human and material parts dedicated to an orderly and controlled movement in pursuit of a clearly defined goal.21 But this all begs the question of what precisely an “energy megaproject” is.

Energy megaprojects obviously necessitate the construction of large or very large technological systems. Delineating how large is, of course, relative (though necessary). We define an energy megaproject as having a financial as well as geographic component: it must be capital intensive and transnational. An energy megaproject is one that involves at least $1 billion of capital investment and a geographic scale transiting at least three countries. For this book, our unit of analysis is these particular systems themselves, but these include not only hardware and material elements such as structures and generators but also “software” such as financing agreements and regulations, as well as the skills and knowledge needed to design, improve, and maintain such systems.

Governance, broadly considered, refers to how humans make decisions and form institutions that craft rules shaping behavior. At its most elemental level, governance is about deciding who can do what, who will
Table 1.1  Sample of historical and existing megaprojects

<table>
<thead>
<tr>
<th>Sector</th>
<th>Megaproject</th>
<th>Location</th>
<th>Period</th>
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<tbody>
<tr>
<td>Buildings</td>
<td>Pyramids</td>
<td>Egypt</td>
<td>2600 BCE</td>
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<td></td>
<td>Gothic cathedrals</td>
<td>Medieval Europe</td>
<td>1300 to 1600</td>
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<td></td>
<td>Sports stadiums</td>
<td>Various</td>
<td>776 BCE to present</td>
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<td></td>
<td>Casinos</td>
<td>Various</td>
<td>1638 to present</td>
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<td></td>
<td>Burj Khalifa</td>
<td>United Arab Emirates</td>
<td>2010 to present</td>
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<tr>
<td>Agriculture</td>
<td>Early irrigation systems</td>
<td>Middle East</td>
<td>500 BCE to 1500</td>
</tr>
<tr>
<td>Waste</td>
<td>Early sewage systems</td>
<td>Israel, France</td>
<td>1800s to present</td>
</tr>
<tr>
<td>Transport</td>
<td>Early national railway networks</td>
<td>United Kingdom and United States</td>
<td>1550 to present</td>
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<td></td>
<td>Henry Ford’s River Rouge automobile production plant</td>
<td>United States</td>
<td>1918 to 2004</td>
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<td></td>
<td>Panama Canal</td>
<td>Panama</td>
<td>1914 to present</td>
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<td></td>
<td>Boston’s Central Artery/Tunnel project (the “Big Dig”)</td>
<td>United States</td>
<td>2007 to present</td>
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<td></td>
<td>Urban subways</td>
<td>Various</td>
<td>1840 to present</td>
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<td></td>
<td>Interstate highways</td>
<td>Various</td>
<td>1956 to present</td>
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<td></td>
<td>International airports</td>
<td>Various</td>
<td>1941 to present</td>
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<tr>
<td>Energy</td>
<td>Hoover Dam</td>
<td>United States</td>
<td>1929 to 1935</td>
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<td>Tenesse Valley Authority</td>
<td>United States</td>
<td>1933 to present</td>
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<td></td>
<td>Shippingport Atomic Power Station</td>
<td>United States</td>
<td>1957 to 1982</td>
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<td></td>
<td>Offshore oil and gas platforms</td>
<td>Various</td>
<td>1891 to present</td>
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<tr>
<td></td>
<td>Three Gorges Dam</td>
<td>China</td>
<td>2003 to present</td>
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<tr>
<td></td>
<td>Itaipu Dam</td>
<td>Brazil</td>
<td>1970 to present</td>
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<tr>
<td></td>
<td>National and international electricity transmission</td>
<td>Various</td>
<td>1910 to present</td>
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<td></td>
<td>and distribution networks</td>
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<tr>
<td>Category</td>
<td>Event</td>
<td>Location</td>
<td>Period</td>
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<tr>
<td>Defense</td>
<td>Manhattan Project</td>
<td>United States</td>
<td>1939 to 1947</td>
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<td></td>
<td>Aircraft Carrier Battle Groups</td>
<td>Various</td>
<td>1940 to present</td>
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<tr>
<td>Telecommunications</td>
<td>Transatlantic cables</td>
<td>United States and United Kingdom</td>
<td>1857 to present</td>
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<td></td>
<td>Early telephone networks</td>
<td>United States and Europe</td>
<td>1890 to present</td>
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<td></td>
<td>Global positioning satellite network</td>
<td>Various</td>
<td>1973 to present</td>
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<td></td>
<td>The Internet</td>
<td>Various</td>
<td>1982 to present</td>
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<tr>
<td>Disaster recovery</td>
<td>Bhopal Union Carbide</td>
<td>India</td>
<td>1984 to 1995</td>
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<td></td>
<td>Boston Harbor Clean Up</td>
<td>United States</td>
<td>1985 to 1997</td>
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<td></td>
<td>Chernobyl nuclear accident</td>
<td>Ukraine</td>
<td>1986 to present</td>
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<td></td>
<td>Fukushima nuclear accident</td>
<td>Japan</td>
<td>2011 to present</td>
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<td></td>
<td>Exxon <em>Valdez</em> oil spill</td>
<td>United States</td>
<td>1989 to 2001</td>
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<td></td>
<td><em>Deepwater Horizon</em> oil spill</td>
<td>United States</td>
<td>2010 to present</td>
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<tr>
<td></td>
<td>Kingston fly ash spill</td>
<td>United States</td>
<td>2008 to present</td>
</tr>
</tbody>
</table>

*Source: Authors.*
monitor it, and how rules are modified and changed over time. The term refers to “any of the myriad processes through which a group of people set and enforce the rules needed to enable that group to achieve desired outcomes.” Traditionally the primary actor providing governance is government institutions nested vertically (cities operate below states and provinces, which operate below national and international institutions) and provide a variety of services (such as an education system, a national defense infrastructure, a currency, and so on).

We, however, use a much more particular notion of “governance”. For us, governance has three interrelated meanings. First, governance can refer to the internal operation and management of the megaproject itself; how well it is built and maintained, and how efficiently or reliably it delivers energy fuels or services. Second, governance can refer to the economics and politics of the system, the coalitions of interest involved in supporting or opposing a megaproject. Finally, governance can refer to the interaction between the technology of a megaproject and the types of social organization it creates—whether it produces competition or collaboration, whether it is controlling or democratic, whether access to it is open or closed.

This book is unique because it looks at multiple scales of energy governance simultaneously. Energy governance is understood not only in a quasi-managerial sense (in terms of how the respective projects are designed, operated and maintained), but also as a form of geopolitics associated with the construction and operation of megaprojects. Thus, the book focuses not only on governments and operators, but also on corporations and the interests of other essential stakeholders, including nongovernmental organizations, civil society and local communities. The book examines technologies as well as technological expectations; policies as well as politics.

Energy analysts and politicians have long conceptualized energy security (another one of these polysemic terms) as reliable supplies of energy and the implications of the strategic withholding of energy. This view recognizes that energy is essential for any form of economic activity; indeed, increasing energy consumption has characterized industrialization and economic development over the past century. As Figure 1.1 reveals, an annual electricity consumption rate of roughly 4,000 kWh per capita is needed to meet the basic necessities required for human development.

