Power to the People

Energy and the Cuban Nuclear Program

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I dedicate this to the memory of
Feliciano Martinez Alvarado and Vicenta Ramos Alvarado,
my loving grandparents.

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Preface

My interest in Cuba's nuclear program began innocently enough in 1991 with a request by William C. Potter, the director at Center for Nonproliferation Studies (CNS) at the Monterey Institute of International Studies (MIIS) to assist a visiting Russian scholar, Alexander Belkin, with a research paper. In my capacity as the project manager at CNS of the then "Emerging Nuclear Suppliers Project," I was familiar with stories and reports that Cuba was attempting to build a nuclear reactor. I was also aware that a recent defector was claiming that the construction was unsafe and that Cuba was also secretly building a nuclear weapons capability. My collaboration with Belkin resulted in a journal article and a trip in 1992 to Cuba. During that trip all of my requests for interviews and materials related to the nuclear program were fruitless. I did visit Cienfuegos, the provincial capital, and met with nuclear officials at their office in town, but I got no closer to the Juragua construction site than a ten-kilometer view across the bay.

I maintained my research interest in the program and eventually received funding to visit the island again in 1995. I was interested in assessing the impact of Cuba's loss of their economic support from the former Soviet Union and its successor, the Russian Federation, on its effort to complete construction of the nuclear reactor at Juragua. Rather than subject myself to the vagaries of the Cuban bureaucracy, I decided that I would go only when I could have a reasonable assurance that I would be able to conduct field research. Thus I waited one year until I was given the "proper" visa and assurances from officials that I could successfully address my research objectives in Cuba. I arrived in January 1996 to a pleasant surprise. At my initial meeting with government officials at the Ministerio de Relaciones Extranjeras (MINREX) I was informed that all of my requests for interviews with officials in myriad government agencies associated with the nuclear program had been approved. The next ten days would open a world of discovery to the complexity of Cuba's grandest technological undertaking since the revolution. Moreover, I also discovered that the

Cubans wanted to establish links to analysts and researchers in the United States looking at the scientific, economic, and political dimensions of the nuclear program. Even better yet was their open invitation to return to Cuba for further field research. Since that time I have returned four more times to interview government officials, guide a documentary film crew, and visit the reactor site, among the activities undertaken to better understand why Cuba is pursuing a nuclear ambition.

This unprecedented access to Cuba's nuclear infrastructure has resulted in a growing interest in my work here in the United States, and as a result, I have participated in numerous conferences and panels to discuss my findings. This has helped me and others to clarify much of the cognitive noise, bursting contradictions and outright lies that have permeated public discussion of this issue in Washington, Miami, and beyond.

This research has, of course, spawned my own professional development and understanding of this facinating project. This book began as my doctoral dissertation, and in the process of transforming it into the present text, I have carefully considered what is relevant to offering readers an understanding of Cuba's "Project of the Century." I have incorporated some new ideas about why Cuba selected the nuclear option and weighed the value added to the analysis of these ideas in a way that expands the boundaries of the dialogue beyond the notion that Cuba's nuclear program is reducible to a zero-sum calculation in terms of U.S. interests in Cuba. Those interests are that Juragua not be completed. Some have argued that the project is little more than a "Cuban Chernobyl"; if there is any international cooperation in the project, the argument goes, then it ought to be limited to issues of nuclear safety and quality assurance, and Cuba should ratify the Tlatelolco Accord. The analysis incorporates elements of the interests of the International Atomic Energy Agency (IAEA) and other states in energy development schemes in Cuba and other areas of potential cooperation and conflict. Those interests are identified as the provision of assistance to Cuba for the peaceful exploitation of nuclear energy. This includes assistance programs in the areas of nuclear safety, quality assurance, licensing and regulatory procedures, and scientific applications of nuclear energy in various sectors. This also encompasses the efforts by a number of states, including Canada, France, Spain, and Israel, to assist Cuba in expanding its electrical generation capability.

For its part, Cuba explicitly seeks to modernize its aging and deteriorating energy sector and infrastructure. To do this, it must be able to attract investment and continue to develop nuclear, conventional, and alternative energy sources. It has linked these objectives to the expansion of science and technology in all areas of Cuba's daily life. This has been undertaken to

establish Cuba as a responsible regional partner in the arenas of energy development, advanced technology, and security.

Within all of these divergent policy objectives are areas of common interests. At the national, regional, and international levels, all agree that there must be (1) safe development in the nuclear sector; (2) the promotion and implementation of nonproliferation norms and values; and (3) the modernization of Cuba's infrastructure and a specific linkage to quality of life issues in the Cuba of the twenty-first century. Any optimism for cooperation in these areas must also be tempered with a dose of potential conflict over Cuba's continued efforts to address chronic energy shortages on the island. Questions remain regarding whether Cuba can successfully develop a nuclear energy capability. This is coupled with Cuba's failure to sign and ratify nonproliferation accords such as the Nuclear Nonproliferation Treaty (NPT) or the Tlatelolco Accord. Should Cuba come close to finishing the reactor at Juragua, a number of other questions are raised: Would the United States be willing to apply provisions of the Helms-Burton law that label a completed nuclear facility as "an act of aggression" against the United States? What actions would the United States take in that case? Could this undermine the already tenuous nature of nonproliferation agreements in Latin America and beyond? Would a completed nuclear plant in Cuba be a waiting "Cuban Chernobyl"? This book is a direct attempt to address these issues in an objective framework of analysis and seeks to be the definitive assessment of the status of Cuba's energy development program at century's end.

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Contextualizing Cuba's Nuclear Program

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Since the early 1980s, Cuba has been attempting to develop a domestic nuclear energy capability. With assistance from the former Soviet Union (FSU), Cuba envisioned a network of nuclear-powered electrical generation stations across the island. This would alleviate its dependence on external sources of fuel for energy and provide it with a shining example of the success of the Cuban Revolution. Indeed, a nuclear complex designed and built by Cuban hands would give some measure of credibility to Cuba's revolutionary model of development. Yet in the period since the "Project of the Century" was conceived in the late 1970s, Cuba has been forced to deal with a series of setbacks that have the potential to relegate this grand infra-structural objective to the "dustbin of history." The Cuban nuclear project has suffered from design deficiencies, construction delays, and, finally, in 1992, the loss of financing from its partners, then the Soviets, and now the Russians.[1] Compounding Cuba's woes have been shortages in the energy supply because of reduced levels of imported oil during the "Special Period in a Time of Peace," shortages causing a significant reduction of the energy supply on the island. The reduction in the energy supply has devastated Cuba's industrial output; it is estimated that economic activity in Cuba declined by almost 85 percent in the two years following the collapse of the Soviet Union.[2] It is also estimated that the Cuban economy has conflated by more than 35 percent in the period since 1991.[3] In addition, there has been a steady stream of allegations decrying the potential of a "Cuban Chernobyl from a nuclear accident at the reactor site in Cienfuegos province" spewing radioactive particles upwind

from millions of Americans in the southeastern United States.[4] As of early 1999, the Cuban nuclear energy program was only partially complete with nearly 75 percent of the civil construction and only 20 percent of the instrumentation and control systems complete on the first unit at the Juragua site in Cienfuegos Province.[5] Cuba remains mired in a difficult situation because it is estimated that the country has been able to generate only 30 percent of the energy required to meet the domestic consumption demand. The severely diminished output has resulted in rolling blackouts, disrupted services, and the shutdown of factories and other industrial installations throughout the island.[6]

Because of this problematic situation, a number of questions can be asked in relation to the development of nuclear capability in a developing state such as Cuba. This includes the role that this project plays within the larger context of the revolutionary model of the development and modernization program now underway in Cuba. This project has been described by the "normative features spawned by the chosen development strategy and the dominant ideology."[7]

- Why would Cuba, a relatively isolated developing nation with a weak economy, attempt to develop a nuclear energy capability?
- Why has Cuba selected the nuclear option? Are there more efficient means of addressing Cuba's energy needs?
- What were the incentives and disincentives of pursuing a nuclear technology capability?
- Within this context, can Cuba's attempts to develop this capability have more to do with symbolic gestures that are flattering to the ideological underpinnings of the revolutionary model of development than they are to addressing real needs?
- If so, what is the ideological foundation of this grand scheme? Is it socialist, nationalist, a combination of the two, or, in the post–Cold War milieu, purely instrumental?
- Finally, is the revolutionary model of development appropriate to the ends desired?

The choice of developing a nuclear energy capability is puzzling when one considers the following. At the inception of the program, Cuba possessed few if any of the technological or capital resources required for this project. The capital-intensive nature of such an undertaking has proven difficult for even a much larger and more economically developed state such as Brazil to complete.[8] The amount of value added to the energy-generating capacity of the existing electrical grid would still leave Cuba with resources insufficient to jump-start its industrial and manufacturing sectors.[9]

With the amount of capital expended in pursuit of this capability—more than $1 billion—Cuba conceivably could have renovated and modernized its entire existing energy-generating complex. These examples follow the line of reasoning that suggests that Castro's penchant for adventuresome projects has consistently diverted managerial talents and enormous resources into nonproductive outlets.[10] Any number of ideas have been offered to answer these questions, but for the most part they have been offered in the form of journalistic reportage and policy advocacy. Heretofore, there has been little in the way of a systematic social science analysis of the case.

This book is a case study examination of Cuba's attempt to develop a nuclear energy capability. In order to understand this case and provide a basis for analyzing these questions, it is prudent to revisit some of the assertions and approaches offered by the modernization and development literature.[11] Moreover, by applying the theories and approaches advanced by this school of grand theory, one might be able to determine the fit between some propositions of the theories about the process of development and the quest for high technology and the actual details of that process. From this we may be able to infer the validity of one or more of the competing approaches. This is to be accomplished by providing an overview of the case history and by beginning the discussion with two related but separate research questions: Why did Cuba choose to pursue a nuclear energy capability, and why has Cuba persisted in its nuclear energy development program? The first question is the primary focus of the thesis at the initial discussion of the case. We cannot answer the second question until we fully explain the sources, justifications, influences, and practical actions undertaken in the pursuit of nuclear power.

The questions posed in this case are puzzling for at least two reasons:

1. There are environmental and nuclear safety concerns raised by critics that seriously question the capabilities of the Cubans. Safety is a concern of mostly American critics who assert that the Cubans under Castro are incapable of meeting requisite thresholds of environmental protection and safety in the operation of a nuclear power station, which leads to the perception of a "Cuban Chernobyl."
2. There are also serious economic factors that preclude Cuba from ever being able to complete a nuclear reactor at Juragua. To reiterate one of the initial questions of this inquiry, why does a developing state, strapped for cash, in serious debt, and almost completely dependent on external sources of capital, seek to develop a highly capital-intensive form of energy generation that may be outside of its reach of capabilities?

This case is important because of the future domestic considerations regarding the maintenance and management of the existing energy-generation capability, which are significant in the case of Cuba's attempt to develop a nuclear energy capability. Moreover, the international scope of Cuba's efforts to develop nuclear energy informs our understanding of the paths that might be employed by other developing states with similar energy demands, capabilities, and shortcomings. States rarely, if ever, develop nuclear energy capabilities in isolation. There are myriad complex relationships that are both necessary and sufficient for the undertaking of such a grand infrastructural project. Adding to the relevance of Cuba's attempt to develop a nuclear energy capability is the relationship to inquiries regarding nonproliferation matters, along with related questions of export controls, the supply of nuclear fuels, and the storage and disposal of nuclear waste.

There is a general set of considerations applicable to all cases of nuclear energy development in developing states.[12] They may not be seen in all cases of nuclear energy development in developing states, but it suffices to say that most are usually present or expected to be so in these cases. These considerations have provided the basis for analyzing the nuclear energy policy decision-making process. It is important to link these considerations to the domestic circumstances underlying specific cases of attempts to develop nuclear energy in developing states. This serves two purposes: first, to provide a more profound basis of understanding the actions that are particular to the Cuban case; and, second, to determine which if any of these actions or considerations in the decision-making process is generalizable.

Cuba's decision to pursue a nuclear energy capability can be viewed as a part of a grander scheme of modernization and industrialization. Within the "grand theory" of modernization and developmentalism there are three specific approaches that potentially provide a firmer basis for analyzing and explaining the policies and activities in this area.

The first approach employed in this inquiry, politically motivated modernization, argues that states utilizing politically motivated models of development and modernization (nationalist and ideologically based models) are more likely to choose projects that are symbolically more flattering to the political ambitions of the standing regimes.[13] Under this approach, the choice of projects is highly determinate of the selection and subsequent completion of large infrastructural and industrial projects in developing states such as Cuba. Moreover, this assumes that this and all subsequent approaches are the elite-oriented, and the decision-making process is exclusive and highly centralized in nature.

The specific expectations of this approach are the following:

1. The policy decision-making process and the resulting policies to be implemented minimize economic rationality at the expense of political expediency.
2. The specific political objectives of policies undertaken under this approach are identified as prestige, status, and symbolic value.
3. Any material objectives that might accrue to the regime and society are viewed as secondary considerations and by-products of the political objectives.

The second approach, economic and technological modernization, asserts that Cuba chose to develop nuclear energy to achieve technological modernization, scientific expertise, and the resulting domestic energy self-sufficiency.[14] The specific expectations of this approach are that the policy objectives of projects under this approach to modernization and development of nuclear energy are technological modernization, the expansion of technical expertise and capability, and the promotion of economic self-sufficiency.

The final approach derived from this body of literature is energy and economic security. It suggests that Cuba chose to develop a nuclear energy capability to address specifically its chronic energy dependency, to develop a civilian nuclear industry, and to inure itself from the detrimental impact of a potential loss of energy sources.[15]

After a general discussion and a definition of the modernization process, the politically motivated, economic and technological, and energy and economic security variants of modernization will be discussed.

Modernization has been defined as a process that increases the economic capabilities of a particular nation or society through industrialization and the political capabilities for that same entity through bureaucratization.[16] The core process through which modernization is achieved is industrialization; economic growth becomes the dominant societal goal, and achievement-motivation becomes the dominant individual-level objective. The transition from preindustrial society to industrial society is characterized by "the pervasive rationalization of all spheres of society,"[17] bringing a shift from traditional, indigenous, usually religious values to rational/legal values in economic, political, and social life. Highlighting an enduring debate, Inglehart states,

> A wide variety of social theories have argued that technological and economic changes are linked in coherent and predictable patterns of cultural and political change. But there has been a continuing debate over the causal linkages: does economic change cause cultural and political change, or does it work in the opposite direction?[18]

In relation to the case of Cuba's nuclear program, the debate over cause and effect endures as one of the salient inquiries regarding Cuba's decision to pursue this capability. In the employment of a politically charged modernization scheme, is it political change that has directed the trajectory of economic and technological changes in Cuban society? Or, as the above-mentioned question suggests, does this process work in the opposite direction, from the economic to the political, and what are the implications for Cuban society if this is the direction of change? If so, will the change under the guise of economic and technological advancement be coherent and predictable as Inglehart suggests? To begin the inquiry, we introduce the first of three plausible hypotheses advanced to provide a fuller explanation of Cuba's nuclear ambition.

Politically Motivated Modernization

The approach of politically motivated modernization asserts that the process of modernization is guided by ideological and political motivations, and all resulting policy objectives and their implementation are reflections of this underlying logic.[19] Moreover, rather than being a post hoc justification of an observed political phenomena, this approach retains a highly predictive value inasmuch as it provides a template of the trajectory of the drive toward and the persistence of Cuba's objective of developing domestic nuclear energy competence. What differentiates this approach from the others is that it centers on the political objectives of a regime as opposed to any material, economic, and socially efficacious ones. This approach also maintains that there are limits to economic rationality in choosing the nuclear option, especially when the perceived political rewards, such as prestige, propagandistic value, and symbolic accomplishment, are more highly regarded than any of the material and economic rewards associated with the attainment of a nuclear power (NP) capability.[20] Under this approach, the economic and social benefits associated with the development of an NP capability are considered by-products of the political rationale that guides these activities. The specific expectations for this case are:

1. The selection of policy choice reflects the overarching political (nationalist and ideological) objectives and possibly minimizes economic rationality.
2. The political objectives of states employing this approach are national prestige, increased international status, and the symbolic and propagandistic capital that can be garnered for domestic and international consumption.

3. The material objectives are secondary in nature to the political ones, and any benefits that can accrue to the regime and society are viewed as by-products of political objectives.