In recent times, discussions of energy security have expanded to embrace electricity reliability as well as natural gas and petroleum security, and entire energy supply chains including energy delivery infrastructure. With rising energy costs, affordability and economic competitiveness have
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joined supply security as common objectives.\(^{28}\) The volatility of energy prices and the growing uncertainty about available imports of both oil and natural gas have elevated the role of policies designed to promote energy efficiency. With climate change and air pollution gaining greater saliency, the sustainability of energy systems has also arisen as an important dimension of energy security.\(^ {29}\) At the extreme, when environmental conditions deteriorate to the point that society cannot function, nation states could reach the point of collapse, impinging on energy (and international) security on a global scale.\(^ {30}\)

For this book, we thus define energy security as “equitably providing available, affordable, reliable, efficient, environmentally benign, proactively governed and socially acceptable energy services to end-users”.\(^ {31}\) This conception of energy security comes from a review of energy security literature\(^ {32}\) as well as research interviews with energy experts\(^ {33}\) and surveys of energy end-users.\(^ {34}\) This emerging multidimensional view of energy security acknowledges that transforming energy systems is at the core of energy security solutions. At the same time, this broad approach incorporates governance and policymaking aspects of energy security alongside those of availability, affordability, energy efficiency, and social and environmental quality.

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Figure 1.1  The United Nations’ Human Development Index and electricity use for sixty countries, 1997\(^ {27}\)
WHAT IS DRIVING ENERGY MEGAPROJECTS?

The challenge of defining energy security in terms that apply across jurisdictions and that include components still subject to much debate has generated multiple justifications for pursuing megaprojects in the energy sector. Some laud energy megaprojects for offering greater opportunities for cross-border investment, the sharing of best practices, and improved resource efficiency. Others have argued that large-scale transnational energy projects can enable countries to stockpile resources and avoid duplication, and allow them to link infrastructure in ways that distribute costs, create synergies, and improve market efficiencies. Indeed, while the pace and scope of megaprojects for infrastructure overall is rapidly increasing—in 2012, roughly 40 percent of infrastructure projects around the world had capital value equal or greater than $10 billion—energy projects represent a large and growing share of all megaprojects.35

We identify seven factors driving the growth in size and number of energy megaprojects: (1) economies and ecologies of scale, (2) the agglomeration of industry, (3) growth in regulation, (4) aging of specialized talent, (5) competition with national energy companies, (6) the seduction of standardization, and (7) the allure of modernism.

Economies and Ecologies of Scale

One obvious reason that firms pursue megaprojects—despite their high likelihood of failure—is the perception that larger projects will produce greater economies of scale. In microeconomics, economies of scale refer to the reductions in unit cost that result from increasing the size and usage of a facility.36 In simple terms, economies of scale imply that the more units a single plant can produce, the more efficient it becomes and the more cheaply it can produce each unit. Economy of scale has been the impetus behind critical innovations in mass production like Henry Ford’s standardization of parts assembled by line, which reduced the price of automobiles to levels middle-class families could afford.

Many economists credit consolidation as a kind of economy of scale responsible for reducing long-term average production costs in several capital-intensive industries. Ambrose et al., for example, cite consolidation of the U.S. airline industry as the reason air travel costs decreased through the mid-1990s, even while the industry increased its profitability.37 In the 22 years after Congress passed the Airline Deregulation Act of 1978, the number of airlines operating in the United States fell from 31 to 14, while the top eight firms enlarged their market share from 81 percent to 91 percent.38 Over the same period, because of consolidation, the proportion of trips that
required passengers to change airlines fell from 11.2 percent to 1.2 percent, which decreased the average cost per passenger mile by more than half.\textsuperscript{40}

Pursuit of economies of scale has not been limited to the transportation and service sectors. The conventional wisdom within the energy industry also has been to target efficiency savings through the implementation of larger, more centralized production facilities. Part of this motivation to centralize and build bigger units is connected to historical contingencies. During World War I, utilities interconnected systems in order to avoid local power shortages and to assist in the development of high voltage transmission.

Throughout the Great Depression, cheap electricity was one prescription for economic revival. Planners and politicians alike started to believe that developing sources of energy supply in increments as large as possible led immediately to improved economies of scale, lowering production costs that could then be passed onto consumers. Prototypical examples of large-scale, centralized energy projects in the United States during this time include the Hoover Dam, Tennessee Valley Authority’s network of 29 hydroelectric dams, and, later, the Shippingport Nuclear Reactor.

Such building of centralized and massive energy systems seemed to work exceptionally well up until the 1970s. Providing an almost textbook example of economies of scale in action, Figure 1.2 shows that the capacity of large power plants doubled every 6.5 years from 1930 to 1970 in the United States. At the same time, electricity prices in nominal terms

\textbf{Figure 1.2}  
\textit{Average residential price of electricity in the United States, 1892 to 1970 (adjusted for inflation to $2004)}

\textit{Source:} Hirsh (1989)\textsuperscript{39}
dropped from almost $1 per kWh to less than 7 cents per kWh. The success of the conventional system became associated with a number of related assumptions. Planners believed that energy systems should consist of relatively few but large units of supply and distribution, and that those units should be composed of large, monolithic apparatuses rather than small, redundant models.42

In the last 35 years, in a similar pattern, the size of natural gas liquefaction and purification facilities has increased from 1 million metric tons per year to over 5 million metric tons per year, driven in large part by the desire to reduce capital costs.43 Increasing concern about the impacts of climate change has prompted renewed interest in large hydropower projects, especially in the developing world, where larger dams not only tend to attract more attention from policymakers, but are perceived as producing power at lower per-unit costs than smaller dams.44 The wind power industry, as well, touts the significant cost savings of larger turbines and more expansive wind farms.45 According to Windustry, one of the industry’s largest promoters, smaller farm and residential scale turbines cost less overall, but are more expensive per kilowatt of energy producing capacity.46 As a result of perceived economies of scale, Figure 1.3 illustrates how the average size of wind projects has steadily increased as more utilities and independent power producers integrate wind energy into their generation portfolios.47 Until 2004, the majority of European wind

Figure 1.3  Installed European wind projects by turbine size (MW), 2001–200841

Source: Emerging Energy Research.
development consisted of wind farms less than 20 MW. By 2012, these projects represented less than 40 percent of annual added capacity, while projects between 50 and 99 MW increased to nearly 20 percent of the total market share.48

The energy industry also has witnessed nearly 70 years of steady consolidation in an attempt to capture economies of scale. Since 1995, more than 40 mergers of U.S. electric utilities have been announced, promising billions of dollars in expected cost-savings.49 However, few utilities have actually realized the benefits of economies of scale. Difficulties in capturing efficiency gains from operating larger corporate structures, barriers to consolidating corporate functions across jurisdictions, and challenges complying with inconsistent regulatory regimes have combined to undermine the advantages of larger production units.50 Despite these failures, industry analysts continue to attribute these problems to failed management strategies rather than structural deficiencies in the economics of large-scale projects.51 Perversely, megaproject failures are presented as justifications for investment in additional projects. After all, how better to prove that the project would have been successful had it only been managed correctly than to address underlying, systemic deficiencies.

Finally, and perhaps counter-intuitively, some promote megaprojects on the grounds of “ecologies of scale” and the “matching principle”. These arguments suppose that energy projects should match the “scale” of the particular energy problems at hand. If a large area of three countries needs more reliable access to electricity, why not build an entirely new, large electricity network at once to serve them? Brookings Institution senior scholar Teresita Schaffer argues that many regional problems that relate to climate change and energy security, such as energy shortages, the production of transboundary haze, or deforestation, cut across countries. It therefore makes sense to match energy investments at those scales.52 Similarly, those in environmental law have argued their “matching” or “equivalence” principle which says that those who are significantly affected by a global good, or a global bad, should have a say in its provision or regulation. The span of a particular energy security problem, the argument runs, should be “matched” jurisdictionally to all those people and institutions concerned about that problem.53

Agglomeration of Industry

Another explanation for continued interest in energy megaprojects relates to the perception that larger projects, with more concentrated production, tend to create more labor efficiency and innovation even if they have failed to produce classic economies of scale. In the early 1990s, American
economist Paul Krugman presented a series of lectures that birthed an economic movement known as New Economic Geography, an attempt to apply spatial thinking to international economic theory.\textsuperscript{54} This movement, in turn, posited that public-sector support of concentrated industrial clusters would generate beneficial “agglomeration externalities”. An agglomeration externality occurs when a production activity generates localized public knowledge or other positive benefits arising from the concentration of production activity in the same vicinity.\textsuperscript{55} (This particular notion of an externality is not to be confused with the negative externalities we discuss in later chapters.)

The classic example of an agglomeration externality in action is the informal exchange of information between Google employees and Apple employees as a result of living and working together in Silicon Valley. According to the theory, formal and informal exchanges between these employees made them more productive in their respective firms, creating innovations and efficiencies that would not have been obtained otherwise.\textsuperscript{56} Emerging economies have provided some anecdotal evidence that the “clustering” of industrial activities has generated efficiencies.\textsuperscript{57} As a result, some developed countries have pursued organized efforts to enhance the competitiveness of certain industrial sectors by investing in “cluster initiatives” or “development corridors”, public–private partnerships designed to concentrate the physical flows of production inputs and outputs in one area. These clusters and corridors are also believed to promote the exchange of business and technological expertise and leverage the savings from larger-scale operations.\textsuperscript{58} China, for example, is home to hundreds of industrial clusters, including Wenzhou (which produces 95 percent of the world’s cigarette lighters), Yanbu (the world’s underwear capital) and Pengjiang (a motorcycle cluster consisting of three cycle factories and over 30 factories producing cycle accessories).

However, only recently have economists used rigorous economic modeling to test whether agglomeration actually creates efficiency benefits for participating companies and public benefits for participating nations. Results are mixed. Noted economist Mercedes Delgado and colleagues used newly available data from the U.S. Cluster Mapping Project and found that agglomeration had a positive impact on the growth rate of average wages and increased the growth rate of patenting (one measure of whether clustering generates innovation).\textsuperscript{59} The results of their studies suggest that, at least for industrialized economies, agglomeration may not only reduce the cost of production but the cost of exchange by enhancing trading relationships and the transparency of local input and output markets.\textsuperscript{60} These conclusions are brought into question, however, by economists S.S. Rosenthal and W.C. Strange, who used data from the
preeminent business information firm Dun and Bradstreet to calculate that the economic activity of small establishments has a larger effect on sector innovation and expansion than equivalent economic activity at large establishments.\(^{61}\) In fact, according to Rosenthal and Strange, additional employment at large establishments has an insignificant or even negative effect on sector expansion compared with small or medium-sized establishments.\(^{62}\) Whatever the actual economic impact of agglomeration, the popularity of New Economic Geography theory (which won Krugman the Nobel Prize in economics in 2008) no doubt has driven the continued investment in megaprojects (energy or otherwise) despite their murky performance record.

**Growth in Regulation**

A substantial factor driving the trend toward energy megaprojects is the expansion of environmental restrictions and reporting requirements. Businesses large and small have complained about a growth in government regulation, insisting that the marginal benefits to human health, safety and the environment do not justify the massive cost of new restrictions and requirements. In 2011, the U.S. Chamber of Congress released a study on the economic challenges facing proposed energy projects.\(^{63}\) The Chamber claimed that private investors were prepared to fund, build and operate energy projects that could materially increase GDP and create a significant number of jobs. However, regulatory inefficiencies consistently stymied these investments by requiring worthy projects to withstand a tortured permitting process.\(^{64}\) In testimony before the U.S. House of Representatives, the American Fuel and Petrochemical Manufacturers (AFPM) organization complained that their members spent an inordinate amount of time and money complying with regulations that generated little to no benefit for the environment while diverting investment capital essential for strengthening the nation’s fuel refining infrastructure.\(^{65}\) AFPM cited a Department of Energy report issued in March 2011, which concluded that the cumulative burden of federal regulations was a significant factor in the closure of at least 66 petroleum refineries in the United States since 1990.\(^{66}\)

Even when projects are subject to the same regulations, the scale of the project may substantially determine its regulatory impact. In fact, because regulatory costs do not usually increase linearly with project size, the growth in government regulation may inadvertently be encouraging greater investment in megaprojects. In fact, the National Small Business Association (NSBA) recently lamented that regulations often place a disproportionate burden on small businesses because the burden on large projects of
complying with federal requirements does not have as great an impact on unit costs as the burden on smaller projects complying with the same requirements.\textsuperscript{67} As one energy facility manager told one of the authors:

Size matters—not necessarily from a capital cost or efficiency standpoint, but it takes a lot of effort to do a small project as it does a large project, so the tendency is for an organization like ours to focus on the bigger projects because they can support the kinds of efforts needed to get the projects done. In contrast, getting smaller projects done requires such a disproportionate amount of senior management attention, legal attention, and other time and effort that it really burdens those projects with greater and greater costs so that people say it’s not worth it.

As a consequence, this manager said they no longer “waste their time” on smaller energy projects.

The U.S. Environmental Protection Agency’s (EPA’s) own studies appear to support the contention that regulations have a greater per-unit cost impact on smaller projects than on larger ones. For example, in an analysis of the impact of U.S. Toxic Substances Control Act regulations on the biotechnology industry, EPA found that the reporting costs and permitting delays required to comply had a marked impact on the profitability of projects depending on their scale. Because reporting costs are constant in dollar terms, they create a much greater burden for smaller projects than larger ones.\textsuperscript{68} Figures 1.4 and 1.5 depict how the EPA found that reporting costs barely affected the cash flow curve of large projects, which remained profitable. In contrast, reporting costs were enough to render smaller projects financially unsustainable.\textsuperscript{69}

It is likely that many firms attempt to minimize the per-unit cost of regulatory compliance by investing in larger projects that are capable of spreading the costs over a greater amount of production. Similarly, when new facilities are burdened with an increasing number of regulatory and permitting hurdles, it makes economic sense to reduce the number of facilities required to produce the same output. The result is a trend toward investment in larger production facilities with centralized input and output flows and away from smaller, more scalable projects that require duplicating regulatory costs.

\textbf{Aging of Specialized Talent}

Demographic factors may also provide an explanation for the rapid increase in the number and size of energy megaprojects. The graying of technical experts is having a very real impact on nearly every part of the energy sector. In the oil and gas industry, the average age of operator
### Figure 1.4 Effect of regulatory reporting and delay on marginally profitable large-scale project

<table>
<thead>
<tr>
<th>Reporting Costs</th>
<th>Delay Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumulative Cash Flow without Regulations</td>
<td></td>
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<tr>
<td>Cumulative Cash Flow with Reporting Costs</td>
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<tr>
<td>Cumulative Cash Flow with Reporting Costs and Delay</td>
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</tbody>
</table>

Source: Environmental Protection Agency.