This approach is rendered inoperative when support for a nuclear energy development program is withdrawn at the highest level of government. All nuclear energy development activities need not be terminated when the reorientation of priorities is sufficient to signal the shift away from this model of modernization and development. Such a shift is manifested in the prioritization of modernization being contingent upon sound underlying economic and environmental rationale. As was previously mentioned, economic rationality is often eschewed when decisions are made under the politically motivated approach to modernization. Although one could argue that political motivation is always in place, by carefully evaluating the implementation of policy one may be able to determine a shift away from the nationalistic and ideological foundations of a policy to other priorities.

Economic and Technological Modernization

The economic and technological approach to modernization may be defined as access to the advanced technology and industrial skills needed in a nuclear power program. The approach may be seen in a wider context as a means of raising the level of scientific and technological development, just as electrification based on nuclear power generation may be seen as an optimal path to economic development based on electrification.[21] Additionally, the education, training, and development of cadres of engineers, scientists, and technicians may be viewed as important by-products of this process, which is viewed as a logical and necessary component of the overarching modernization process, with special attention to the ability of a society to create knowledge and technical expertise. This approach is viewed as a means of mastering nature, and the assimilation of science and technology requires a positive attitude of society toward innovation and experimentation.[22] Under this hypothesis we would expect several things, including:

1. The policy objectives of projects selected under this approach are technological modernization, the expansion of technical and capability, and the promotion of economic self-sufficiency.
2. The important by-products of this approach are the training and development of cadres of scientists, engineers, and technicians and the creation of knowledge and technical expertise.

This approach is undermined when it becomes apparent that sound economic decision making is disregarded for other, less tangible objectives.

It is often argued that developing states are more prone to adopt developmental schemes that are more symbolically than materially rewarding. It may also be the case that the nuclear energy development activities are couched in terms and objectives germane to this approach but are lacking in the underlying rationality. This is especially important to note in the case of this approach because the ultimate goal of these developmental schemes is the same. The key indicator for assessing if the nuclear energy development schemes adhere to this approach is whether or not they are economically feasible. This can be assessed only after a cost-benefit analysis of the program is undertaken.

Energy and Economic Security

The development of centrally generated electricity may offer unique economic advantages, and after careful analysis, nuclear fission may emerge as a means of generating electricity at the lowest real cost. The introduction of nuclear power may help to diversify and augment the domestic supplies of energy in general, and electricity in particular, thereby diminishing dependence on any one source of supply and reducing the dependence on imported energy sources.[23] In particular circumstances still to be defined in this inquiry, centrally generated electricity may offer unique economic advantages in comparison to other sources of energy generation, and after analysis, nuclear energy may emerge as the means for Cuba to produce energy at the lowest real cost.

There is an underlying relationship between (1) a nation's energy needs and external dependence or exposure, (2) economic and political stability, and (3) broader security concerns. The nature and intensity of these relationships will, of course, vary from country to country in the developed and developing world, and within a country over time. When dealing with security in the context of energy, we are concerned with the broad and unavoidably subjective connotation of the term. Such a grand interpretation encompasses economic, political, strategic, and military aspects of security, as opposed to the more minimalist interpretation that focuses on specific military threats and defense programs. Economic security focuses on national resource sufficiency and, in particular, access to goods and services in world markets in affordable terms. Political security suggests the maintenance of domestic stability, whether it is based on rule by the consent of the governed or on varying degrees of authoritarian measures. Either way, law and order prevail, and economic political and social activities are conducted with little or no hindrance. Strategic and military security is partly outward looking and may be gauged by the degree and intensity of per-

ceived external threats and the military capability that can be marshalled to meet those threats. It is also inward looking in that it involves the diversion of domestic resources and services to meet those threats. Under this approach the expectations are as follows:

1. The choices of policy objectives focus on maintaining access to secure sources of energy; in some cases the choices involve the development of stand-alone energy sources such as nuclear energy.
2. The choices of policy seek to limit a state's external dependence on, and exposure to, world energy markets.
3. The implications of energy development under this approach are a long-term focus on the effects and interactions between energy, the economy, and security in a given state, resulting in a balance between economic growth and security planning.

It should be clear that a nation's energy policy and management carry significant implications for both its security and economic domains. Energy shortages at home require adept diplomacy and adequate bargaining power to fill the breaches. External and internal security, as well as external trade policies and economic development plans, have their roots in the successful or unsuccessful management of energy policy. Energy policy management must aim at maintaining the present equilibrium (if satisfactory) or advancing the policy to safer and more secure levels. This includes a review of the relevant literature and a discussion of the expectations from each of these approaches as they relate to the conception, implementation, and evaluation of nuclear energy development in Cuba.[24]

Research Methodology

How does one confirm or disconfirm which, if any, of these plausible approaches and hypotheses more fully explains Cuba's initial decision to develop nuclear power capability? And which, if any, of these hypotheses can provide an explanation for the persistence of Cuba to complete its nuclear energy objectives in the face of daunting obstacles? The case evidence identifies nuclear energy policy objectives, along with the selection of policy instruments, to achieve those objectives. This case study is an exploratory observation of the Cuban nuclear energy development program and policies from the late 1970s to the present by using a method of process tracing of Cuba's nuclear policy under the microscope of competing approaches to modernization in a developing state.[25]

The criteria for the selection of this case is justified for the following reasons:

1. This is a case with large within-case variance in the value on the independent variable, dependent variable, or conditional variable across time or space. In other words, the historical trajectory of Cuba's efforts to develop a nuclear energy capability has been fraught with obstacles, such as safety deficiencies and financing, which has forced Cuba to alter or re-evaluate their policy objectives. Additionally, the end of the cold war with the accompanying loss of Soviet-bloc trading partners and aid donors have significantly altered Cuba's aspirations. For these two reasons we can suggest that the impact upon the variables being employed in this investigation has caused them to be altered to these changes over time.
2. This is a case about which the competing approaches make opposite and unique predictions. The approaches to modernization processes and industrialization make competing predictions about what we can expect from the decision of developing states to pursue a nuclear energy capability.
3. This is a case that resembles current situations of policy concern. Cuba's decision to exploit nuclear energy is certainly not a unique phenomenon. Nevertheless, it does hold a special place within the spectrum of international policy analysis, given the fact that it is the last "socialist" state in the Western Hemisphere. Cuba is attempting to develop a nuclear energy capability in contradistinction to U.S. policy, and it maintains a significant, albeit disproportionate, hold on the fixation of the U.S. policy community. All these reasons make the Cuban case, and the analysis of competing approaches of nuclear energy development, worthy of study.

Within this context, to examine and analyze the expectations highlighted, this investigation will employ the case study method. This method is most suitable for this kind of investigation where the researcher (1) asks "how" and "why" questions; (2) does not and cannot control the actions of the subjects and/or events being studied; and (3) focuses on contemporary events in their natural context.[26] Moreover, the case study method is useful when the researcher attempts to shed light on particular decisions; processes, institutions, and events; why and how each of these events operated and were made; and what resulted.[27] This case study is undertaken to assess the expected actions compared against Cuba's empirical record in nuclear energy development. The objective is to determine which if any of these approaches best explains the efforts of Cuba to develop a nuclear energy capability.

The tracing of the trajectory of energy development policy will determine if policy objectives and implementation correspond to the proposi-

tions advanced by a specific model of nuclear energy development, or if another model of development provides a fuller explanation of this path to development.[28]

The investigator explores the chain of events in the decision-making process by which the initial case conditions is translated into case outcomes. The cause-effect links that connect independent variable and outcome are unwrapped and divided into smaller steps; then we look at observable evidence of each step. Does this chain of events or the decision-making process unfold in the manner predicted by the theory? Specifically, do actors speak and behave as the theory predicts? Do they perceive and respond to stimuli in the manner predicted? Do timing and details of their behavior match predictions? Do the timing and details of other events that comprise the process of developing a nuclear energy capability, which translates initial conditions into outcomes, match the theory or approach predictions? The tighter the fit between the theory's or approaches predictions about that process and the actual details of process, the stronger the validity of that theory.

Most theories and analytical approaches make many predictions about causal process. Hence, process tracing allows the investigator to test many propositions within a single case observation. For example, a traceable process of causation for the hypothesis that "revolutionary models of modernization eschew economic performance for symbolic gestures" might be as follows: as a revolutionary state attempts to develop large infrastructure projects, the concern for political consolidation causes a lower priority for economic factors in development and thus lower and less efficient economic performance. Here we have one theory but many predictions.

Moreover, process propositions are often unique—i.e., no other known theories or approaches predict the same patterns. Hence, process tracing often offers strong tests of a theory. If a case supplies abundant and reliable data that bear upon unique process predictions of this sort, then a single case can provide a very strong test of a theory. As noted above, the investigator will still be unsure of what antecedent conditions the theory may require to operate; discovering these conditions remains an important task. They can be found only by exploring other cases. In this vein, the study of nuclear energy and development in Cuba is anything but a unique phenomenon. However, the validity of the theory and its ability to explain at least one case have the potential to be strongly confirmed. Yet this is not the overriding concern of this investigation. Theory testing comprises only a small area of the available objectives within the spectra of social science inquiry. Specifically related to this case, the application of theory is a more important although infrequently utilized means of measuring the validity of a given theory or methodological approach than is theory testing.

The data collection includes five previous visits to Havana for field research, including personal interviews with officials, researchers, journalists, and other experts knowledgeable about Cuba's nuclear activities. The research also includes interviews with counterparts in the United States who have been involved in the monitoring and analyzing Cuba's nuclear activities. Data collection includes a number of personal interviews, published and unpublished monographs, articles, official speeches, and reports on the Cuban nuclear program. It also utilizes various electronic information sources and Internet databases, including but not limited to the Center for Nonproliferation Studies database[29] and Lexis/Nexis news database for citations and articles pertinent to the research.

The presentation of evidence consists of three distinct but related parts. First is an assessment of the state of the energy sector in Cuba at the inception of the nuclear program. This assessment is a description of the structure, requirements, and capabilities of the energy sector in Cuba from the late 1970s and throughout the period in which Cuba has attempted to develop an advanced energy capability. The second part includes the identification and description of the exact policy objectives and rationalizations for the pursuit of nuclear energy. The third and last section is an assessment of the impact of external factors influencing Cuba's nuclear development efforts, including bilateral cooperation, international/multilateral cooperation, and opposition from Cuba's chief regional adversary, the United States.

The evidence presented is derived from four years of ongoing investigation and field research into Cuba's nuclear program. This includes interviews with a number of officials from Cuba's various nuclear-related agencies; numerous primary sources such as official government documents, government publications, and reports; and numerous secondary sources including press reports and journal articles.

The criteria for evaluating evidence require that one provide specific examples of evidence necessary to conclude which of the three possible explanations are more robust. In other words, part of the hypothesis-generation process should identify clearly and specifically which kinds of data, evidence, arguments, public statements, and so forth would allow the reader to conclude which one of the three possible explanations is supported. The simple issue is that we need to know—before the investigation—what kind of information and evidence would let us conclude which of the three hypotheses is more compelling.

In the case of politically motivated modernization specifically we would expect that Cuban officials would hinge much of the rationale for development schemes in terms of prestige, reputation, and the propagandistic value-added of infrastructural projects. These kind of statements are found

in press releases, official government speeches and documents, and personal interviews. This kind of evidence is corroborated by secondary sources such as newspaper reports, external policy analyses, and technical assessments. Specifically, these types of evidence would show that Cuba's efforts to develop a nuclear energy capability would be void of the infrastructure and bureaucratic development commonly associated with such grand undertakings. Through these same sources one would expect to find support for this model by Cuba's choice of a rapid form of nuclear capability that would eschew the development of indigenous human resources for the symbolic short-term achievement of completing a nuclear program. Even with such an achievement, Cuba would still remain exposed to the vagaries of external supply and dependence. Under such a development model, the ultimate purpose of any undertaking by the ruling elite is the consolidation of political power.

Under the economic and technological modernization model, one would expect to see that statements from government officials would almost always be cast in terms of the economic rationality of the development scheme. Specifically, examples of this type would contain statements regarding the development of special capabilities and resources in Cuba over time. Policy analysis would reveal that the parallel development of support bureaucratic and legal structures, including but not limited to educational, training, regulatory, and licensing institutions. This type of analysis would also provide evidence of technical expertise and human resource development in concert with larger policy objectives. Technical assessment reports available from international and multilateral organizations will also provide additional evidence in support of this model. Under this model we would not expect to see an overriding concern for a developing dependency on imported high-technology components and equipment from outside of the island. Because Cuba remains a closed society it is important to account for the possibility of misinformation and false information from Cuban sources. This issue is addressed by cross-reference of Cuban sources with independent and external analyses where possible. In the case of personal interviews the researcher asked a number of questions phrased differently and sought interviews with the same personnel during different field research visits to Cuba.

In support of the economic and energy security model we would expect to find that official statements would be focused on the maintenance of secure sources of energy. In the case of Cuba this concern would almost exclusively deal with the development of stand-alone energy sources such as the nuclear energy program. These statements would also emphasize how the nuclear program would minimize Cuba's exposure to the vagaries of the world energy market. These statements would also be couched in terms of

balance between economic growth and security planning in the long term. This approach would be supported by the implementation of policy that would develop national capabilities as well as inure Cuba from external disruptions in energy imports. Government statements would also include the concern of perceived external threats.

The assessment of the state of energy in Cuba includes an evaluation of the apparent costs of nuclear energy development. The basis of the evaluation can be arranged into five broad areas:

1. Investment Capital—Whatever is the long-term real cost of nuclear-generated electricity, creating and supporting a nuclear energy generation capacity, with the necessary industrial and regulatory infrastructure.
2. External Dependency—Whereas one motive for acquiring NP may reduce dependence on imported fuels, gains in that regard have to be set against the extent to which a nuclear power program entails additional dependence on external suppliers for materials, equipment, technology, services, and skilled manpower.
3. Supply Inflexibility—In any developing country, such as Cuba, even a single reactor of minimum size now readily available in the international nuclear market would represent a large proportion of the total electricity supply system, with obvious implications for the vulnerability of the system with the removal of a single generating unit from service to the system for any significant period of time.
4. Institutional Gravity—In addition to the financial cost of establishing and operating the administrative and regulatory institutions specifically needed in running a nuclear power plant (NPP), the tendency for such a program to draw a substantial portion of the best scientific, technical, and administrative talent in a developing program into a highly centralized institutional structure may be regarded as socially, economically, and politically expensive.
5. Energy Intensity—This is an economic calculation that generates the "energy intensity" of a nation's energy sector by looking at the relationship between the GDP growth rate and the real amount of GDP expended to satisfy a nation's energy demand.

The next stage of analysis consists of identifying specific policy instruments and the path employed to increase Cuba's energy capability. This analysis assumes that Cuba has expressly chosen the nuclear option after considering other energy alternatives. Those alternatives will be discussed by assessing their potential benefits and costs to the Cuban energy sector as compared to the nuclear option.

In this case the distinct paths or options for the development of a nuclear energy capability available to Cuba are identified as:

1. A Turnkey Project—This is defined as a project in which an external nuclear industrial enterprise comes into a country, designs and constructs a ready-to-operate nuclear power station, and provides the requisite technical, material, and operational support. The path of this kind of project is relatively short in time (two to four years) and relies heavily on external support for continued maintenance and operation of the facility.
2. A Technical Assistance Program—This is defined as a program in which the importing country sets out to have its own architects, scientists, engineers, and technicians participate in all aspects of the planning, design, construction, and operation of a nuclear power station. This program may also include sending scientists and engineers outside of the country to receive advanced education and training if none is available in the developing state.

A technical assistance program is potentially much more time-consuming than the turnkey option, but "theoretically" it assists in providing the developing state with the domestic capability of conducting all of the operational and maintenance activities related to a nuclear power station.

The third stage of analysis consists of examining the external factors and influences in the development of Cuba's nuclear energy capability. This stage of analysis examines the relationships in which Cuba has engaged in order to move toward its objective of developing a domestic nuclear energy capability, along with the parallel scientific and technological advancement programs. The analysis of these relationships focus on three areas:

1. Bilateral Nuclear Cooperation—This section is primarily focused on Cuba's relationship with the former Soviet Union and the present Russian Federation, which has been Cuba's major partner in the nuclear enterprise. This examination will consider what impact the practices of the Russian nuclear culture exerted on Cuban policy decisions in the program of energy development. It will also consider how involved Russia has been in the day-to-day decision making and implementation of policy.
2. International and Multilateral Nuclear Cooperation—This examines the impact of cooperation with international nuclear and nuclear-related organizations on Cuba's energy development program. Such organizations include the International Atomic Energy Agency (IAEA), the Organismo por el Prohibicion de Armas Nucleares en

America Latina (OPANAL), the World Association of Nuclear Operators (WANO), and the American Nuclear Society (ANS), among others. This section will also investigate what effect if any this type of cooperation has had in promoting the advanced technology sector in Cuba.