### Figure 1.5 Effect of regulatory reporting and delay on marginally profitable small-scale project

<table>
<thead>
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<th>Reporting Costs</th>
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Source: Environmental Protection Agency.
The governance of energy megaprojects

technicians is over 45, while the average age of contractor technicians is over 50. More than 50 percent of oil company workers and contractors are expected to retire in the next five to ten years. The electric utility sector faces a similar brain drain. One in three U.S. utility workers is age 50 or older. Utility executives estimate that half of the technical workforce will reach retirement age by 2016.

The same trend is occurring in the nuclear power industry, which continues to lose much of the expertise that it does have to retirement, attrition and death. The Nuclear Energy Agency surveyed 16 nuclear member states in the Organisation for Economic Co-operation and Development and concluded that some countries were “at risk” due to lack of educational capability for training in nuclear-related fields. It documented declining university enrollment in nuclear engineering courses, an overall aging of the nuclear workforce, dilution of university course content related to nuclear physics, and changing expectations among young engineers that predisposed them away from working at nuclear power plants. As the study noted, “the nuclear industry does not attract the high numbers of good quality graduates and post graduates as it did when it was a fast developing and emerging industry a number of years ago. There are also problems with the retention of younger trained staff who are readily marketable to other sectors after a period in the nuclear industry.”

In the United States, the Department of Energy has warned that the lack of growth in the domestic nuclear industry has gradually eroded important infrastructural elements such as experienced personnel in nuclear energy operations, engineering, radiation protection, and other professional disciplines; qualified suppliers of nuclear equipment and components, including fabrication capability; and contractor, architect, and engineer organizations with personnel, skills, and experience in nuclear design, engineering, and construction. Since all commercial American reactors are light water reactors, system operators have little experience with newer gas cooled and other advanced reactor designs used throughout the world. Only two companies in the world, Japan Steel Works and Creusot Forge, currently have the heavy forging capability to create the largest reactor components. In the 1970s, more than 400 suppliers of nuclear plant components existed, but the number dropped to 80 suppliers in 2008. Moreover, the Nuclear Energy Institute cautioned in 2005 that “half of the industry’s employees are over 47 years old, and more than a quarter . . . already are eligible to stop working”, implying that the industry had far fewer available specialists with the requisite knowledge necessary to facilitate any rapid expansion of nuclear power.

Another assessment in the United Kingdom warned that “the nuclear
industry is facing a skills crisis”. Fewer than 6 percent of the estimated 100,000 people who work in the industry were under the age of 24, and at British Energy, which operates eight nuclear power stations and is the country’s biggest electricity provider, 40 percent of staff are set to retire within the next ten years. No British university offered a dedicated nuclear engineering course as of 2007 and a number of “vital occupations” remained unfilled. One nuclear consultant found it “amazing that so many people jumped on the bandwagon of this renaissance without ever looking at the industrial side of it”. Another industry survey identified an “under-supply of qualified people” compared to the proportion of needed jobs in the nuclear power sector. It found a 20 percent deficit for high-level jobs, especially related to decommissioning, process and machine operators, and senior managers. The National Skills Academy for Nuclear, a trade group in the United Kingdom, estimated that as many as 16,500 new workers would be needed to operate existing facilities by 2015. The survey warned that “the sector needs to quadruple the number of apprentices over the next five years.”

Megaprojects are complex and technologically sophisticated, requiring experienced senior technical workers. The aging of this critical workforce is creating new challenges to attract new workers to the energy industry and provide them with adequate training before highly-experienced workers leave the industry. According to a 2006 survey of utility executives, the greatest talent shortages are likely to occur amid senior technical and mid-technical career talent. But the supply of power engineering graduates needed to replace them has plummeted. Already, firms responsible for Canadian energy projects are facing difficulties training new workers quickly enough to meet the workforce demands required to maintain the sector’s growth. Even if they are unaware of it, some firms may be accelerating investments in megaprojects as a means of capitalizing on technical and managerial expertise before this talent is lost. To put it bluntly, some firms may be pursuing megaprojects now because they do not foresee having a workforce capable of successfully implementing these projects in the future. Larger, more complex projects are one means of squeezing the greatest amount of future productivity from a shrinking pool of talent that may take decades to replace.

**Competition with National Companies**

Another factor driving interest in energy megaprojects is the recent advent of national energy companies and the competitive pressures they place on private multinational firms. The International Energy Agency (IEA) estimates that, unlike the last 30 years, which saw 40 percent of
all oil come from publicly-traded companies within the Organisation for Economic Co-operation and Development (OECD), the next 30 years will see over 90 percent of production coming from national oil companies in the developing world.\textsuperscript{83} The emergence of national energy companies as major fuel producers influences the development of megaprojects in two mutually reinforcing ways. First, because national energy companies have access to cheap capital and are motivated by more than profit, they can pursue larger projects with potentially greater market impact. These large developments put economic pressure on private companies to compete by investing in larger, more capital-intensive projects of their own. One study concluded that, without exception, national energy companies have important national goals beyond maximization of shareholder returns.\textsuperscript{84}

Indeed, national energy companies are often tools of a country’s foreign and strategic policy, not the least of which is a secure national fuel supply. India’s rapid appetite for energy, for example, may explain why the Oil and Natural Gas Corporation (ONGC) of India (whose principal stakeholder, the Government of India, controls nearly 85 percent of the company’s stock) continues to invest in a wide range of controversial projects, including a natural gas pipeline from Iran that is vehemently opposed by the United States.\textsuperscript{85} National energy companies also enjoy a considerable market advantage through public subsidies provided to domestic consumers. In Iran, for example, semi-private cab drivers benefit from subsidized gas priced at an astonishing 10 cents per liter.\textsuperscript{86}

Second, national energy companies may have access to vast, publicly-owned resources without the political and regulatory constraints that would make their exploitation unprofitable for private developers. However, because many national companies lack the financing or technical expertise required to exploit these resources efficiently, often they partner on megaprojects with multinational private corporations in joint-ventures where the national corporation retains controlling interest. This arrangement is perceived as offering a marriage made in heaven, whereby the government partner gains capital and technical expertise while the private partner gains streamlined regulatory approval and access to public resources.\textsuperscript{87}

**Seduction of Standardization**

One other explanation for why firms continue to invest in energy megaprojects despite their disappointments is the optimistic assumption that trial and error will eventually result in standardized megaproject management and construction techniques. Megaproject firms continue to have faith that they will discover the “correct” megaproject standards that can be replicated to ensure project success thereafter. In short, this theory
suggests that getting megaprojects wrong is an essential prerequisite to getting them right.

At first glance the theory may appear counterintuitive. But standardization has been the holy grail of energy megaproject management for decades. Consider the standardization of design and licensing of nuclear reactors. After mulling over suggestions from the nuclear power industry concerning methods for streamlining the regulatory review of nuclear plant features, in March 1973 the U.S. Atomic Energy Commission (AEC) announced that it was prepared to consider applications for review and licensing of standardized designs for nuclear reactors and major plant systems. The AEC promised priority scheduling and expedited review of applications conforming to any one of three procedural options. Under the first option (the reference system concept), once a standardized design received approval, the AEC would limit examination of subsequent applications to their compatibility with the site parameters utilized in the standardized design. Under the second option (the duplicate plant concept), the AEC would review a single license applications for the construction and operation of duplicate plants at more than one site. The third option (the license to manufacture concept) was similar to the reference system option, except the AEC would review the construction and operational procedures of a plant that would be manufactured at one location, but installed at another.

Remarkably, the AEC touted enhanced reactor safety as one of the more important benefits of increased standardization. But, of course, shortly after the AEC’s standardization push, the near-melt down at Three Mile Island (followed by the actual meltdown at Chernobyl) destroyed the safety rationale behind design standardization. Three Mile Island and Chernobyl both tragically demonstrated that nuclear energy’s greatest danger comes not from flaws in design or standardized procedures, but from flaws in their implementation due to human error. One study by the French Atomic Energy Commission assessed whether technological innovations could help eliminate the risk of human-induced accidents at nuclear power plants and concluded that there was simply no way to “design around” the kinds of maintenance and testing mistakes that were the major precipitating factors behind the twentieth century’s greatest nuclear disasters.

Though proponents of next-generation nuclear reactors continue to argue that standardization of design will expedite licensing, speed construction and reduce capital costs, an interdisciplinary team at MIT used some of the most advanced tools available to assess the risk of human error in the nuclear industry and concluded that “the potential impact to the public from safety or waste management failure . . . make it impossible today to make a credible case for the immediate expanded use of nuclear power.” Simply put, the lesson of the nuclear power industry is that
standardized designs cannot (and probably should not) eliminate human interaction and standardized procedures are only successful to the extent that they are followed. Human error will always be the monkey wrench thrown into the best designed systems.

Despite these historical lessons, megaproject firms continue to pursue standardized project design and management protocols, convinced that leveraging design similarities across projects will reduce capital costs and improve operations. Some leaders in the oil and gas industry already are moving aggressively toward standardization of design and management procedures to overcome the challenges that have caused megaproject failures in the past. The CEO of ExxonMobil, for example, recently promoted the concept of “design one, build many” as the key to executing megaprojects effectively.

Standardization, however, is not limited to design and materials. Many industry leaders believe that standardizing the project development and management process will streamline decision making, reduce time lags between tasks and define more efficient methods of meeting project goals. For example, one senior vice-president for Statoil, a Norwegian oil and gas conglomerate, recently remarked that standardizing exploration and discovery protocols would dramatically reduce Statoil’s internal validation process and enable megaproject teams to make decisions more quickly and effectively. Realization of this replicable project design and management template may be the single most salient explanation for the continued investment in megaprojects despite their consistently poor record of project management.

Allure of Modernism

In the late 1920s, German architect and master-builder Herman Sörgel proposed an ambitious plan to cut off the Mediterranean Sea from the Atlantic Ocean and Black Sea by building giant dams at Gibraltar and Gallipoli. As water evaporated from this inland sea, Sörgel estimated that the sea level would drop by as much as 100 meters, uncovering additional land along the Mediterranean coast. Sörgel envisioned huge hydroelectric power stations placed at the mouth of incoming rivers, generating power to secure all of Europe’s future energy requirements. According to Sörgel’s calculations, elaborate dam and irrigation facilities could transform large parts of the Sahara into fertile land and temper the tropical climate of central Africa to degrees that would encourage European settlement. Sörgel christened this technologically-created Eurafrikan continent “Atlantropa” and saw it rivaling America and Asia both in size and economic productivity. Though Sörgel’s continent never came to be, his dream represents a type of
socio-technical romanticism that some historians and sociologists suggest continues to be the driving force behind mega-projects today (especially megaprojects in the developing world). According to this theory, modern large-scale projects serve not only a technological function, but are meant to provide a means by which to rationally structure the chaotic existence of humankind. Like the Great Wall of China, or the Seven Wonders of the Ancient World, today’s Three-Gorges Dam and Burj Khalifa serve as artistic markers of humanity’s highest cultural achievements.100

For some historical sociologists, the fact that these projects tend to be spatially situated in the developing world is no accident, since many political and cultural leaders there see megaprojects as indicators of a Western lifestyle of surplus, steel and concrete proof of the quantum leaps in development and modernization that enable countries to prosper after a legacy of colonial domination.101 Jawaharlal Nehru, the first Prime Minister of an India independent from British rule, went so far as to call the country’s new hydroelectric dams “the new temples of India”.102

Ironically, however, some theorize that these same megaprojects also serve the material interests of powerful neocolonial actors through capital accumulation for financial institutions, multinational construction firms and globalized corporate interests.103 Cornell University sociologists Paul Gellert and Barbara Lynch, for example, contend that the ideologies that inform megaproject development are the work of “epistemic communities”, elite groups of actors from state agencies, international lending institutions and the globalized private sector. These communities share an optimistic culture of decision making that favors massive, rapid landscape changes and rationalizes the exclusion and displacement of affected populations as the natural evolution toward modernity.104 Members tend to believe that, once conceived, megaprojects become inevitable, and they see themselves as being in a better position than others to minimize risks.105

The modernist faith in technology and belief in the ability to overcome nature lead international lending institutions, construction firms and monumentalist states to be biased in favor of larger-scale projects, creating what Gellert and Lynch describe as a “Big is Beautiful” vicious cycle.106 First, the institutional logic of international lending is to favor large loans, which may encourage an inaccurate assessment of project utility. Second, because international lending institutions will only support projects amenable to international bidding, projects must be big enough to interest multinational construction firms. But, because feasibility studies, engineering plans and economic projections expand the megaproject gestation process, the accumulated transaction costs “feed the growth of large firms, who in turn solicit state and international investment so that they can keep their inventory of large and specialized equipment working and moving...
with assurance from one job to the next”.

According to this explanation, megaprojects conceived from modernist visions become concrete and steel inevitabilities to feed a vast and growing global industrial-financial complex. Like the military-industrial complex that U.S President Dwight Eisenhower famously warned of, the need to sustain this global industrial-financial complex may be a significant factor driving megaproject development well into the twenty-first century.

**ASIA’S ENERGY SECURITY CHALLENGES**

In analyzing the management of energy megaprojects we have chosen to focus exclusively on projects within Asia. Partly we made this choice because anticipated growth in Asian energy consumption, both in terms of per capita use and total use, is expected to rise dramatically in the next few decades; it is also because Asian energy production and consumption will soon be the largest single source of greenhouse gas emissions. As a whole, per capita electricity demand in the Asia-Pacific was only about 1,300 kWh in 2005 (compared to the world average of more than 2,500 kWh). Analysts predict that under a business-as-usual scenario, between 2005 and 2030 Asian-Pacific energy demand will grow at 2.4 percent per year, whereas global average energy demand growth during the same period is expected to be only 1.5 percent per year. Over the same period Asian-Pacific net imports of fossil fuels will more than double. The region’s oil dependency will increase from 57.5 percent to 66.4 percent.

All the while, the environmental costs of energy production and use within the Asia-Pacific region will continue to rise. China is now the world’s largest emitter of greenhouse gases, responsible for about one-quarter of the world’s total in 2008, and India has more than doubled its carbon emissions from 1990 to 2008. Since 1990, emissions from coal alone have increased 185 percent in China, and 141 percent in India.

Essentially, these trends highlight four related energy security challenges afflicting Asia, and motivating countries to pursue megaprojects: (1) rapid increases in energy demand, (2) energy poverty, (3) lack of energy diversification, (4) the need for energy diplomacy.