3. United States Opprobrium to Cuba's Nuclear Efforts—Since the late 1980s, the United States has included abandoning construction of the NPP at Juragua as a condition for the normalization of relations with Cuba. The United States has also passed domestic legislation geared to limiting international cooperation with Cuba on the nuclear program.

This section of the thesis examines the impact of U.S. efforts on the Cuban nuclear program, including their effectiveness and shortcomings.

Expected Findings

One cannot consider answering the original research questions without reviewing the entire trajectory of policy choices and their implementation in Cuba's attempt to develop a nuclear energy capability. This review includes an evaluation of how closely the evidence corresponds to the expectations of the three approaches. This includes correlating the expectations with the findings and explaining the hypothetical and actual deficiencies of the three approaches. At this point, an answer to the original research questions posed in this inquiry should emerge.

Through the employment of the process-tracing methodology, one should expect that the motive and incentive for developing a grand infrastructural project, such as building a nuclear reactor in Cuba, ostensibly serve two purposes. First, the idea of completing a nuclear reactor with highly trained Cuban hands would be brilliant propaganda in confirmation of the success of the Cuban revolutionary model of development. By extension, Cuba's development activities should always be viewed with this in mind. As it relates to the notion of propaganda, the first question should be: How much political capital could be garnered by engaging in such an activity? By developing cadres of highly trained professionals, does the activity further the overarching aim of consolidating power on the island?

Second, economic efficiency and performance are not the indicators with which observers should concern themselves in relation to the Cuban nuclear energy development program, although both factors are significant. Their significance was especially evident while Cuba could rely on the willingness of the Soviet Union for financing most of the country's development schemes.

In the wake of the demise of the Soviet Union and the end of the cold war, economics has become increasingly important. But Cuba's continuing efforts to develop a nuclear energy capability partially confirm that the political objectives of the revolutionary model of development still maintain considerable currency in Cuba's processes of policy and decision making. Related to the source of these ongoing contradictions is whether the mode of development is really development at all. Considering however admirable the advances in public education and public health are, the Castro regime in effect has merely extended to the masses a well-established, albeit elite-oriented, infrastructure in these areas from the prerevolutionary period. More recently, Cuba's effort to develop tourism and biotechnology can be viewed as additions to the pantheon of symbolic icons that the regime utilizes for political consolidation.

Cuba's ongoing and persistent failure to develop nuclear energy during the past twenty years presents a dilemma of sorts for the Castro regime. The start-and-stop nature of the project reflects Castro's dilemma. To admit that the dream of constructing a network of nuclear reactors across the island may never come to pass would be to admit that the model itself has failed. This dilemma partly explains why the current regime has not fully abandoned the project. It also partially confirms many of the overly ambitious predictions that proponents of modernization and neomodernization theory have advanced.

I expect to find that the symbolic rationale established during the early stages of the nuclear energy development program has been discarded for an approach that is much more economically rational in regard to grand infrastructural projects. While Cuba was initially concerned with development projects that mostly flattered the ideological and mostly symbolic underpinnings of the Cuban revolutionary process, it was also inured from facing the realities of the world market because of its client status with the Soviet Union. In fact, this shielding from reality may partly explain the continuing push throughout the Castro period for technological ascendancy. A preliminary analysis of Cuban nuclear activities suggests that officials involved in initiating the nuclear program gave primary consideration to political reasons, viewing economic dividends as important but less significant. At the outset the government attempted to emphasize the economic benefits of a reduced dependency on imported oil. Cuba's actions left little doubt as to the prime motivation for the venture by choosing to pursue a course that combined technical assistance from the Soviets and, later, from the Russians while developing Cuban human assets in high technology. This was perceived to be the most flattering to the political ambitions of the Cuban leadership. It also reflects a continuation of the historical Cuban search to

master new forms. Much of Cuba's modern thinking has been dominated and influenced by a conscious attempt to leave behind its Spanish colonial legacy and the vestiges of those forms that dominated it for more than four hundred years. Cuba's desire for independence began in the mid-nineteenth century, was accompanied by a search for new forms (e.g., scientific and technological transfer and acquisition), and represented a rejection of things Spanish and the adoption of modalities from the north. Indeed, a nuclear reactor built by Cuban hands would become a brilliant propagandistic confirmation of the successes of the Cuban Revolution and the Cuban model of development, but it also represents the culmination of Cuba's desire and ability to adopt and integrate the highest advances of science and technology into everyday life.

The remaining chapters of the book consist of the following: chapter 2 is a review of the relevant literature, exploring both the theoretical and substantive foundations of this examination that inform both the plausible hypotheses and the actual case. The theoretical review includes an in-depth discussion of the relationship between the foundations and expectations of grand modernization theory and their practical application in developing states. This review encompasses a discussion of the role of energy development in modernizing and developing states, the basis for analyzing decision-making processes, the economic considerations for energy development, and the relationship between energy development and economic and political considerations in developing states. The substantive section of the literature review explores the case-specific literature on nuclear energy and energy development in Cuba. The reason for dividing these two bodies of literature is to determine what shortcomings exist in these works and to establish a concrete linkage between the theory and praxis of this case study.

Chapters 3 and 4 are comprised of the evidence collected in support of this examination. Chapter 3 focuses on assessing the state of energy in Cuba at the start of the nuclear program and at present. This chapter is divided into three sections. The first section is comprised of a detailed description of the structure and function of the energy sector with an assessment of the energy requirements, resource constraints, and intensities in this sector. The next section is a cost-benefit analysis of the policy objectives and instruments, including the energy generation options in Cuba and the model of energy development. The chapter closes with a discussion of the actual energy option model of development selected by the Cuban government in its pursuit of a nuclear energy capability.

Chapter 4 looks at the external factors of influence on Cuba's efforts to develop nuclear energy. The discussion centers upon the bilateral, multi-

lateral, and international aspects of Cuba's cooperation in the nuclear field. The section on bilateral cooperation reviews Cuba's relations with its primary development partner, the Soviet Union, as well as partners in Canada, Europe, and the Latin American region. The section on multilateral and international cooperation focuses on Cuba's membership, role, and the country's interaction with myriad international organizations, and nuclear and energy-related associations in which Cuba has participated in the period since the inception its the nuclear program. The chapter will also briefly look at the impact of U.S. opprobrium to Cuba's efforts in the energy sector.

Chapter 5 consists of the analysis of the case study utilizing the process-tracing methodology. The analysis can be broken down into three distinct sections. The first includes the selection and implementation of specific energy development policies and instruments, assessing the model of energy development utilized to achieve those objectives. The next section examines the plausibility of the three approaches employed in this examination; it is accomplished by comparing the expectations of each approach against the actual behaviors and actions exhibited in the case study. The final section ties together the analyses of the practical and hypothetical actions, in this case in a set of findings that speak directly to the original research questions posed.

Chapter 6 is a summary discussion of the case study, including a discussion of the case-specific and general implications of Cuba's attempt to develop a nuclear energy capability and recommendations for future research.

Theoretical and Substantive Dimensions of Modernization and Development in Cuba

2

This chapter examines the case in the context of theoretical and substantive foundations that inform the hypotheses being advanced. The theoretical review is divided into three sections. The first is a discussion of the relationship between the foundations and expectations of grand modernization theory. This includes the practical application of this theory to developing states; an examination of the idea of modernization by revolution; a discussion of the political consequences of modernization; and a review of the pertinent critique of above-mentioned ideas. The second section is a discussion of the role of energy development in modernizing and developing states, including the basis for analyzing decision-making processes, the economic considerations for energy development and the relationship between energy development and economic and political considerations in developing states. This section of the review specifically pertains to the development of the three hypotheses being employed in this case study examination. The third section is a review of the substantive literature exploring the case-specific literature on nuclear energy and energy development in Cuba. The reason for dividing these three areas of literature is to determine what value and shortcomings exist in these works and to establish a concrete linkage between the theory and praxis of this case study.

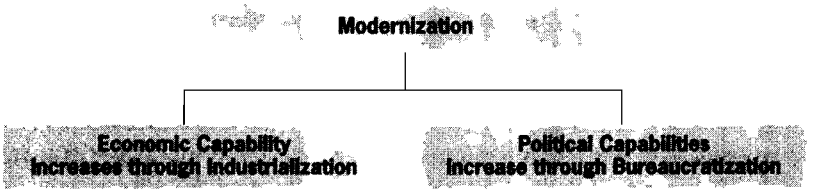
At this point there are two major areas of inquiry that are absent from the existing literature. First, there has been little or no linkage of the issue of nuclear energy development in developing states to any analysis based on social science theory. That is, there has been little in the way of theory appli-

cation.[1] Second, the linkages to incentives and disincentives for the development of nuclear energy in general have been underanalyzed in the literature;[2] any linkages specific to Cuba have not been systematically and rigorously addressed.[3] This chapter seeks to establish these two points as the foundation of the analysis of this case, bearing in mind that the original research queries seek to examine Cuba's decision to pursue a nuclear energy capability.[4] Prior to engaging in a discussion of the working hypotheses that will be explored, it is important to place these points within the context of the trends in Latin American social science and comparative political inquiry.

Modernization Theory in Latin American Social Science

For the most part there has been a considerable change in the research agenda for social science in the area of Latin American studies. The changes have "evinced a cyclical tendency to embrace and discard grand theoretical schemes."[5] Modernization theory, which gained widespread popularity in the 1960s, was one of these grand schemes.[6] The argument advanced by modernization theory posits simple causal connections. Economic development creates middle class sectors in developing states, whose members in turn espouse political democracy, either as a tactical means of gaining power or as an expression of enlightened values (whether they were socialist or nationalist in nature, the difference mattered little to theorists at the time). The greater the level of economic development, the greater the likelihood of "democratic" politics.[7] Another variation of this approach holds that modernization is a process that increases economic capabilities of a particular nation or society through industrialization and enlarges political capabilities for that same entity through bureaucratization. The core process through which modernization is achieved is industrialization; economic growth becomes the dominant societal goal, and achievement-motivation becomes the dominant individual-level goal. The transition from preindustrial society to industrial society is characterized by "the pervasive rationalization of all spheres of society,"[8] bringing a shift from traditional, indigenous, and usually religious values to rational-legal values in economic, political, and social life. Cyril Black argues that modern society results from the adaptation of "historically evolved institutions . . . to the rapidly changing functions that reflect the unprecedented increase in man's knowledge, permitting control over his environment that accompanied the scientific revolution"[9] (see Figure 2.1). This postulation appeared to find empirical support in rudimentary cross-national analysis.[10] It carried support for U.S. security policy and foreign aid at the time of its introduction in the academic and public policy circles. Others emphasized the importance

Figure 2.1: Defining Modernization



The core process of modernization is industrialization; economic growth becomes the dominant social societal goal, and achievement-motivation becomes the dominant individual-level goal. Thus stated, the development of the energy sector, including electrification through nuclear power generation, can be viewed as a means to modernization.

Source: Inglehart, *Modernization*, 1997.

of a society's ability to create knowledge and technique in the modernizing process. To master nature and assimilate science and technology requires a positive attitude toward innovation and experimentation.[11] If the ability to assimilate and generate knowledge is linked to the value system of the society, then leaders must find ways to inculcate and nurture the "right" values. For most modernization theorists these values were approximations established on the basis of the Western experience with modernization processes. In all it may have created an almost dogmatic fervor for its application to real-world dilemmas confronting the developing states.

Moreover, modernization theory provided ready templates for the implementation of development and modernization schemes that were wholly inappropriate and unsuited for their time or place. The examples are strewn throughout the development literature of such grand designs gone awry.[12] It may also be that theorists and practitioners are forced today to contend with the ruins of these failed attempts to develop and may still be attempting to correct these failures with similarly unsuitable development schemes.

The literature suggests that the ultimate focus and object of development and modernization are the construction of ostensibly democratic regimes based on free-market economies. As Inglehart stated:

> One reason why modernization theory aroused such great interest was its promise of predictive power: it implied that once a society entered the trajectory of industrialization, certain types of cultural and political change were likely to take place, ranging from lower birth rates to greater penetration by government, higher life expectancies, increased mass political participation, and perhaps even democracy.[13]

Karl Marx emphasized economic determinism by arguing that a society's technological level shapes and guides its economic system, which in turn determines its cultural and political characteristics. Some of Marx's successors shifted the focus from economic determinism toward a greater emphasis on the impact of ideology and culture. "Thus Lenin argued that by itself, the working class would never be able to achieve class consciousness for a successful revolution: they needed to be guided by an ideologically aware vanguard of professional revolutionaries."[14] So why then has economic development under this vanguard been met with mixed results? From the perspective of one commentator, the principal weakness of socialist developing states lies in their inability to find the equivalent of competition and enthusiasm as motivating factors for modernization. These conditions are as much political as they are economic and "fly in the face of all prevailing trends and predilections."[15] This is to postulate that nonmarket (socialist) substitutes for the stimuli and incentives of freedom and competition are necessary for overcoming this apparent shortcoming. These substitutes—loyalty to socialist and nationalist ideals and the bestowal of awards and rewards—are said to promote a disinterested curiosity and sap creative energy. "These substitutes are little more than a promissory note without a maturity date."[16] The judgment of this approach is that only nations that have generated autonomous and creative technology have been characterized by freedom of initiative and enterprise. The exceptions are socialist states able to build on a substantial educational and industrial base inherited from the old regime or colonizer. To understand more fully the context in which this phenomena has occurred, it is important to address the relationship between development and revolutionary regimes.

Modernization by Revolution

A discussion of modernization and development by revolution or under an ostensibly revolutionary or ideologically based regime is pertinent to a discussion of development schemes in a developing state such as Cuba. Samuel Huntington, in his seminal work, *Political Order in Changing Societies*, states that modernization processes are characterized by their revolutionary nature.[17] A major proposition advanced by modernization theorists was that economic development creates the conditions for political democracy. The causal process reflected a belief that political stability would be the natural and inevitable result of the achievement of, first, economic development and then social reform.[18] Huntington argues that economic development and political stability are two independent goals and that progress toward one had no necessary connection with progress toward the other. Moreover, in relation to modernization, "Revolution is the ultimate expression of the

modernizing outlook."[19] This is the belief that man has the inherent ability to control and change his environment. Revolution can thus be viewed as a feature of modernization. It will most likely occur in societies that have experienced some social and economic development and in which the process of political modernization has lagged behind the process of social and economic change.[20] The experience of socialist regimes has been that centrally planned command economies have consistently experienced poor performance and exacerbated preexisting dislocations.

The strength of socialist governments is that they can govern well; they can provide effective authority. Their ideology provides a basis of legitimacy, and their party organization provides the institutional mechanism for mobilizing support and executive policy. The challenge that socialist states posed to modernizing states was not that they were good at overthrowing governments, but rather that they were very good at making governments. They may not have provided liberty, but these governments provided authority by creating governments that *governed.* Huntington states, "While Americans laboriously strive to narrow the economic wealth between classes, socialists offer modernizing countries a tested and proven method of bridging the political gap. Amidst the social conflict and violence that plague modernizing states, the socialist states provided some assurance of political order."[21] Stimulus to nationalist mobilization may be furnished either by a foreign political, economic, and military presence in a country before the collapse of the old order or by a foreign political and military intervention after the collapse.[22] Moreover, full-scale revolution involves the destruction of old political institutions and patterns of legitimacy, the mobilization of new groups into politics, the redefinition of the political community, and the acceptance of new political values. According to Huntington, all revolutions involve modernization in the sense that the expansion of political development requires the creation of new patterns of political order.

The revolutionary process in Cuba involved a relatively small period of intense violence, but the economic consequences were relatively severe. From 1958 to 1961, the economic output fell approximately 50 percent. Since the end of the cold war, Cuba's economic output has similarly fallen into disarray, and it may take many years, perhaps decades, to reach again the level of economic production it had achieved immediately before the demise of the Soviet empire. A revolutionary state (or any regime in transition) is almost always dependent upon the creation and stabilization of new institutions of political order for achieving new rates of economic growth.