**Increases in Energy Demand**

Asia will likely need “big” energy projects to satisfy “big” growths in energy demand. With truly massive growth in energy consumption expected between 2008 and 2035—recent projections anticipate the need for at least $1 trillion of investments in new energy infrastructure every year, under
Introduction

Business-as-usual projections\textsuperscript{113}—transnational energy projects are seen as useful tools for building large amounts of much-needed energy capacity in one fell swoop. But projected demand for energy investment becomes truly colossal if global society is to cut emissions from the energy sector by 50 percent of 2005 levels by 2050, the stated goal of the countries belonging to the Group of Eight, consisting of Canada, France, Germany, Italy, Japan, Russia, the United Kingdom, and the United States.\textsuperscript{114} The International Energy Agency, the energy planning agency of the OECD, predicts a staggering $316 trillion dollars of needed investment to achieve that goal.\textsuperscript{115} Even the conservative Asian Development Bank projects that Asia alone will need to invest $290 billion in regional energy infrastructure between 2010 and 2020 in addition to $8 trillion in overall national infrastructure.\textsuperscript{116}

Asia’s voracious demand for energy predominately is driven by two factors, or “twin culprits”. The first is “consumption-led” demand. As classes of Asian people achieve increases in standards of living, they live more energy-intensive lifestyles involving automobiles, air conditioning, and greater amounts of disposable goods. The second culprit is “industrial-led” demand related to economic growth. The structural shift from non-mechanized forms of agriculture, manufacturing, and production to more energy-intensive ones, especially for development of some commodities—iron and steel, cement and glass, paper and pulp, basic chemicals, and nonferrous metals—will require vast new sources of energy.\textsuperscript{117} Looking to the future, analysts expect that developing countries in Asia, driven by China and India, will increase their share of global energy consumption from 24 percent in 2005 to 35 percent in 2030, while the share for OECD countries will decline from 52 percent to 41 percent, respectively.\textsuperscript{118}

Perhaps surprisingly, the growth of electricity demand in some Southeast Asian countries has outpaced China and India. Over the period 1985 to 2005, per capita electric power consumption increased much faster in Southeast Asian countries than the rest of the world. Between 1985 and 2005, world average consumption rose by a factor of 1.6. China rose by a factor of 3.2. But compare those numbers to Vietnam, which rose by a factor of 6.3, or many other Southeast Asian nations like Thailand (4.8) and Malaysia (3.7). Table 1.2 also indicates that China and most Southeast Asian countries (except for Singapore and Malaysia) were still far below global average electricity consumption levels. Indeed, if these projections hold true, regional demand for energy in Southeast Asia will equal the current, combined total electricity demand of Japan, Australia, South Korea, and New Zealand. Yet Southeast Asia, home to 8.5 percent of the world population (530 million people), possesses only about 1 percent of the world’s oil and coal stocks and less than 4 percent of the world’s natural gas reserves.\textsuperscript{119}
While Southeast Asian electricity growth is surprising, the energy statistics for China—its reliance on coal, its scramble for all other energy resources—are also startling. China relies heavily on coal as a primary fuel for industrial use and electricity generation. Coal combustion provided 65 percent of China’s electricity in 1985, but ballooned to more than 80 percent in 2006 (though it shrank to 71 percent in 2008). From 2002 to 2007, demand for electricity in China grew by about 12 percent and more than 70,000 MW of capacity were brought online to meet the demand. A majority of this capacity was coal-fired. Indeed, China currently is constructing the equivalent of two 500 MW coal-fired plants per week, or a capacity comparable to the entire power grid in the United Kingdom every year. More than half of China’s total coal use is in the non-electricity sector. Coal provides 60 percent of Chinese chemical feed-stocks, 55 percent of industrial fuel. Nearly 45 percent of China’s national railway capacity is devoted exclusively to the transport of coal. Coal is therefore China’s most abundant and widely used fuel, while China is also the world’s largest coal producer (mining about 2.3 billion tons per year compared to just 1.1 billion tons in the United States). Put another way, China already uses more coal than the European Union, Japan, and the United States combined. Meeting the demand for energy throughout China and the rest of Asia, the thinking goes, will require scores of megaprojects.

**Eradication of Energy Poverty**

According to the most recent data available as of 2009, 1.4 billion people lack access to electricity. Nearly 85 percent of them live in
rural areas. Almost 2.7 billion people rely on woody biomass fuels for cooking (see Table 1.3). An additional one billion people have access only to unreliable or intermittent electricity networks. In relative terms, the poorest three-quarters of the global population consume only 10 percent of all global energy supply. Yet 55 percent of those without access to electricity globally, as well as 72.3 percent of those dependent on traditional fuels globally, reside in Asia. This concentration of energy poor in Asia creates a strong incentive to build energy infrastructure to expand the availability of energy services for the poor and disenfranchised.

In addition to being energy poor, by total population Asia is just plain poor period. About one billion people live below $1.25 per day in the Asia-Pacific region. Seventy percent of all Asian poor are women. Nine hundred million workers in Asia earn less than $2 per day, leading one recent study to proclaim that “the state of human deprivation compels us to consider a paradigm shift to universal energy access and a minimal standard for quality of life. Energy security policies must be pro-poor.” An independent UNDP study concurred, noting that the urban poor typically have some access to electricity but its quality is substandard. Service is unreliable and intermittent. Connections are informal. The rural poor often go without modern energy services entirely. When they do have access to electricity, it tends to be from inefficient stand-alone diesel systems, poorly run micro-grids that are expensive and susceptible to failure, or patchy (often illegal) connections to limited national grids.

Table 1.3 Number of people without access to electricity and dependent on traditional fuels

<table>
<thead>
<tr>
<th>Region</th>
<th>Number of people lacking access to electricity (millions)</th>
<th>Number of people relying on the traditional use of biomass for cooking (millions)</th>
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</thead>
<tbody>
<tr>
<td>Africa</td>
<td>587</td>
<td>657</td>
</tr>
<tr>
<td>Sub-Saharan Africa</td>
<td>585</td>
<td>653</td>
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<td>Asia</td>
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<td>1,937</td>
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<td>China</td>
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<tr>
<td>India</td>
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<td>Other Asia</td>
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<td>659</td>
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<tr>
<td>South America</td>
<td>31</td>
<td>85</td>
</tr>
<tr>
<td>World</td>
<td><strong>1,417</strong></td>
<td><strong>2,679</strong></td>
</tr>
</tbody>
</table>
Energy Diversification

Given Asia’s astonishing energy poverty, security of supply has become a key economic and political concern for many governments. From their perspective, therefore, megaprojects conceivably could help diversify energy production both geographically and technologically. Such diversification would be needed to help insulate Asian economies from unexpected interruptions in both the supply and distribution of energy fuels and electricity.

For example, in China, Beijing recently had to ration its gas supply to shopping malls and supermarkets as a result of extreme winter weather in January 2010. A few years earlier, in 2008 India walked out of a deal to build an Iran–Pakistan–India (IPI) gas pipeline—on which discussions were conducted over 13 years—over security issues and the inability of Pakistan to agree to provide penalties for supply disruptions. Japan buys nearly 90 percent of its oil from the Middle East, making it vulnerable to disruptions of even a few days on the Strait of Hormuz or through shipping routes from the Middle East.128

Threats need not be international or external. Laborers for India’s public sector petroleum company, Oil and Natural Gas Corporation Limited, went on a three-day strike in early 2009, shutting down the Hazira plant that processes oil and gas from offshore operations. Their strike created shortages of CNG (compressed natural gas) required for public transportation in Gujarat, an Indian state home to more than 60 million people. Large parts of China also had to confront energy shortages in 2010 due to a combination of weather and infrastructure factors: difficulty transporting coal in the snow, less hydropower output due to freezing temperatures, and reduced coal supplies from Shanxi province due to mine closures. In 2008, Bali, Indonesia experienced shortages of gasoline and diesel when oil tankers had trouble accessing the island during a series of storms. And in Kalimantan, Indonesia’s large province on the island of Borneo, long lines formed at petrol stations due to a shortfall of over 10,000 liters of gasoline due to delays in oil tanker traffic. In Jakarta and Java as well, shortages of premium gasoline and LPG occurred after a refinery had maintenance problems. Also, disruptions of electricity have hit every single Indonesian province in both 2007 and 2008.129

Energy Diplomacy

The unique geopolitical dimensions of energy security in Asia also compel studying megaprojects in this region. Political scientist Shannon O’Leary has identified numerous serious civil wars and conflicts from 1990 to 1999
directly sparked by tensions over energy resources: oil revenues help fund five separate civil wars in Angola, East Timor/Indonesia, the Kurkuk region of Iraq, Southern Sudan, and the Xinjiang province of China, and natural gas enabled a conflict in Aceh, Indonesia. Moreover, because of their depletable nature—a barrel of oil in China cannot be used by India—conventional energy resources can play prominent roles in major geopolitical rivalries and interstate wars.

In World War I, Entente and Central powers both believed control of coal, oil, and gas resources was the key to victory. Before World War II, Japan, suffering from a dearth of available raw materials, invaded Manchuria in 1931 to acquire their coal reserves. In response to Japan’s later invasion of China in 1937 and to show support for the United Kingdom, in January 1940 the Roosevelt Administration abrogated the 1911 Treaty of Commerce and Navigation with Japan. This meant licenses for the export of gasoline and aviation fuel as well as machine tools to Japan were suspended. Without domestic resources, Japan invaded the oil-rich Indonesian islands, and the resulting tensions were a contributory factor in the Japanese decision to attack Pearl Harbor.

Even today, Asian countries remain embroiled in intensive interstate rivalries over oil. In 1992 China formally stated its right to the “use of force” to protect its claims to oil and gas resources in the South China Sea. In 1995, China seized an area of Philippine-controlled land and attacked a few fishing vessels in order to procure offshore oil and gas reserves; in 1998, a naval stand-off between China and Vietnam deteriorated into a firefight that left 70 soldiers dead. In the “Kikeh oil dispute”, competing efforts between Brunei and Malaysia to sign contracts with oil companies deteriorated into a tense naval stand-off in April and May 2003. In 2007 demonstrations in Vietnam over China’s attempts to claim the Spratly Islands in the South China Sea convinced their national oil and gas companies to exit from the region. Most recently in 2012, Vietnam’s parliament passed a maritime law that reasserted the country’s right to the Spratly and Paracel Islands; China responded by calling the move a “serious violation” of their sovereignty and then declared those islands officially Chinese, giving them “prefecture status” and instructing the media to refer to them as the “biggest prefecture in the country”. Tensions escalated further when, after this announcement, the Chinese state-owned oil company CNOOC announced it was opening up nine new oil and gas blocks within this new prefecture. Some of these new exploration and development blocks reached to within 37 nautical miles of the Vietnamese coast. To protect these new assets, the Chinese military also publicly noted that they were launching “combat ready” patrols; both sides have threatened “military strikes” should the situation escalate further.
Multilateral energy infrastructure projects, therefore, have been promoted on the grounds that they promote peace and cooperation by fostering a type of stabilizing energy interdependence. David Von Hippel from the Stockholm Environment Institute and his colleagues have argued that a variety of energy projects are becoming “important” tools of diplomacy throughout Asia. He has noted that:

- Electricity transmission interconnections are becoming common diplomatic tools connecting reserves of fossil fuels with power plants that need them to generate electricity to urban demand centers;
- Oil and gas pipelines across countries are becoming more prominent, especially those that reach into Siberia or connect offshore reserves in international waters;
- The sharing of nuclear technology, the development of new reactor designs, and the transport and storage of spent nuclear fuel are all occurring in a variety of multilateral and bilateral forums designed to promote regional (and even global) stability.

Others have argued that energy projects involving multiple countries can engender a shared sense of vulnerability to the risk of accidents and disruptions and therefore can promote “coordination and cooperation”. One recent study even went so far as to argue that “a shared need for [energy] resource commerce can be a means of fostering cooperation between states” and that in some cases “pipelines become conduits of peace-building”.

For these collective reasons—responding to dramatic increases in the demand for energy, eradicating energy poverty, diversifying energy supplies, and encouraging energy diplomacy—many Asian planners and policymakers have embraced the idea of energy megaprojects.

CASE SELECTION AND RESEARCH METHODS

In selecting particular energy megaprojects within the Asia-Pacific region for closer inquiry, there were a surprising number of options. Though the national economies in Asia depend upon a mix of energy sources (ranging from massive coal-fired generation in China to hydroelectricity in the Mekong Delta to geothermal reserves in the Philippines), the prospect of transnational cooperation on energy infrastructure has piqued the interest of many nations. The Association of Southeast Asian Nations (ASEAN) continuously touts the potential of building an ASEAN Power Grid, which would facilitate the flow of energy services throughout the region.
and hasten the economic integration of member states. In South Asia, we hear analysts repeatedly discuss plans for an Iran–Pakistan–India (IPI) gas pipeline as well as a Turkmenistan–Afghanistan–Pakistan–India gas pipeline. Across Northeast Asia, South Korea and Japan continue to talk about a regional electricity grid, and plans for a trans-Siberian oil pipeline—stretching from Lake Baikal in Russia to the Sea of Japan—already are underway. Australians have talked about an Australian–Asian “Superhighway for Clean Energy”, Indians have formulated plans for “Ultra Mega Power Projects” (each with a capacity above 4,000 MW), and the United Nations Economic and Social Commission for the Asia Pacific has endorsed an “Asian Energy Highway” to promote regional energy connectivity that would require trillions of dollars of investment.

For our purposes, we wanted comprehensive coverage of different energy projects, at different phases of development, involving a diverse mix of countries, being backed by different types of institutions. Thus we have chosen to study a completed and operational oil pipeline in Azerbaijan, Georgia, and Turkey financed by a multinational oil company; a natural gas pipeline network about half completed, but already operating throughout Southeast Asia being pushed by an intergovernmental organization; an international hydroelectricity network to be interconnected to Brunei, Malaysia, and Indonesia supported by a particularly influential Chief Minister in Sarawak; and a very large scale solar energy array connecting China, Japan, Mongolia, North Korea, and South Korea that is still in the planning stages, but being advanced by a nonprofit foundation.

The $4.6 billion Baku–Tbilisi–Ceyhan pipeline, advocated by British Petroleum, is a major initiative backed by the United States and the European Union designed to tap the oil reserves in the Caspian Sea and deliver oil through Azerbaijan, Georgia, and Turkey to markets worldwide. The Trans-ASEAN Natural Gas Pipeline Network (TAGP) is a $40 billion proposal that would link together the gas reserves of Thailand, Singapore, Indonesia, Malaysia, and the Philippines. The $105 billion Sarawak Corridor of Renewable Energy on the island of Borneo envisions 12 dams built in Malaysia and the creation of a regional electricity network feeding Sarawak, Sabah, Brunei, and Kalimantan (part of Indonesia). Gobitec is a $550 billion proposal to build a very-large solar array in the Mongolian Gobi Desert along with more than 3,500 kilometers of high-voltage direct current transmission lines designed to deliver electricity to higher-priced markets in China, Japan, and South Korea (with an option to include North Korea). Table 1.4 provides an overview of these cases.