Economic success is relatively immaterial to revolution, while economic deprivation may be essential to its success. The conservative

predictions that food shortages and material hardships will lead to the overthrow of the revolutionary regime are sometimes not fulfilled for one very simple reason: material deprivations, which would have been insufferable under the old regime, are proof of the strength of the new one. However illogical to an outside observer, the less their food and material comfort, the more the people come to value the political ideological accomplishments of the revolution for which they are sacrificing so much. The more the Castro regime became firmly entrenched, the more older Cubans learned to live with less and younger Cubans to embrace their deprivation as a symbol of the revolution. Revolutions might be undermined by affluence, but they are rarely overthrown by poverty. Economics is relatively unimportant to both revolution and revolutionaries who view economic disaster as a small price to pay for the broadening and redefinition of the national community.[23]

The goal of the revolution is a new homogeneous community. Forcing dissident or inassimilable elements into exile is a means of producing that community. Consequently, what conservative foreigners (or exiles) view as a weakness of the revolutionary system is actually a means of strengthening it. The willingness of Castro to permit substantial numbers of unhappy Cubans to leave the island served to enhance the long-run stability of his regime. In a prerevolutionary society, those who are alienated are the many and the poor to whom migration is impossible. In a postrevolutionary society, the alienated are the few and the affluent who can more easily be eliminated by decimation or migration.[24] This analysis retains a remarkable significance and salience to the current situation in Cuba some thirty years after its original formulation.[25]

Modernization from within and Processes of Industrialization

Understanding Castro and Cuba's attempt to modernize in the post-revolutionary period requires an examination of the literature pertaining to the political consequences of modernization in developing states.[26] This includes a discussion of the source of the modernizing notion and the effect on the possible success and failure of development and modernization policy in developing states. John Kautsky argues that industrialization and its social and economic consequences are similar wherever the process takes place (at least at certain stages of technological development and advancement). The political consequences of modernization seem to differ depending on whether modernization or the modernizing vision was developed from within the society through the operation of forces native to it or if it came to a society from without.[27]

This distinction leads Kautsky to suggest that the process of political

change accompanying economic development in developing states will be different from that which accompanied it in developed states. His view counters the widespread ethnocentric assumption that developing states are simply lagging behind the West in their politics and that in politics as in economics "Modern" equals "Western."[28]

Added to this notion is the assumption that there is a common or broadly similar background that most societies share. What distinguishes them is the way that modernization comes to these societies. The ideas, processes, and material elements that initiate modernization are of indigenous origin in the case of modernization from within and of external origin in the case of modernization from without.[29] Industrialization requires many elements of modernization as its precondition. Where modernization involves industrialization, it relies on investment capital of domestic origin in the case of modernization from within and from foreign sources in the case of modernization from without. The differences between the political consequences of the two processes, as argued by Kautsky, can be briefly outlined:

1. One of them results from the different rates of speed with which modernization from within and without proceed. Modernization from within, involving development of the antecedents of industrialization—increased trade and communication—as well as industrialization itself, is a relatively slow process.
2. The process of modernization also affects the adaptability of societies to these changes. When modernization develops gradually from within, adaptation is eased by the fact that property ownership continues to be the primary source of economic and political power. In contrast, where modernization has arrived much more suddenly, the ruling order often finds itself defenseless in the face of attacks against it.
3. Another distinction between these processes results from the fact that where modernization and industrialization intrude into society from without, the upsetting effects on various strata of society can be blamed on an outside source. This can lead to a certain degree of unity vis-à-vis the foreign enemy or forbidding external environment. Where modernization has (or claims to be) developed from within different strata can blame only each other for its consequences.
4. The political effects of these processes are significantly different. It means that states that underwent a process of modernization from within are not likely to be models for the political future of other developing states.[30]

The differences also mean that many of our concepts and categorizations of politics are not very appropriate for the analysis of politics in societies modernized from without. After deriving expectations from the modernizing processes presented, Kautsky also predicted how particular modernizing regimes would react in response to some of the inherent shortcomings contained in a particular development model. Moreover, these predictions are useful in developing more fully the analysis of specific industrialization processes, because he sets out the justifications employed by modernizing regimes to explain failure to complete grand infrastructural undertakings. One important notion undergirds this discussion. Although their policies may inhibit industrialization and may justify its absence or slow progress, revolutionary modernizers nevertheless continue to invoke industrialization as their goal.[31] They remain modernizers in the sense that they are people committed to the goal of modernization and industrialization, rather than people who can necessarily and successfully bring it about. Here the question is raised as to whether or not it is possible that some developing countries will be successfully industrialized in the foreseeable future, if ever at all. And then what will happen politically if they do not advance industrially beyond the prerevolutionary stage?[32] Although these are important questions, they lie outside the specific focus of this analysis. They are included because they impact some of the issues raised later in this review of the literature.

Nonlinear or Neomodernization

Ronald Inglehart proposes a revised approach to modernization theory. He agrees with the central tenet of modernization theory: that economic development and cultural and political changes are linked in coherent and somewhat predictable patterns. His approach also serves as a critique of the shortcomings in modernization theory. Some trajectories of change and development are more predictable than others because certain structures of values, beliefs, and political and economic institutions are "mutually supportive, while others are not."[33] Thus if one knows one component of society, one can predict, according to Inglehart's perspective, what other components will be present with far better than a random success.

While Inglehart's reconceptualization adheres to those originally advanced by Marx, Weber, and their followers in believing that changes take predictable, rather than random, trajectories, he takes exception with most modernization theorists on four key points:

1. Change is not linear. It does not move in one continuous direction until the end of history. Instead, it reaches points of diminishing returns and, in the estimation of Inglehart, begins to move in a fun-

damentally new direction. From Inglehart's view, during the past few decades, such a phenomenon has been taking place in Cuba.

2. Previous versions of modernization theory were overly deterministic, with the Marxist variant bordering on economic determinism and the Weberian strain verging on cultural determinism. Determinism in all of its forms—political, economic, and cultural—is oversimplified. Causal linkages tend to be reciprocal, rather than unidirectional. Unless those systems are mutually supportive, they are unlikely to survive or they would need to rely on naked coercion to do so.
3. As with Kautsky's assertion, Inglehart rejects any ethnocentric conceptualization of those who have equated modernization with Westernization.[34]
4. Democracy is not inherent in the modernization process. There are alternative outcomes of which Cuba is but one example.[35]

The critique of the modernization school follows many of the strong and pointed revisions advanced by Kautsky and Inglehart. In addition, some have argued that instead of dispensing prosperity as predicted, economic development accentuated the concentration of wealth and exacerbated existing inequalities in those developing societies.[36] Political outcomes took a decidedly authoritarian turn and spoke little to the persistence of socialist experiments with development, especially related to Cuba. Moreover, the rise of qualitative methodologies placed a heavy critique on this type of research. The critics of modernization theory argued that the rich descriptions favored by many "area specialists" employing grand theories such as modernization were highly "personalized" and lacked methodological rigor. Modernization theory was similarly unable to withstand the challenge from "world systems" and dependency theorists that followed in the 1970s.[37] Its postulations and analytical framework were apparently disproved, and modernization theory fell into widespread disfavor. Interestingly the *dependistas* and "world systems" advocates found themselves in similar positions by the 1980s, cast off as the Marxian postulations were increasingly inadequate to explain the persistence and then rapid disappearance of tutelary and authoritarian regimes throughout the international system.

In the meantime modernization theory has shown signs of coming back to life. One of its principal precepts—the postulation of a systemic relationship between economic development and political democracy—appears to have gained broad support from the processes of liberalization, democratization transition and consolidation, and redemocratization in Eastern Europe, Latin America, and elsewhere in the world.[38] Now couched in more cautious terms, the proposition holds that economic development is only a necessary prerequisite for democracy, not a sufficient condition for

the realization of political democracy. But for the proponents of modernization, the implication is crystal clear. Modernization theory was essentially correct. For some analysts it was merely ahead of its time.[39] But this suggests that modernization theory still requires additional empirical indicators to boost its explanatory value in face of the still-relevant argument that it is still overly descriptive and normative in its execution.

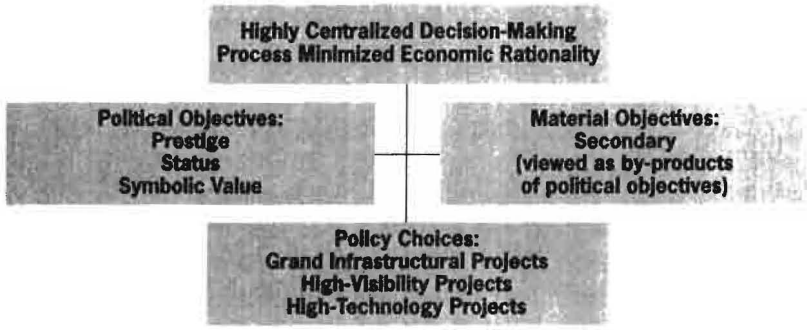
Specific to this inquiry, it is important to refer to the literature on the political, economic, and security incentives and disincentives for the development of nuclear energy capabilities. This serves to provide a direct linkage between the theoretical aspects of development and energy development in developing states, as well as directly addressing the hypotheses being advanced in this examination. It also serves to provide us with some of the methodological tools to analyze the case of Cuba's attempt to develop a nuclear energy capability.

The discussion of the aforementioned relationship between politics and modernization provides an ample opportunity to develop more fully the theoretical basis of the first of the three plausible hypotheses being advanced in this examination, politically motivated modernization. This process or modernization scheme is guided by ideological and political motivations, and all resulting policy objectives and their implementation are reflections of this underlying logic. Rather than being a post hoc justification of an observed political phenomenon, this approach retains a highly predictive value inasmuch as it provides a template for the trajectory of the policy toward, and an explanation for, the persistence of Cuba's objective of developing a domestic energy capability. What differentiates this approach from other ones is that it centers on the political objectives of a regime as opposed to any material, economic, and socially efficacious ones. This approach also maintains that there are limits to economic rationality in the choice of the nuclear option. This is especially so when the perceived political rewards such as prestige, propagandistic value, and symbolic accomplishment are more highly regarded than any of the material or economic rewards associated with the attainment of a nuclear power capability.[40] Under this approach, the economic and social benefits associated with the development of a nuclear power capability are considered by-products of the political rationale that guides these activities (see Figure 2.2).

Nuclear Energy Development in Developing States

States develop energy capabilities under a number of different circumstances and for a number of different reasons. The reasons can center on a developing state's relation to secure a relatively cheap source of energy or the

Figure 2.2: Energy Implications of Politically Motivated Modernization



need for political symbols that ostensibly extol the virtues of a given political and development regime. For some, though, this issue is no longer one of a relationship between nuclear power and economic development, in general, but rather one of identifying criteria by which a developing state may determine whether commercial nuclear fission represents a rational option for them. Under this approach the operative question is one of a cost-benefit analysis. The problem for developing states is to know what costs should be considered and what benefits should be considered, and by what standard (or under which measurement) they should be compared.[41]

Ian Smart asserts that any government or utility in a developing country contemplating the development of nuclear power capabilities would be wise to exploit (or at least to consult) other states' practical experience in planning, costing, and operating nuclear plants. He continues, "To reject such evidence would be merely wasteful."[42] We should not assume that we are setting out to provide a quantitative analysis and comprehensive assessment of the need for nuclear energy in a developing state. But it is prudent to consider these points qualitatively in a heuristic manner that edifies the analyst's flexibility with the details, nomenclature, and rationalizations used in the development of nuclear power programs. Simultaneously, as a part of this process, each national case must be seen as unique, not only because national energy economies vary but also because the basis for assessing the social and socioeconomic costs of alternative energy strategies is necessarily peculiar to each national society. From this we should ascertain that a cost-benefit analysis of nuclear power must be conducted indigenously and in terms relevant to that nation and society.[43] It may also serve as a template by which we can assiduously and prudently analyze Cuba's actions in the pursuit of a nuclear energy generation capability.

At this level of generality, all benefits that may accrue from a national

program of nuclear energy development are familiar. They also serve as the focal objectives of any nuclear energy development scheme. They fall into three broad categories, the first of which is energy economics. In particular circumstances, centrally generated electricity may offer unique economic advantages, and after analysis the peaceful exploitation of nuclear energy may emerge as a means of generating electricity at the lowest real cost. The second category is that of energy security. The introduction of nuclear power may help to diversify supplies of energy, in general, and electricity, in particular, thereby diminishing dependence on any one source of supply and/or reducing dependence on imported energy sources. The last category, economic and technical modernization, refers to access to the advanced technology and industrial skills needed in a nuclear power program. It may be seen as a way of raising the level of scientific and technical development in a particular state, just as electrification based of the exploitation may be seen as an optimal path to economic development based on industrialization.[44]

For the purposes of this examination, the analysis will focus on the interactions between the first two categories, that of energy economics and energy security. This will be discussed later in this chapter. It will treat the third category, economic and technical modernization, as a stand-alone category for analysis as it reflects much of the relevant modernization literature.

Similar to the above-mentioned benefits, the apparent costs of nuclear power development can be arranged in five broad categories: investment capital, external dependence, supplies inflexibility, institutional gravity, and energy intensity. These categories can be described in the following manner:

1. Investment Capital—Whatever the real long-term cost of nuclear energy, creating and supporting a nuclear energy capability, with the necessary industrial and regulatory infrastructure, commonly preempts a larger share of capital in whatever form available for investment in energy supply systems—and also of available foreign exchange—than does a generating system designed for fossil fuels.
2. External Dependence—Whereas one motive for acquiring nuclear power may be to reduce dependence on imported fuels, gains in that regard have to be set against the extent to which a nuclear program entails additional dependence on external suppliers, notably in the developed world, for materials, equipment, technology, services, and skilled manpower.
3. Supply Inflexibility—In almost any developing country, even a single reactor of a minimum size would represent a large proportion of the total electricity system, with obvious implications for the vulnerability of the system to the withdrawal of a single generating unit from service.
4. Institutional Gravity—In addition to the financial cost of establishing

and running the administrative and regulatory institutions specifically needed in a nuclear power program, the tendency for such a program to draw a substantial proportion of the best and the brightest scientific, technical, and administrative talent in a developing country into a highly centralized institutional structure may be regarded as socially, economically, or even politically expensive.

5. Energy Intensity—Energy intensity *(I)* is defined as the ratio of the primary energy consumption *(E)* (measured in tons of oil equivalent) to the gross domestic product (GDP) (measured in thousands of dollars at a given year of reference). Frequently only commercial energy is used in calculating the energy intensity. The concept of energy intensity is proving to be useful in analyzing trends in energy consumption and their implications in a number of developing countries.[45] The implications are relevant to this analysis because modern technology is an extremely powerful factor in the way energy is used and economic activity develops in a state such as Cuba. Moreover, if the GDP in a developing state grows the only method of offsetting the resulting increase in energy growth (and the emission of pollutants and greenhouse gases associated with it) is to have decreasing energy intensity.[46] This relationship can be measured by the following equation:

$$\frac{\Delta I}{I} = \frac{\Delta E}{E} - \frac{\Delta(\text{GDP})}{(\text{GDP})}$$

Commitment to a nuclear energy program may make long-term economic sense to national planners, but if outside observers regard it as an extravagant use of scarce resources in the short term, the country might have difficulty in obtaining bilateral and multilateral assistance. Alternatively, a program of civilian nuclear development undertaken by a country that is itself embroiled in regional conflict may prompt suspicious or apprehensive neighbors to suspect an ulterior and more nefarious military motive, a possibility given credence by several current cases.[47] There are also less tangible, measurable, and predictable costs that may have to be considered. There is the possibility that, even in the absence of any current intention to produce a nuclear weapons capability, developing a nuclear power capability may seem to open an option to produce them in the future. Indirectly, the motivation for embarking on a nuclear energy development program may be bolstered by a sense of available benefits of increased international prestige, status, and influence, of which commentators from developing states and the nonproliferation community have often spoken.[48] "How real those benefits are must be a matter of opinion since the evidence is confused and conflicting."[49] In any case, a discussion of these noneconomic and non-

energy factors—and analogous costs—have been previously discussed in some detail in this chapter.

Any consideration of the "quantifiable" cost and benefits in any national case must involve a parallel assessment of their probable effects in an unusually wide range of contextual settings:

1. There is a distinction to be drawn between the domestic policy context and the context of international circumstances and relationships.
2. The domestic policy context has to be subdivided because "any national decision about nuclear energy touches questions, not only of energy supply and economic planning, but also of scientific and technological development, in the broadest sense, and even of social organization.[50]

The implications of a nuclear energy development program reach far beyond the scope and field of energy as such. Nonetheless, it is within this context that a national assessment for the consideration of nuclear power must begin.

Having established the basis for this consideration, the first question to be addressed by national policymakers is what role electricity will occupy in the country's future energy system. "That is arguably an even more difficult question to answer in developing than in a developed state because it involves issues of both demand and distribution, which are likely to be volatile in a rapidly changing society."[51] This requires that an extremely detailed and convincing analysis of probable electricity demand over a future period of at least thirty years is available before the consideration of supply and energy options can reasonably begin.[52]

The consideration of the nuclear power option in a developing country now becomes possible through comparison of the various alternative means of generating electric power. The comparison of the peaceful exploitation of nuclear energy with oil, gas, coal, hydropower, or other renewable sources such as wind, sun, and waves is a complicated and contentious process, but it is not one that requires any unfamiliar economic technique of assessing viability.[53] There are particular characteristics of nuclear energy that have to be taken under advisement, most of which fall conveniently into the categories of scale, location, costs, opportunity costs, national energy security, the promotion of energy efficiency,[54] national development, and the social implications of such an undertaking[55] (see Figure 2.3).

On the Relationship between Energy, Economy, and Security

In particular circumstances still to be defined in this inquiry, centrally generated electricity may offer unique economic advantages in comparison to

Figure 2.3: Energy Implications of Economic and Technological Modernization

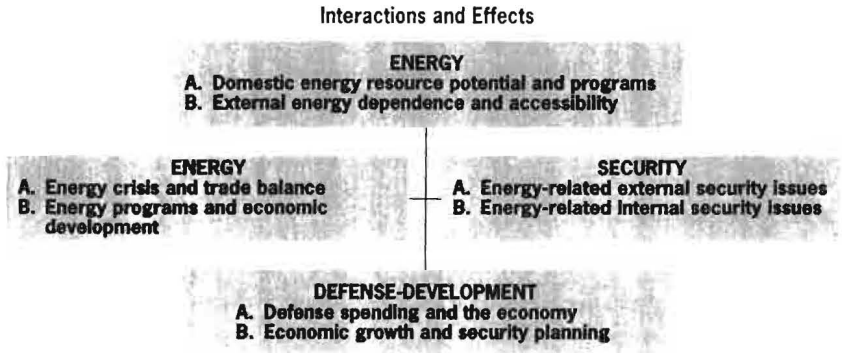
other sources of energy generation, and after analysis, nuclear energy may emerge as the means for Cuba of producing energy at the lowest real cost.[56] The introduction of nuclear power may help to diversify and augment the domestic supplies of energy, in general, and electricity, in particular, thereby diminishing dependence on any one source of supply and reducing the dependence on imported energy sources.[57]

There is an underlying relationship between (1) a nation's energy needs and external dependence or exposure; (2) economic and political stability; and (3) broader security concerns. The intensity of these relationships, of course, will vary from country to country in the developed and developing world, and within a country over time. When dealing with security in the context of energy, we are concerned with the broad and unavoidably subjective connotation of the term. Such a grand interpretation encompasses economic, political, strategic, and military aspects of security, as opposed to the more minimalist interpretation that focuses on specific military threats and defense programs. Economic security focuses on national resource sufficiency and, in particular, access to goods and services in world markets in affordable terms. Political security suggests the maintenance of domestic stability, whether it is based on rule by the consent of the governed or on varying degrees of authoritarian measures. Either way, law and order prevail, and economic, political, and social activities are conducted with little or no hindrance. Strategic and military security is partly outward looking and may be gauged by the degree and intensity of perceived external threats and the military capability that can be marshaled to meet those threats. It is also inward looking in that it involves the diversion of both domestic resources and services to meet those threats.

The focus of this approach is on the effects of domestic energy shortages and external energy dependencies on the security and economic policies of industrializing or developing states. Issues confronting these states are analyzed under the dual context of crisis and postcrisis.[58]

It should be clear that a nation's energy policy and management carry significant implications for both its security and its economic domains. Energy shortages at home require adept diplomacy and adequate bargaining power to fill the breaches. External and internal security as well as external trade policies and economic development plans have their roots in the successful or unsuccessful management of energy policy. Energy policy management must maintain a satisfactory equilibrium or advance the policy to safer and more secure levels (see Figure 2.4). Additionally, Thomas introduces three categories of developing states with nuclear energy programs. The first group consists of countries that were significantly affected by higher oil import prices during the oil crisis and have subsequently embarked on nuclear energy programs. Their conversion to nuclear power capabilities raised the specter of nuclear proliferation in their respective regions. These countries—India, South Korea, and Taiwan—are highly energy dependent, and they have promoted nuclear energy development. These states are also high proliferation risks because of their respective external concerns. A second group, including South Africa and Pakistan, share similar attributes with those countries in the first group, but there are "far greater internal and external security pressures (in the latter group) and consequently greater temptations to acquire nuclear weapons.[59] This group is typified by the viability of the nuclear energy option to their national energy issues. But there are security concerns because of the questionable intentions of these states' nuclear programs and their propensity to acquire or develop nuclear

Figure 2.4: Energy Impacts on Security and the Economy



weapons. The third group of states has difficulty in obtaining oil because of cost and limited access, and there is an absence of major security concerns. The possible diversion of nuclear energy resources to a weapons capability has much to do with the satisfaction of national pride and international prestige. Argentina and Brazil are examples of states in this group. During the 1980s, the escalation of nuclear energy programs followed a spiral action-reaction phase of "one-upsmanship" that is characteristic of arms races and at the time suggested the possibility of a latent nuclear arms race between the two.[60] Cuba did does not fit any of the categories presented, but its inclusion is significant because of a number of factors. The security concerns of Cuba's actions are raised because of the lingering Russian economic and technical influence in Cuba, the Cuban decision to embark on a nuclear energy development program, and Cuba's failure to ratify the Treaty of Tlatelolco. The use of Russian technology to set up the nuclear energy capability is a concern, as well as the transfer of Russian know-how, which may make it possible for diversion of a weapons capability in the future. Moreover, the suspect safety standards of Russian nuclear reactors lend credibility to the notion that a Chernobyl-like accident might occur, potentially threatening the greater Caribbean basin.

The Limits of Economic Rationality

Implicit in most discussions of nuclear power choice is the assumption that national decisions to develop nuclear energy capabilities are based on careful consideration of the economic costs and benefits of nuclear power. Great attention in the debates over nuclear power, therefore, is given to such issues as the availability of alternative energy sources, future energy demand, the assurance of uranium supplies, and the economic dividends from recycling plutonium. Moreover, the implicit understanding from such undertakings are that nuclear safety norms, adequate materials protection, control, and accounting are all a part of that calculation.[61]

Nuclear power proponents cite the possibility of rising fluid fuels costs, rising energy demands and the potential loss of energy sources, the alleged lower costs of nuclear-generated electricity as compared to alternative sources of power (based on estimates of high-capacity nuclear plant operation), and the economic necessity of nuclear power for energy-poor developing nations. These arguments in turn are countered with reference to the declining growth rate of global demand, the enormous capital costs of nuclear plants (relative to coal-fired facilities), the failure of nuclear plants to operate at expected output levels, the ample supply of fossil fuels for the foreseeable future, and the economic irrationality of nuclear power for developing countries, which lack concentrated energy demands.

Although both schools tend to emphasize the role of economic rationality in the nuclear power decision-making process, it is likely that psychological and political considerations are just as important in national decisions to develop or expand nuclear power capabilities. This is particularly apparent with respect to developing countries.[62] More generally, those countries most attracted to nuclear power are frequently those for whom civilian nuclear programs are least promising economically.[63] An assessment of a nuclear energy development program of the requisite factors such as "technical and organizational infrastructure, grid size, generating unit size, and financing conditions tend to adversely affect the competitiveness of nuclear power, particularly in developing states."[64]

Nuclear Energy Development in Cuba

The Cuban program to develop nuclear energy has gained significance in the period since 1991. There exists a small but well-informed literature on Cuba's attempts to develop a nuclear energy capability. There also exists a body of literature devoted to the historical developments in Cuba's movement toward modernization, including the developments in economic dependency and technological ascendancy.[65]

Since the breakup of the Soviet Union, concern regarding the program has taken a position of some significance among the issues that make up the United States's foreign policy toward Cuba. Several recent pieces of legislation have been directed at promoting a transition to democratic governance in Cuba: the Cuban Democracy Act of 1992 (the Torricelli Act), the Cuban Democratic Solidarity and Liberty Acts of 1996 (the Helms-Burton Act or Cuban *Libertad* Act), and the 1997 International Atomic Energy Agency (IAEA) Accountability and Safety Act (H.R. II 82). All contain provisions directed at blocking third parties including the Russian Federation from funding and constructing the nuclear reactors at Juragua.[66]

Until the recent past, most of the research that centered on Cuba's nuclear program was government-produced policy and scientific and technical analyses.[67] Although these reports and analyses are seemingly exhaustive in their coverage, because of the conflictual nature of relations between the United States and Cuba, almost all of these analyses rely on secondary sources for information or have not been corroborated by independent analysis, and thus they remain open to debate and criticism. For many analysts, this is the key issue in the discussion related to nuclear safety in Cuba. Because of the ongoing debate in the West over whether or not the reactors could operate safely, there has also been a steady output of journalistic treatments of the subject.[68]

Only a very few academic scholars have written specifically on the subject and there has been almost no application of social science theory to explain the wider influences and implications of this isolated and seemingly "unique" phenomenon.

One of the earliest treatments on the issue was an article published by Jorge Perez-López.[69] Perez-López provided an assessment of the state of energy on the island but questioned the underlying rationale of the project for a country with significant resource constraints and the effects of the Chernobyl disaster on Cuban designs. Perez-López argued that the effect of the Chernobyl nuclear accident would be marginal in arresting Cuba's nuclear ambition considering the country's poor energy base, deep economic and political commitment to nuclear energy, and the absence of domestic opposition to nuclear technology.[70] Another study looked at the relationship between energy, security, and economy in revolutionary Cuba in the latter stages of the cold war. It concluded that while nuclear energy could contribute positively to the Cuban energy balance, it will not solve Cuba's energy vulnerability.[71]

The first comprehensive treatment on the scope and objectives of the Cuban nuclear project was written by Fidel Castro Díaz-Balart in 1986.[72] It was a thick tome, by the then-Director of the Cuban Nuclear Agency, and was heavily descriptive of the structure and functions of the nuclear complex and the long-term scheme for the development of nuclear energy and nuclear science in Cuba. Its rich description and ambitious tone give an interesting account of the hope that the Cubans placed on the development of nuclear energy as one of the keys to economic development and modernization into the twenty-first century. It bears mention that the attempt to develop energy in Cuba has occupied the fascination of policymakers on the island for well over fifty years.[73] In 1990, Castro Díaz-Balart published *Energia Nuclear y Desarrollo: Realidades y Desafios en Los Umbrales Del Siglo XXI.* The main proposition advanced in the book was a defense of the advantages of nuclear energy, arguing for the indispensable need for its assimilation.[74] Another Cuban associated with the nuclear program also authored an interesting addition to the literature on Cuba's nuclear activities. As a defector in 1992, Jose R. Oro, a geologist, arrived in the United States under much hoopla over his revelations of "new" developments in Cuba's nuclear program, including allegations of a more nefarious rationale, the development of weapons of mass destruction. He subsequently authored *The Poisoning of Paradise,* in which he argues that the Cubans were disregarding standards and norms associated with the safe construction and operation of a nuclear reactor, and environmental considerations were being disregarded because of a lack of adequate economic and material resources required for

the construction of the nuclear reactor. Oro warned that Cuba's use of nuclear power posed a clear and present danger to the environment in Cuba and beyond. Although his book makes many claims, Oro cites so little supporting evidence that a reader cannot be certain that the information is objective or reliable.[75] These two examples fall prey to the same doubts expressed in relation to the reports generated by the respective governments, that they rely on secondary sources for information or that they cannot be independently verified or refuted.

Another source of information on the Cuban nuclear program is the proceedings of two sets of congressional hearings that were conducted to investigate the claims of a potential nuclear accident in Cuba.[76] These high profile, highly partisan hearings garnered much media coverage and have been instrumental in placing the nuclear issue near the top of U.S. interests in relation to Cuba.

To date, other analysts have provided a number of articles analyzing Cuban nuclear energy policy, nonproliferation, and the structure and functions of the those activities in Cuba.[77] These articles have sought to provide a background for conducting research that is theoretical in nature and rigorous in methodology. Such a background has served the policy community well and is recognized as an important contribution to our understanding of the multiple debates surrounding the Cuban nuclear program. Other such examples are the works of María Dolores Espino, Sergio Díaz-Briquets, and Jorge Perez-López. They analyze the nuclear program within the context of modernization and development and its relation to the environmental implications for Cuba and the greater Caribbean.[78]

The study will discuss how we have derived the three diverging approaches from the modernization literature that refers specifically to the development of national nuclear energy capabilities in developing states. It will also explain why the discussion of modernization under revolution and the source or influence of the modernizing ideal impact the decision-making processes at play in developing countries. Then follows a discussion of the shortcomings of the existing substantive literature in addressing these approaches and why the issues beg for more thorough explanations and analyses. This book is an attempt to link the theory and praxis of national energy capabilities in developing states through a single case examination that utilizes process tracing.

Summary

This chapter has examined the theoretical and substantive foundations of Cuba's attempt to develop a nuclear energy capability in an effort to provide

a backdrop by which the plausible hypotheses advanced in chapter 1 and the actual case can be discussed and understood in its entirety. The review of the literature was divided into three sections. First was an in-depth discussion of the relationship between the foundations and expectations of grand modernization theory and the practical application of the theory to developing states. It included an examination of the notion of modernization by revolutions, a discussion of the political consequences of modernization, and a review of the pertinent critique of the above-mentioned ideas. This discussion offered insight into the reasons why states choose various paths to modernization. This included a discussion of the rationale of socialist and revolutionary modernizers and the opportunities and risks for these regimes as they attempt to modernize. The criticism of mainstream modernization theory centered on the ethnocentric aspect of its formulations where modern equals Western. Having taken this into account, later iterations of modernization theory insisted that many of the prescriptive notions advanced during the 1960s were merely ahead of their time. One of its principle precepts—the postulation of a systemic relationship between economic development and political democracy—appears to have gained broad support from the processes of economic liberalization, democratization, and democratic renewal in Eastern Europe, Latin America, and elsewhere in the world. Now couched in more cautious terms, the proposition holds that economic development is only a necessary prerequisite for liberal democratic governance, and not a sufficient condition for the realization of political democracy.

The second section was a discussion of the role of energy development in modernizing and developing states, including the basis for analyzing decision-making processes, the economic considerations for energy development, and the relationship between energy development and economic and political considerations in developing states. This section of the review specifically pertained to the development of three plausible hypotheses being employed in this case study examination. It also provided many of the indicators needed in the subsequent analysis of the Cuban nuclear program. States develop nuclear energy capabilities under a number of different circumstances and for a number of different reasons. While it could be argued that the issue is one of the relationship between nuclear power and economic development in general, the preponderance of the discussion in this section centered upon identifying the criteria by which developing states may determine whether the exploitation of nuclear fission represents a rational option for them. The introduction of nuclear power may help to diversify and augment the domestic supplies of energy, in general, and electricity, in particular, thereby diminishing the dependence on any one source

of supply and reducing the dependence on imported energy sources. Understanding the relationship between energy, a state's economy, and its security posture can lead to understanding its objectives and eventually its actions in the government's effort to provide secure and reliable sources of energy for its society. This section concluded with a caveat about the limits of economic rationality, especially for developing states in their pursuit of nuclear energy capabilities where psychological and political considerations may supercede economic ones in those considerations.

The third section of the review explored the case-specific literature on nuclear energy and energy development in Cuba. It included a discussion of Cuban sources, which heretofore have not been included in the existing literature and which promise to expand our knowledge base and understanding of specific activities related to the development of nuclear energy capability in Cuba.