With our cases selected, our analysis relied substantially on semi-structured research interviews and original field research as our primary tools of data collection. In all, over the course of August 2007 to August
<table>
<thead>
<tr>
<th>Case Study</th>
<th>Energy Source</th>
<th>Length/Area</th>
<th>Location</th>
<th>Volume/Size</th>
<th>Cost (US$)</th>
<th>Majority Shareholder/Operators</th>
<th>Major Financiers</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baku–Tbilisi–Ceyhan (BTC) Pipeline</td>
<td>Crude Oil</td>
<td>1,760 km</td>
<td>Azerbaijan, Georgia, and Turkey</td>
<td>1 million barrels of oil per day</td>
<td>$4.6 billion</td>
<td>British Petroleum, Chevron, State Oil Company of the Azerbaijan Republic, Inpex, Statoil Hydro</td>
<td>International Finance Corporation, European Bank for Reconstruction and Development, export credit agencies of seven countries, and a syndicate of 15 commercial banks</td>
<td>Completed and operational</td>
</tr>
<tr>
<td>Trans-ASEAN Gas Pipeline (TAGP)</td>
<td>Natural Gas</td>
<td>3,952 km</td>
<td>Indonesia, Malaysia, Singapore, and Thailand</td>
<td>3.1 billion cubic feet</td>
<td>$14.2 billion (constructed so far) to $40 billion (for the whole network)</td>
<td>Petronas, Pertamina, TotalElf, Chevron, PTT, Premier Oil, Myanmar Oil and Gas Enterprise, Nippon Oil, and SembGas</td>
<td>Asian Development Bank, Japanese Bank for International Cooperation, consortium of private banks</td>
<td>About half completed</td>
</tr>
<tr>
<td>Region/Project</td>
<td>Type</td>
<td>Area/Capacity</td>
<td>Countries</td>
<td>Size</td>
<td>Cost</td>
<td>Partners/Agencies</td>
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<tr>
<td>Sarawak Corridor of Renewable Energy (SCORE)</td>
<td>Hydro-electricity</td>
<td>70,709 km²</td>
<td>Brunei, Malaysia, Indonesia</td>
<td>20,000 MW</td>
<td>$105 billion</td>
<td>Regional Corridor Development Authority, Sime Darby, Sino Hydro, Three Gorges Dam Corporation, Ministry of Finance (Malaysia), State Government of Sarawak</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Authors.
2011, we conducted 253 research interviews at 113 different institutions in 20 separate countries.\textsuperscript{138} Participants were selected to represent upper management positions in their respective institutions, and institutions were selected to include a sample of different stakeholders involved in each case study. A semi-structured format was utilized that enabled the authors to ask a standardized set of questions, but also allowed the flow of the conversations to follow new topics or return to incompletely-answered questions. Standard questions included:

- What were the most significant drivers behind each project?
- What were some of the most meaningful challenges encountered?
- What lessons do such projects offer for political science, public policy, and energy studies?

Some of these interviews were digitally recorded for the sake of record keeping; when participants elected not to have the conversation recorded, we took careful notes and cross checked their accuracy later.

We have maintained the anonymity of the sources of our interview data for multiple reasons. First, the institutional review board guidelines at one of the author’s former institutions required that confidentiality be mutually agreed upon at the beginning of each interview. Second, anonymity protects respondents from retaliation over divulging potentially controversial information. Third, anonymity can encourage candor, as people often speak their minds if they no longer have to worry about their statements embarrassing them or inviting retaliation later. Fourth, most individuals were not speaking on behalf of their institutions, but were instead giving their personal opinions, making institutional affiliation less relevant (though still important for sampling purposes). Therefore, although the Appendix does offer an alphabetical list of all institutions included in our sampling, most of the direct quotes used throughout this book are presented without attribution.

Our method of data collection does mean that respondents could “strategically manipulate” answers to influence the outcome of the study. However, to further ensure accuracy and validity, the authors triangulated data from the interviews, and then supplemented them with direct field visits as well as a review of existing academic literature. To assess the BTC pipeline and TAGP network, one of the authors traveled to Azerbaijan, Georgia, Indonesia, Japan, Malaysia, Philippines, Singapore, Thailand, Turkey, Russia, Ukraine, and the United States (home to physical parts of the BTC, areas of the TAGP, or the headquarters of key stakeholders). That author also made site visits to oil refineries, drilling fields, and terminals in Baku, Sumgayit, and Surakhani, Azerbaijan; the BTC pipeline...
corridor in Tbilisi and Tabatskuri, Georgia; and the import terminal into Thailand at Ratchaburi for the Yetagun and Yedana natural gas pipelines from Myanmar. To get the perspective of those involved with building and operating parts of SCORE in Malaysia, one author visited a dam operating in Batang Ai, as well as two others under construction at Bakun and Murum. To get input directly from communities, an author spoke with community leaders, tribal elders and ordinary villagers from long-houses in Asap, Bakun, Upper Bakun, Danang, Murum and Lubok Antu, including Uma Badeng, Long Lawen, Long Wat, Nepi Pasir, Rumah Kelap, and Uma Daro. These villages included settlements of the Bukitan, Iban, Kayan, Kenyah, and Penan tribes. For Gobitec, the authors visited Mongolia and South Korea and also toured solar energy testing facilities and prototype systems in both countries. The authors were lucky to have simultaneous translation in all local languages for each visit. Our last phase of research encompassed a thorough review of available project documents and applicable peer-reviewed studies.

As the next chapter presenting our conceptual framework shows, the book takes an inherently synthetic socio-technical approach to examining the conditions conducive to energy megaprojects. It reveals the influence that technological evolution has had on the industries pushing such projects as well as the stakeholder interests behind them. It also investigates the complex interplay between political, economic and social elements which lend support to megaproject initiatives. It lastly incorporates interdisciplinary research methods and concepts from a variety of disciplines including business management, the historiography of technology, economics, and psychology.

NOTES

2. Id., p. 333.
3. Id., p. 336.
4. Id.
7. Id.
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10. Id.

11. Id.


13. Id., p. 3.


15. Id., p. 2.


35. AECOM (2012).


38. Id., p. 2.


40. Id.

41. Id.


46. Id.


48. Id.


50. Id.; p. 8.

51. Id.


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56. Id.


60. Id., p. 33.


62. Id., p. 300.


64. Id., p. 3.


66. Id., p. 7.


69. Id., p. 11.


71. Id.


73. Id.


75. Ibid., p. 14.


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81. Id., slide 11.
84. Id., p.1.
85. Id., p.6. In 2009, India withdrew from the project over pricing and security issues, and after signing a civilian nuclear deal with the United States. However, in March 2010, the Indian government called on Pakistan and Iran to convene tri-lateral talks on the project to be held in Tehran. See United Press International (2010), “New Delhi calls for IPI talks”, UPI, 19 March. Available at: www.upi.com/Science_News/Resource-Wars/2010/03/19/New-Delhi-calls-for-IPI-talks/UPI-15881269006235/.
86. Id., p.3.
89. Id., p.530.
90. Id.
96. Id., p.7.
97. Id.
99. Id., p.52.
100. Id., p.47.
101. Id., p.51.
104. Id., p. 20.
107. Id.
121. Khuong and Sovacool (2010).

Ibid.


Tan, “The Security of the ASEAN Energy Supply Chain”.


We did not conduct all of these interviews alone, and readers are invited to peruse the “Acknowledgments” for the names of colleagues that helped us.