The reason for dividing these three areas of literature is to determine what shortcomings exist in these works and to establish a concrete linkage between the theory and praxis of this case study. To this point there are two major areas of inquiry related to the issue that are absent from the existing literature. First, there has been little or no linkage of the issue of nuclear energy development in developing states to analysis based in social science theory. That is, there has been little in the way of theory application. This examination seeks specifically to add to this body of literature. Second, the linkages to incentives and disincentives for the development of nuclear energy has, in general, been underanalyzed in the literature, and the linkage specific to Cuba has not been addressed rigorously or systematically. This review has provided a concise and exacting set of tools with which to analyze those incentives and disincentives in a cost-benefit manner. This investigation establishes these two points as the foundation of the analysis of this case, within the context that the original research queries seek to examine Cuba's decision to pursue a nuclear energy capability. Those two points will be explored in depth in the next two chapters.

The Quest for Power

3

Analyzing the Costs and Benefits of Cuba's Nuclear Energy Policy

> There is no design control, no procurement document control, no controls on materials and purchases, no control equipment.... Who is going to operate this plant? The indispensable international requirement for operation of a nuclear reactor is that the operator be trustworthy, and that people believe that this person will respect international law and will be capable of operating and maintaining this plant with strict compliance with safety standards.... It is obvious that Fidel Castro does not meet any of these requirements.
>
> —Nils Díaz,[1] Director of Nuclear Engineering Sciences at the University of Florida in Congressional Testimony on the Cuban Nuclear Project, July 25, 1991

Since the late 1970s, Cuba has pursued a nuclear energy capability by attempting to build two nuclear reactors at the site of Juragua in Cienfuegos province. This policy was ambitious by any measure. Originally, Cuba envisioned a network of nuclear reactors across the island. When completed, the nuclear facilities would represent a remarkable accomplishment for the Cuban revolution, highlighting developments in technological and scientific expertise. The purpose of this chapter is to provide a cost-benefit analysis of Cuba's nuclear project that accounts for the way the economic, political, and nuclear safety issues surrounding the development of nuclear energy may have or have not influenced the decision-making processes of nuclear energy development in Cuba. This can be viewed as a part of the Cuban "quest for power."[2] This can also be viewed as part of a broader body of research that looks at the relationship between natural resources, economic development, energy security, and environmental policy in postrevolutionary Cuba.[3] It requires that we remind ourselves that environmental, development, and security problems deserving our attention do not necessarily exist today but are (at least potentially) prospects for the future, whether near or distant. Moreover, we must take into consideration under the present circumstances

been because Cuba had no other choice faced with the loss of Soviet sources for fossil fuels, but Cuba's response to these factors were measured in terms consistent with the economic and technological modernization model. The evidence also offered support for the expected behavior of the economic and energy security approach, although not directly. The development of the stand-alone nuclear energy capability would limit Cuba's exposure to external dependency for energy, but there is little to suggest that this was the focus of the activities in this area. Moreover, one could argue that the development scheme to achieve a nuclear capability was, in reality, merely an exchange of one type of dependency for another, albeit more highly advanced. There was little or no mention of the nationalist or ideological imperatives in which official government policy is often cast in Cuba.

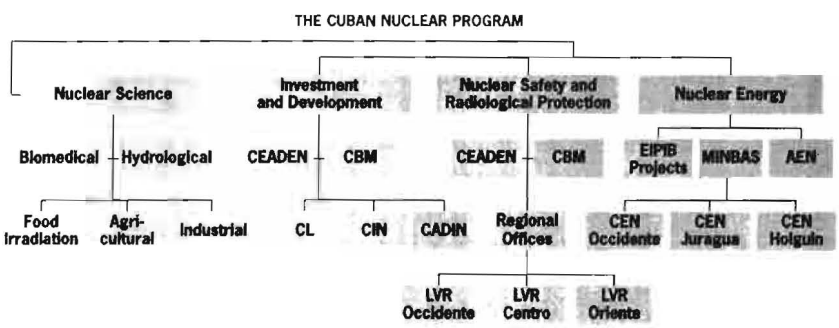
Assessing the State of Nuclear Energy in Cuba: Structure and Function

This section is an exposition of the development of Cuba's nuclear complex from the period of 1982 until the present. It will provide a detailed account of Cuba's bureaucratic structure through its formation and subsequent evolutions. These changes were often significant reorganizations that were responses to the fluid nature of external stimuli, internal constraints, and policy shortcomings.[45]

Figure 3.1 illustrates how the Cuban nuclear program is divided into four principal branches: the nuclear energy sector; investment and development, including the introduction of nuclear techniques into diverse sectors of the economy; the basic and applied nuclear science research sector; and the national system of radiological protection and nuclear safety.

Whereas the directorate of research and development and radiological protection and nuclear safety both fell under the auspices of SEAN, the other two branches were coordinated with seven ministries and central agencies of

Figure 3.1: The Cuban Nuclear Complex



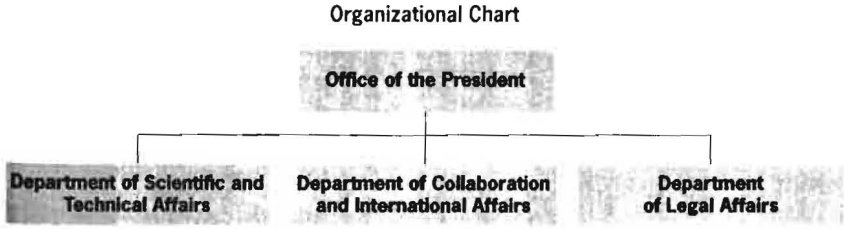
the state. The construction and operation of nuclear reactors fell to the Ministry of Basic Industry, which formed the Nuclear Directorate and a projects enterprise (EIPIB), which joined the Investment Unit of the CEN Juragua and the Construction Enterprise for Nuclear Works to build the reactor.

Participating in a diffused manner in the development of the plans to spread the employment of nuclear applications in the country are the Ministries of Public Health, Agriculture, Sugar, and Higher Education; the Academy of Sciences; and the National Institute of Hydraulic Resources.

In Juragua, in Cienfuegos Province, the construction of the first Central Energetico Nuclear (CEN) placed it in the center of national nuclear activity, and by the breadth, complexity, and importance to the economy, the reactor constituted one of the most significant works ever undertaken in the country. In 1983 construction was started on the first reactor, and in 1985, the second, with the goal that the facility begin operation at the beginning of the 1990s. The plans called for four more reactors of Soviet design, VVER pressurized water reactors with a potential of 417MW each with a containment enclosure and other measures for safety and operation. This resulted in a more advanced model (model V/318 with antiseismic features) than the thirty-three similar units operating in seven countries in Europe.

From the start, Cuba paid special attention to the rigorous selection of future specialists and at the level of their scientific and technical training. In the 1970s and up until the middle of the 1980s, this group of specialists was educated in the Soviet Union and in the countries of Eastern Europe. At the start of 1987, the Instituto Superior de Ciencia y Tecnologia Nucleares opened in Havana, equipped with laboratories and "modern" equipment. More students completed studies in nuclear physics, radiochemistry, and nuclear engineering[46] (see Figure 3.2). The center contributed greatly to the advancement of new specialists and engineers and the requalification of personnel after graduation. The magnitude of these expansion efforts was realized in the formation of highly trained cadres of nuclear scientists. Many more technicians and workers were trained at the Centro Politecnico

Figure 3.2: Agencia de Energia Nuclear (1999)



Electronuclear de Juragua since its founding in 1981. The personnel involved in the construction of the nuclear reactors were trained here.[47] Another branch of the training and education infrastructure are the Institutos Preuniversitarios Especializados en Ciencias Exactas (IPECE) located in different provinces. In 1980 a CEAC initiative led to the founding of the first of these institutes, IPECE Humboldt 7, located near San Antonio de los Baños, in La Habana Province. Quickly these institutes were extended to other provinces, and in 1990 their enrollment constituted 28 percent of the students pursuing specialties with interest in the nuclear program.

Cuba also expanded its activities in the field of nuclear medicine. By 1990, there were twenty-one agencies working in these areas including radiopharmacology, where specialists were training in visualization techniques and radioimmunoanalysis.[48]

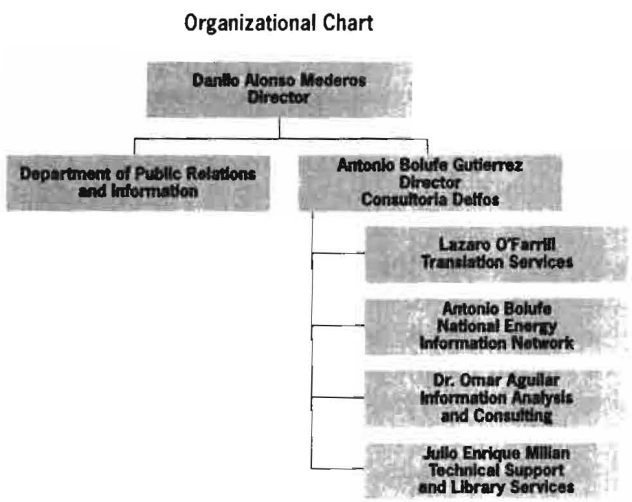
Of particular interest is the Institute of Oncology and Radiobiology and its department of nuclear medicine, which is equipped with a gamma camera and other equipment provided by the UNDP. It has served as the base for research and services in area of oncology and radiobiology and is a center for promoting such programs. Another relevant application of nuclear techniques is in the irradiation of food. In March 1987, Cuba inaugurated a pilot plant of Soviet construction, donated by the IAEA. This first radiological installation was located at the Institute of Research for the Food Industry, and during the first phase of operation, it irradiated different agricultural products such as potatoes, onion, garlic, cacao, and spices. The Centro Nacional de Sanidad Agropecuaria [the National Center for Farm Animal Health] (CENSA) has carried out similar activities, with the installation of a Gamma Cell–500, a self-shielding irradiator of Canadian construction donated by the UNDP and installed in March 1985. As a result, the application of nuclear techniques has contributed to the general development of the economy. These applications have contributed to successful development in the industrial and agricultural sectors, the sectors with the highest concentration of activities. The distribution of agencies employing nuclear techniques in various sectors of the economy was 15.5 percent for medicine, 59.5 percent for industry, and 28.0 percent for agriculture.[49]

All of these efforts were directed toward the integration of nuclear energy in all of its peaceful uses, and all of them have promoted the development of basic and applied research, which is an essential component of the infrastructure necessary to meet the elevated scientific requirements of the Cuban nuclear program. Another positive advance in this area was the creation of the Centro de Estudios Aplicados al Desarrollo Nuclear (CEADEN), which was inaugurated in October 1987 by Fidel Castro and the then-director-general of the IAEA, Hans Blix. The center is dedicated to applied

research, the assimilation and development of new techniques, and the provision of scientific and technical services to different national institutions. Its primary activities are linked to analytical chemistry, radiochemistry, radiobiology, nuclear electronics, and the technologies to secure primary materials for the nuclear program. Examples of this work are two workshops hosted by CEADEN and the IAEA in Havana in October 1997, the Workshop on Nuclear Physics and the International Symposium on Nuclear Related Techniques in Agriculture, Industry, Health, and Environment. The two workshops were attended by more than two hundred nuclear scientists from twenty countries.[50]

All of the research and development undertaken has been documented by the Centro de Informacíon de la Energía Nuclear[51] (see Figure 3.3). The agency was founded in 1983 and has been the source of thousands of documents detailing research and development activities. It has also published hundreds of monographs and articles in specialized journals and scientific publications throughout the world. All of this work compliments the National System of Scientific and Technical Information, a computerized information database and network available to all national agencies working in this area. The center also publishes a scientific journal, *Nucleus,* and offers specialized media and translation services. This agency is also charged with disseminating of public information regarding the development of nuclear energy and bringing a deeper and more objective public awareness of the realities of nuclear energy.[52] In 1995 the center formed a government-

Figure 3.3: Centro de Informacion de la Energia Nuclear (CIEN) and Consultoria Delfos

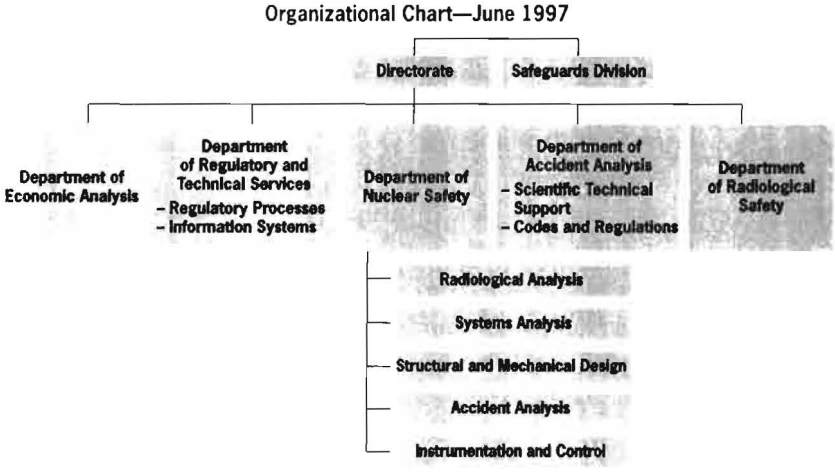


authorized nongovernmental organization (GANGO), Consultoria Delfos (see Figure 3.4). This consulting agency on nuclear and energy information is a for-profit organization offering translation services, analysis, data searches, and retrieval.[53]

Another essential link in this infrastructure is the Centro de Investigaciones Nucleares, an agency founded in 1988 in cooperation with the USSR. It is equipped with a 10MW research reactor, a critical model for the study of the characteristics of VVER-type nuclear reactors, neutron physics laboratories, radioisotope production, and radiological protection facility. In addition, another group of facilities was designed to meet Cuba's growing demand for radiopharmaceuticals and components marked for uses in medicine and other areas of the economy. The Centro de Aplicacíon y Desarrollo de la Instrumentacíon Nuclear was created to "guarantee" the development of the national nuclear program.

From all of the activities mentioned, from the construction of the CEN Juragua to the different sectors utilizing ionized radiation, the factor of concern for radiological protection and nuclear safety has been an absolute priority. The approval of the Decreto-Leyes (Decree-Laws) Nos. 56/82 and 98/87 and the work on other regulations signified a substantial advance, and they created an integral system of measures, laws, and regulations as a part of the standardized legal basis guaranteeing the safe use of nuclear energy and the protection of man and the environment against radiation. For the supervision and functioning of this system, the government created the Centro de Proteccíon e Higiene de la Radiaciones [Center of Radiation Protec-

Figure 3.4: Centro Nacíonal de Seguridad Nacional

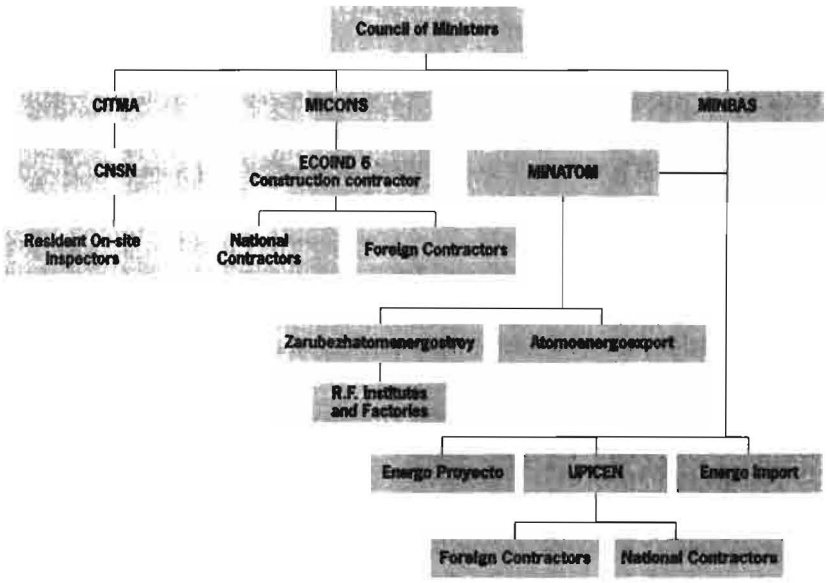


tion and Hygiene] (CPHR). This agency was charged with the technical coordination and radiological oversight of the entire country. It is also linked to a national network to detect environmental radiation, which includes laboratories in the western, central, and eastern parts of the island as well as other points throughout the nation. By 1990, the breadth of this effort resulted in twelve hundred nuclear technical activities attended to by nearly eight hundred specialists, and a group of workers responsible to monitor the fourteen hundred workers, all under strict individual dosimetry control. In 1989, an intergovernmental agreement between the USSR and Cuba called for technical assistance in the area of state supervision of the CEN Juragua and other facilities under construction. To attend to these important matters of nuclear safety, a group of principal inspectors was formed from different agencies within the government, who work with the resident inspectors at the different facilities under construction and the regional delegations from SEAN to maintain systematic control. This prompted the formation of the Centro Nacional de Seguridad Nuclear (CNSN) to supervise the system.[54]

Cuba dedicated special attention to quality control during the initial stages of construction of the CEN Juragua and assumed responsibility for compliance with the norms and standards promoted by the IAEA in the area of nuclear safety, especially after the nuclear accident at Chernobyl. The radiological security of the CIN and the CEN Juragua were to be guaranteed by a series of strict measures that included projects, assembly techniques, and operation of the facilities. At the nuclear plant, the cooling of the active zone of the reactors and their integrity are secured in every circumstance whatsoever, including improbable risks such as the direct crash of an airplane into the facility, an earthquake, or a tidal wave. All radioactive gases and aerosols are specially filtered before release into the atmosphere. All waste liquids and solids are to be treated for contamination and stored in special containers under conditions of minimum risk. At the site there is to be systematic monitoring of the water, air, and soil of varying distances in radius from the site of the facility, in accordance with international practice (see Figure 3.5).

More important are the changes that have occurred in the areas of nuclear safety, materials handling, and the control of sensitive materials in the period since the demise of the Soviet Union. In 1995, all nuclear activities were placed under the new Ministerio de Ciencia, Tecnologia y Medioambiente [Ministry of Science, Technology and the Environment] (CITMA), the creation of which also reorganized the nuclear bureaucracy itself by creating the Agencia de Energia Nuclear (AEN) as the coordinating agency for all other agencies except for the nuclear safety agency, CNSN (see Figure 3.4). CNSN became a parallel agency to AEN in charge of nuclear

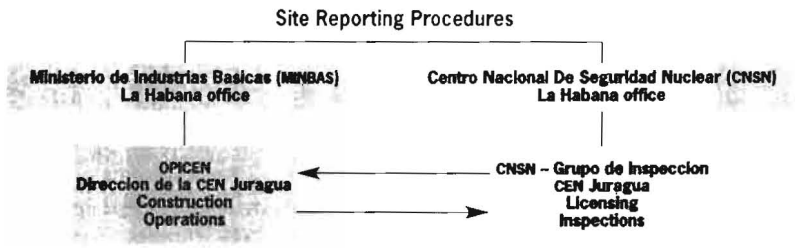
Figure 3.5: Organizational Structure of the Main Participant Organizations at the Juragua Nuclear Facility (1999)



safety, export controls, and all regulatory functions. It began as an attempt to streamline reporting within the agency and at the interagency level. Faced with significant resource constraints and in compliance with Decree No. 208/96 "Regarding the National System of Accounting and Control of Nuclear Materials," the Cubans sought to reorganize CNSN so that it would correspond to similar agencies internationally.[55] It is intended to be a stand-alone, independent agency responsible for the following areas: safeguards compliance, licensing and inspections, regulatory monitoring, economic analysis, and information systems. The Cubans were seeking to distance their practices from the previous Soviet-modeled system to one that corresponds to the system employed by the U.S. Nuclear Regulatory Commission. Moreover, under this reorganization the CNSN includes specific areas of licensing and inspection for the following areas: radiological analysis; systems analysis; structural and mechanical design; accident analysis; and instrumentation and control systems (see Figure 3.6).

In relation to the activities at the nuclear reactor construction site, the Cubans are confident that they have established a system for licensing, monitoring, and reporting at the site that has the ability to conform to all international standards for reporting, safety, and materials handling. MINBAS is responsible for the construction at the site. The construction man-

Figure 3.6: Reporting Procedures between MINBAS and CNSN at the Juragua Construction Site



agement group OPICEN reports directly to the CNSN regulatory group at the site, the Grupo de Inspeccíon. Both groups can confer with their respective agencies in Havana, and both agencies have established channels of communication in the capital. In interviews with nuclear safety specialists, the design of the reactor has been modified to incorporate the changes in licensing regulations. Moreover, this new regulatory structure employs sixty to seventy specialists to carry out the duties of CNSN. Because of the limited amount of resources available to the agency in the post–cold war period, judicious employment of these resources is paramount.[56]

Overall, the reorganization represents a concerted effort to streamline Cuba's licensing and regulatory practices. There still remain doubts as to the efficacy of this system because of the present resource constraints and because no independent evaluation of the system has been conducted.

In designing and creating a viable nuclear bureaucracy the Cubans have behaved in a manner consistent with the expectations of the economic and technological model of nuclear energy development. Specifically, the approach argues that as a by-product of the development process we would find that there would be training and development of scientists, technicians, and specialists within an expansive bureaucracy. Moreover, these activities would directly be supporting the creation of a Cuban source of knowledge and technical expertise in specialized areas. This provides a base for expansion and assimilation of high technology, related to the exploitation of nuclear energy, to many different areas of Cuban life.

This evidence also supports the economic and energy security approach, as the development of these human resources also serves to provide Cuba with a stable human resources to meet its energy needs and would also minimize its exposure in this area. Cuba would no longer have to look outside the island for the requisite highly trained personnel to staff its nuclear infrastructure.

Costing the Development of Cuba's Nuclear Energy Capability

National Energy Security

Without a doubt Cuba has based its development and its exports of fossil fuels on external suppliers. Nearly 90 percent of Cuba's oil must be imported. In addition, Cuba has relied exclusively on foreign capital investment for support and maintenance of the energy sector. The loss of Soviet oil was a painful lesson on the overreliance on any one source of oil exports, but more importantly, it pointed to the fragile nature of Cuba's energy sector, for which the consequences have been devastating. The selection of the nuclear option was, and continues to be, a viable option for Cuban policymakers, but even this consideration has been tempered by the shaky financial basis for such an undertaking.

The Castro regime has adeptly managed this "failure" by continuing to deflect attention away from the Cuban energy policy shortcomings on the Russians and the Americans. But until such time as the Cubans find a secure source of oil for consumption and development, any success in the energy sector will be both hollow and fictive. The development of nuclear energy capabilities has been impressive thus far, but a nuclear energy source appears to loom long off in the future, providing no effective remedy to the current situation. In 1998, the cost of oil imports represented 60 percent (or $978 million) of Cuba's total exports earnings.[57]

National Development

The development scheme involving the peaceful exploitation of nuclear power has proven to be a project with mixed results. On the one hand, Cuba has been remarkably successful in creating and developing a wide-ranging and diversified nuclear infrastructure. In the period since the early 1970s, more than fifteen hundred nuclear engineers have been educated and dispersed throughout different sectors of the Cuban economy.[58] The figure is on par with both Argentina and Brazil, countries with significantly larger populations and economies.[59] Cuba has significantly expanded its electricity-generating capability since the Cuban Revolution, and its impressive efforts to develop nuclear energy applications are testament to its developmental resolve.

These accomplishments, though, are mitigated by Cuba's failure to complete the nuclear reactors at Juragua. This Russian-Cuban venture has already spent in excess of $1 billion, and there is no real estimate of the costs of creating and developing the nuclear infrastructure and human capital associated with the Juragua program. It can certainly be argued that the application of nuclear science and scientific techniques has been of great

benefit to Cuban society. However, there are lingering doubts as to whether the investment will actually generate long-term benefits. In rationalizing the selection of the nuclear option, Fidel Castro Díaz-Balart stated:

> It was the clear understanding of the need to create a solid infrastructure for the assimilation of nuclear energy and the introduction of nuclear science and technology into the country's economy, including investment, the formation of cadres, research, cooperation and other matter, that directed important political and organizational decisions.[60]

Yet this development manifesto may have disregarded the appropriateness of nuclear energy for Cuba. In a 1970 monograph, Boris Semevski, a noted Russian geologist, did not even discuss nuclear energy as a possible alternative for overcoming Cuba's acute shortage of organic fuel. Semevski concluded that the planned construction of two thermoelectric power stations with a total generating capacity of 1,200MW would "finally solve the shortage of energy and make Cuba the Latin American leader in energy production per capita."[61] It was only a few years later when Cuba launched its ambitious scheme to construct a network of nuclear power facilities across the island.

Social Implications

The expansion of Cuba's energy sector has had far-reaching and impressive results since the 1959 revolution. Even with the severe economic impact of the end of the cold war, Cuba remains one of the paragons of the developing world in quality of life indices. Unfortunately, Cuba's forced reliance on inefficient energy-using technologies has significantly affected the livelihood of Cuban society. Because of the "rationed" distribution of energy to the national electrical grid, many Cubans routinely and daily face hours without electricity. It is not uncommon to see entire sections of metropolitan Havana eerily darkened while tourist hotels and nightspots are brightly lighted. Telephone service is regularly interrupted without warning and with no idea when it might be resumed. With Cuba's tropical climate, the loss of electricity and refrigeration means the spoilage of valuable foodstuffs. For some Cubans it has also prompted a reliance on oil and gas for lighting and cooking with some instances of fires and explosions. Everyday tasks like washing clothes become impossible tasks with the loss of electricity.

The shortage of fuel has prompted the switch to renewable energy sources. Windmills, solar panels, and biomass generators are increasing in use. In addition, a bicycle revolution has swept Cuba. The government has imported more than 1 million bicycles from China in recent years, and the well-marked bicycle lanes throughout Havana and other major cities are usually clogged.

The wider implications of the energy shortage period have been the reduction of industrial and agricultural output and an increase in unemployment. The shortage is compounding the already strained access to consumer resources and is forcing many Cubans to spend their entire day in search of the evening's meal with only a few meager pesos. Prior to the 1959 revolution, only 60 percent of the population was served by electricity, and most of this service was concentrated in large metropolitan centers. By the early 1990s, more than 90 percent of the Cuban population received regular electrical service. In the late 1990s, Cuba's efforts to provide regular electrical service to its population has been sporadic at best, at times completely debilitating. Farm production dropped by 50 percent in the period of 1990 to 1994 with the loss of fuel for farm equipment and machinery. Manure has replaced chemical fertilizers, worms have replaced insecticides, and oxen and humans have replaced tractors. A new land reform program has broken up most of the state's large collective farms and given the land to the workers, creating an innovative system of profit-driven companies. What was once the most mechanized agricultural system in Latin America has been turned into the world's largest area under organic and semiorganic farming.[62]

It is accepted that the structure of energy supply and demand in a given developing state can serve to alleviate poverty and that especially promising approaches seek to satisfy basic human needs. Cuba's postrevolutionary energy policy was wildly successful in this regard while the Soviets were ready and able to provide Cuba with favorable trade arrangements to meet those objectives. In the period since the demise of the Soviet Union, Cuba has significantly backslid, and any and all subsequent efforts and policies in the energy sector must regain lost ground before the expansion of the sector can be considered.

Investment Capital

Since 1992, Cuba has been seeking financing from partnerships with countries with the financial resources to assist it in completing construction at its nuclear power facility at Juragua. Together with the Soviet Union (and now the Russian Federation), Cuba has invested more than $1.2 billion in the effort to develop a nuclear energy capability. In 1992, Russia demanded $200 million in cash for the instrumentation and control system needed to complete Juragua Unit No. 1. It was a reversal of sorts for the Cubans. When Russian officials agreed in April 1992 to continue funding for the construction of the reactors, the regime appeared to have cleared the last hurdle in its ten-year quest for nuclear ascendancy. Cuba needed only to negotiate payment of $21 million to the German firm, Siemens AG, for the installation and control systems at Unit No.1. This was all but forgotten by September

1992 when Fidel Castro proclaimed in the "State of the Revolution" address that Cuba was temporarily "suspending" construction on the project. In announcing the bitter and painful decision, Castro blamed the Russians for demanding the $200 million. Yet in November of the same year, Cuba and the Russian Federation announced that work on the project would resume with assistance from the French firm Electricite de France (EdF). Although this agreement called for the resumption of construction at Juragua, no concrete plans were ever detailed and the project fell by the wayside. In 1993, the Russian Federation advanced $30 million to Cuba to place the construction site into a "state of suspension" until such time as it would be able to secure adequate funding to resume and complete construction. And so it has gone since 1993. Cuba has been entertaining prospective investors to fill the role of the *tercer socio* (third partner) in a joint venture project to complete the reactor. The enterprise included the commissioning of the Italian firm, Ansaldo SpA, to conduct a feasibility study for completing of the project. The study was made the behest of Cuba, Russia, and Brazilian interests. The study placed the cost of completing the project at $800 million. That figure is significantly more than the $21 million Cuba was negotiating with the Germans, or the $200 million asking price of the Russians. Moreover, as the study was never publicly released, an observer can only conjecture as to what aspects of the work at Juragua are still in need of completion. U.S. nuclear industry officials question the validity of the Ansaldo figure and place the cost of completion in excess of $1 billion dollars.[63] This figure may or may not include the retrofitting of equipment or systems that are not in compliance with safety standards and the reinforcement of some structural work at the site or decommissioning costs. Given that estimates place the cost of completion at somewhere around the $1 billion mark, one has to wonder how the third partner would recoup its investment. The proposed joint venture would be a partnership between Cuba, the Russian firm Atomoenergoexport, and a third partner. This deal would ensure that the third partner would be the first to recoup its investment ($500 million over three years), the Russian firm second ($300 million in addition to more than $1 billion already invested), and the Cubans last. The joint venture would sell electricity generation from the plant to the Cuban state electrical power company. According to this plan, from the time the deal is signed, it would take approximately thirty-six to forty-two months for operation to commence.[64] Based on Russia's record in collecting domestic energy rents, the investment would be rather suspect. Russia has only been able to collect one cent on the dollar of electricity sold for domestic consumption.[65] From this perspective the prospects for investment in the nuclear energy sector look bleak. There has been a renewed interest in renovating existing thermoelectric facilities

on the island. The financial constraints severely limit Cuba's ability to act in any meaningful way to address its energy woes. It does not appear that there are any short-term fixes to the dilemma. For all intents and purposes, it is the most significant barrier to Cuba's economic vitality, and as such, the energy sector is forced to wait until such time as Cuba is economically able to devote the significant finances required for advancement in this sector.

External Dependence

Cuba's reliance on external sources of oil significantly limits its ability to promote economic growth that is so much needed at this time. Because Cuba imports more than 90 percent of its oil, its economic vitality is contingent upon an uninterrupted supply of oil. Arguably, the pursuit of nuclear energy would limit and constrain Cuba in a similar fashion. As we have seen, Cuba has spared no effort in developing its nuclear energy infrastructure, especially at the human level. Yet, because Cuba must import all nuclear materials and components, it would be similarly reliant on the uninterrupted supply of materials, parts, and components for its nuclear infrastructure. This was evident in the author's visits to Cuba in the past three years. While the author has been impressed with the structure and function of all of the nuclear agencies and facilities he visited, it is clearly evident that much of the high-tech instrumentation is inoperable because spare parts are lacking or because complementary equipment is not available. The economic constraints would hinder Cuba's ability to maintain the highest standards of operation, maintenance, and repair required in a nuclear energy program. From all of the evidence gathered it is uncertain that Cuba is sufficiently equipped to meet these standards. Moreover, there is no indication that Cuba is prepared, or even desires, to undertake the fabrication to equipment, parts, and instrumentation to meet these needs.

Supply Inflexibility

The addition of one 417MW nuclear reactor would add 11.2 percent to Cuba's generating capacity. Should the reactor come on-line, Cuba would still require an additional 25 percent in generating capacity to make up for the drop in electricity production since 1990. If the reactor were to go off-line for any significant repairs, Cuba would be no better off than if it had never attempted to build the nuclear power reactors in the first place. One could even argue that under this analysis, there is little or no justification for pursuing a nuclear energy capability. If Cuba could realize its ambitious plans to expand the energy sector by bringing the planned six units on-line, then the 2,500 additional megawatts of generating capability would bolster

Cuba's total capacity by more than 50 percent. Cuba would then begin to lessen its dependence on fossil fuels. As it stands, Cuba has only two partially constructed reactors and no immediate prospects for investment in the venture. The fact that Cuba continues to negotiate modified cold war period oil-for-sugar barter swaps with the Russian Federation points to its continued dependence on others to provide it with sufficient sources of oil for energy.[66] Others have suggested that Cuba could ease the inflexibility of its energy supply by modernizing the existing power generation facilities at its 156 sugar mills, which take the residue from the sugarcane and burn it as fuel. The biomass (bagasse) burning facilities presently generate 15.7 percent of the total capacity for Cuba. But upgrading these facilities would also require a major investment, which is highly unlikely under current economic and political conditions. Some analysts contend that the total generated through this process could be doubled and that it would be a far better solution in terms of increased electricity production than building a nuclear plant.[67] This option is mitigated by the fact that the supply of the bagasse is seasonal in nature,[68] limited to the sugar harvest season, and that most of the sugar mills are not connected to the national electrical grid.[69] Cuba's energy supply is highly inflexible because of its overdependence on a single source for its oil imports. It is further constrained by its tenuous economic condition, in which a significant portion of its export earnings is devoted to purchasing enough oil to fuel its energy sector. While the trade protocols with the Russian Federation provide short-term relief, they do very little to correct the supply inflexibility and overreliance on a single source. These deals also provide Cuba with protection from the vagaries of the world markets for its sugar exports and oil imports, and they shield it from the impact of having to respond to market forces. This situation is an invitation for another potentially debilitating economic reversal should the supply of oil ever be reduced or curtailed for another unforeseen event.

Institutional Gravity

The creation and expansion of human capital in the nuclear sector in Cuba have been wildly successful. The nuclear bureaucracy is impressive in its scope and objectives, covering all aspects of nuclear science and the application of nuclear techniques throughout the various sectors of the economy. The focus has been one of resource creation as opposed to resource extraction. Cuba has sought to make its nuclear energy sector self-sufficient through the creation of various institutions of higher learning, research, and training, resulting in more than fifteen hundred trained and qualified nuclear engineers. It has also created the means of training the personnel at

the various nuclear facilities throughout the island. But the question here is: At what cost have all these impressive achievements been made? It has already been argued that Cuba has eschewed other less costly and more immediately realizable options in pursuit of the nuclear option, and that much of the assistance received from the Soviet Union could have been channeled toward much more productive centers of the Cuban economy. The construction of thermoelectric facilities could have satisfied and may still satisfy the Cuban energy demands, but they would not have reduced Cuba's dependence on imported oil.

Moreover, while the positive spin-offs from advanced nuclear applications to the Cuban economy and society have been impressive and noteworthy, these accomplishments are also analogous to having a Ferrari in the Middle Ages. This is especially evident in the post–cold war period where Cuba is consistently unable to meet the basic human needs of its population. Certainly, Cuba could have pursued other paths to economic and energy self-sufficiency, but the Cuban elite insisted at the outset of the program, and still do, that nuclear energy is a viable option for Cuba. In costing the development of a nuclear energy capability in Cuba it is implicit that this refers to the economic viability of such an effort vis-à-vis an evaluative criteria that is standard to most projects aimed at the development of such a capability. It directly addresses the expectations of the economic and technological modernization model, as well as the economic and energy security development model. For the former, it is a part of the promotion of economic rationality to achieve self-sufficiency in the energy sector. In the latter, it is a means of assessing the effects between economic growth and security concerns as they pertain to energy security. In both cases, the behavior is consistent with an economically based approach to the development of a nuclear energy program. The political motivations of modernization, while undoubtedly present in this case, are effectively muted through this evaluative process and are relegated to a secondary or tertiary level concern in policy decision making.

Opportunity Costs

The consideration of opportunity costs in the development of a nuclear energy capability in Cuba is an extension of the previous section, but it looks at those areas to which a strict economic analysis is less applicable although no less important to a state attempting to develop nuclear power. These costs are also essential factors in the decision whether or not to pursue such an endeavor. Moreover, the may provide additional supporting evidence for the three approaches being advanced in this book.

The Specter of a "Cuban Chernobyl"

Prior to Cuba's decision to suspend construction of the two reactors at Juragua, numerous questions had been raised concerning the safety of the reactors, the lack of international scrutiny of the construction site, allegations of shoddy workmanship, and the potential for a "Cuban Chernobyl," a mere 200 miles from the southern shore of the United States. This section will attempt to clarify the risks and rewards of Cuba's pursuit of a nuclear energy capability, including those related to nuclear safety, reactor design, the potential impact of a nuclear incident, and a summary of assessments of the state and integrity of the Cuban nuclear program. A review of economic constraints will focus on Cuba's search for a legitimate source of financing to complete the project, as well as details surrounding the formation of the a joint venture, the Juragua Consortium between Russia and Cuba. Finally, this section will briefly touch upon the "impact" of the Helms-Burton Amendment of 1996 and the political implications of Russia's apparent recommitment to competing Juragua.

Nuclear Safety

Critics assert that the prevailing economic difficulties have forced the Castro regime to cut corners, approve shoddy workmanship, and compromise safety considerations. The debate over safety at Juragua raises the possibility of a "Cuban Chernobyl." Critics contend that if a theoretical "major" or "serious" incident were to take place, large amounts of radioactive discharge could spew into the atmosphere and surrounding waters. The radioactive fallout would create a "dead-zone" with an 18-mile radius where nothing could survive. There would also be a 200-mile area where there would be serious health risks; food production would be impossible, and pockets of high contamination could drift as far as 300 miles away. A major incident would create a radioactive cloud capable of creating serious ecological damage as far north as Tampa, Florida, with secondary fallout extending to a 900-mile radius (depending on prevailing weather conditions).[70] The prevailing ocean currents would carry the radioactive fallout westward through the Jagua Trough, possibly spreading the contamination to the southern Cuban archipelago, including the Isla de Pinos.[71]

The Cuban reactor was the first Soviet nuclear venture in the Western Hemisphere. The challenges of building the reactor so far from home and in a completely different climate led to extensive delays in the construction schedule.[72] Moreover, defectors familiar with procedures and practices at the reactor construction site label Juragua a "technical disaster."[73] Vladimir Cervera, an engineer working in quality control at the reactor, stated that x-ray analysis showed that the welding pipes in the cooling system were

weakened by air pockets, bad soldering, and heat damage. He went on to say that of the pipes that were originally approved, 15 percent were later found to be flawed. Another defector, geologist José Oro, stated that the plant has numerous faulty seals and structural defects, and that since December 1990 the steam system has been left outdoors, exposing the equipment to highly corrosive tropical salt air and inflicting critical damage. The stability of the equipment is essential to reactor safety because leakage or other structural failure could result in a meltdown.[74] Russian and Cuban officials responsible for safety, construction, and quality control defensively and flatly deny that Juragua's safety is a legitimate concern. They point to Finland's Loviisa Soviet-designed VVER nuclear reactor as evidence of a safely operating Soviet-designed nuclear power facility.[75] Cuban specialists who had worked at the Juragua site are quoted as saying that the Juragua facility is virtually earthquake- and tornado-proof. They also say that the humid climate and the possibility of a direct air crash have been taken into consideration in the construction of the containment structure.[76] They do acknowledge that a nuclear incident is possible but contend that the area of fallout would be limited to an area of no more than 30 km (18.6 miles) and would pose no threat to other countries. Furthermore, they argue that the probabilities for Juragua are in line with those of other pressurized water-cooled reactors (PWR).[77] In response to the criticism of Cuba's nuclear policy, a leading Cuban official stated that "Cubans would never build a nuclear plant that isn't safe; we are the ones who have to live here; we are the ones the most concerned with it."[78] Dr. Daniel Codorniú Pujals, President of the Agencia de Energía Nuclear (AEN), contends that even with the prevailing economic difficulties, Cuba has been able to reorient its focus on maintenance and conservation.[79]

Even with these reassurances from Cuban officials, the doubts persist. In testimony before the House Subcommittee on the Western Hemisphere, Kenneth O. Fultz of the Resources, Community, and Economic Development Division of the U.S. General Accounting Office stated:

> It is possible that in the event of a severe accident, the containment structure—the ultimate barrier to the release of radioactive material in the event of an accident—could be breached, and a radioactive release could occur.... If Cuba obtains the assistance needed to complete its nuclear power reactors, U.S. officials will need assurances that all safety concerns are resolved and that the reactors are built and operated in a manner that does not pose a risk to the United States.[80]

Moreover, the assessments of risks from earthquakes and dispersion of radioactive pollutants suggest that an active seismic fault could produce

large to moderate earthquakes. In fact, in 1992 this fault produced a quake that registered 7.0 on the Richter scale. A 1988 assessment estimated that the Cienfuegos area could produce an earthquake with a probable maximum magnitude of 5.0 on the Richter scale.[81]

At a 1996 seminar in Washington, D.C., Thomas Cochran, a senior scientist with the Natural Resources Defense Council (NRDC), discussed the safety concerns regarding the Juragua project. Cochran dismissed the potential of danger that the power plant might pose to the United States. He concluded that rather than being based on scientific findings, these concerns were fueled by anti-Castro sentiments that have prevented pursuit of a policy that could ensure safe operation of the plant.[82] One could not expect a Chernobyl-type accident in Cuba. Unlike the Chernobyl RBMK-type reactor, the VVER reactor design incorporates a second containment structure for preventing the release of radiation in case of an accident. Juragua is a "one-of-a-kind" reactor that is similar in design to twenty-seven other Russian-designed reactors currently operating in the former Soviet Union and Eastern Europe. These reactors have operated for four hundred reactor years without a major accident. Cochran emphasizes that if a nuclear accident were to occur, most of the environmental degradation and radiation discharged would be limited to Cuba. He was, however, critical of the Cuban expenditure on nuclear energy, stating that upgrading the power generation capability of the island's 156 sugar mills using cogeneration of bagasse would be far less expensive and could provide up to one-quarter of Cuba's energy needs.[83]

Economic Constraints

In the search for a legitimate source of financing to complete construction of the Juragua project, it is necessary to discuss the nature of Cuban cooperation with the Russian nuclear technology export firms Atomoemergoexport and Zarubezhatomenergostroy and the role that Russian specialists continue to play at the site. Both firms continue to have a limited number of engineers at the site (estimated at about two hundred), most of them working in a supervisory capacity. Numerous international firms have been mentioned as potential partners, including Ansaldo SpA of Italy, Siemens KWU of Germany, and Electricite de France (EdF). Nevertheless, when these firms are queried about their involvement with Cuban nuclear plans, all deny that they have any plans to provide assistance in constructing the reactors. Once a willing firm is found, any association would ensure that the third partner (*tercer socio*) of the joint venture (*empresa mixta*) would be first to recoup its investment in the project; the Russians would be second and the Cuban partner last.[84] The joint venture proposes to sell electrical generation

to the Cuban state electrical power firm. From the time that the joint venture nuclear cooperation deal is finalized it would take approximately thirty-six to forty-two months for operation to begin. This places the startup date at fall 2001 at the absolute earliest.

Political Considerations

The Helms-Burton Amendment of 1996 expressly proscribes any assistance to the Cuban nuclear program and seeks to penalize any states or firms who trade with Cuba with a dollar-for-dollar reduction in foreign assistance or the imposition of economic sanctions from the United States. Because Russia has committed itself to providing Cuba with assistance to finish the construction at Juragua, and because Russia is receiving aid from the United States for its nuclear program, it is uncertain what the amendment will mean for relations within the policy triangle. Compounding the uncertainty is the provision within this new law that exempts application of the penalties to aid to Russia covered under the Cooperative Threat Reduction (CTR) Act of 1991. Virtually all assistance going to Russia's nuclear infrastructure is covered under the CTR. Moreover, Russia's Ministry of Atomic Energy (MINATOM) operates with a high degree of autonomy that calls into question how effective sanctions emanating from the Helms-Burton legislation will be against the Russians. The uncertain international environment for accepting U.S. law, the increased Russian commitment to cooperating with Cuba, and the Cuban resolve to complete Juragua set a complex of obstacles and imperatives before a rational resolution of the potential for a nuclear facility of questionable integrity.

A Cost-Benefit Analysis of Policy Objectives

The Model of Development

The analysis of Cuban nuclear activities suggests that officials involved in initiating the nuclear program gave primary consideration to political objectives, viewing potential economic dividends as important but less significant. At the start of the program, it appears that Cuba emphasized the economic and developmental benefits. Fidel Castro Díaz-Balart claimed that the Juragua units would each represent significant savings of oil when operating. Yet, Cuba's action left little doubt as to the prime motivation for the venture. Of the two forms of nuclear cooperation available to Cuba, the turnkey project or the technical assistance program, the former would result in the construction of a ready-to-operate nuclear power station within three years. The latter, perceived to be less efficient, would enable Cuba to develop a nuclear infrastructure with highly trained personnel and special bureaucracies. In

1980, it was estimated that this process would take ten years to complete. The disadvantage to the turnkey option was that Cuba would be reliant on Russian expertise for operation and training of personnel at the CEN Juragua. Cuba opted for the latter option, which was perceived to be "the most flattering for the political ambitions of the Cuban leadership."[85] Although it had been argued that Cuba only needed to expand its thermoelectric generation capability to meet its existing and future energy demand, it nevertheless embarked on its ambitious scheme to construct a network of reactors across the island. Cuba's nationalism was an important motivating factor for the project. At the time the country needed a symbol to prove its increased international stature and a means of exhibiting the capabilities of the Cuban model of revolution and development. Arguably, Cuba selected the wrong model of development if political propaganda value was the underlying rationale for the nuclear energy development project. More than fifteen years have passed since ground was broken on the Juragua Unit No. 1, and Cuba remains at least three years from potentially realizing its nuclear ambition.

Policy Objectives and Instruments

The policy objectives of Cuba's nuclear energy development have simultaneously succeeded and failed. Cuba conceived the nuclear program to progress along two paths. The first one was specifically devoted to the development of nuclear energy generation facilities; the other, to the creation of a nuclear scientific and technical infrastructure for research and the application of nuclear science and techniques in different sectors of the Cuban economy. Cuba originally planned to construct twelve nuclear reactors at three primary sites in Cuba. Each facility would be comprised of four nuclear reactors with support facilities. These reactors would certainly meet and even exceed Cuba's energy requirements well into the twenty-first century. Nuclear energy plans in succession have been downgraded to only two reactors at the three sites; to the two units under construction at Juragua; and finally, the now seven-year-old "state of suspension." In that time period, Cuba has seen its energy production drop by more than 10 percent and now faces the prospect of a failing energy infrastructure. Interestingly, the drop has prompted a resurgence of interest and activity from foreign investors in Cuba's thermoelectric generation capabilities, as will be discussed in the next chapter.

Cuba's creation and development of the nuclear scientific and technical infrastructure stand as the most successful and impressive aspects of its nuclear ambition. In the period since the end of the cold war, this area has been the most active, expanding the scope and mission of the bureaucracies

to meet the challenges posed by the loss of most of its resource base and finances. The author's visit to Cuba in May 1997 was marked by one significant departure from his previous visit in January 1996. In a speech on January 17, 1997, Fidel Castro indicated that Cuba would begin to consider alternative means of energy generation to nuclear power. Such a consideration is reflected in the reorientation of the bureaucratic structure and the change in the name of the Centro de Informacíon de la Energia Nuclear (CIEN) to the Centro de Informacíon de la Energia.[86] In dropping "nuclear" from its name, it reflected a sea change in the priorities of the Cuban government as they pertain to energy production. By their admission, Cuba's policies, which were implemented to develop nuclear energy, harbored "romanticized" notions of the Cubans' ability to attain a nuclear energy capability.[87] This is not to say that nothing has come of their efforts. The Cubans take pride in the human development that has accompanied their efforts to develop nuclear energy. Highly trained nuclear engineers, scientists, and technicians staff the nuclear agencies. To take full advantage of this human capital, the new orientation toward energy generation must be supported by such notions as practicality and efficiency.

The reactor construction site at Juragua remains in a state of paralysis. Site visits indicate that activity at the construction site is almost nonexistent. Moreover, by de-emphasizing the quest for a nuclear energy capability, the Cubans may indirectly be admitting that the reactor under construction at Juragua might never see a day of operation. Nagging doubts about the integrity of construction at the site and the possibility that replacement and backfitting of poorly constructed systems might drive up costs could render the "Project of the Century" to the dustbin of history.

Within the context of paralysis, an observer may wonder why Cuba would be seeking cooperation agreements with the IAEA in the areas of nuclear safety and quality assurance. The search is indeed questionable if Cuba is investigating other forms of energy generation. Yet, the long-term designs of the nuclear bureaucracy point to a future where Cuba may have all of the related agencies, safety practices, and legal structures in place for a vibrant nuclear program, short of an operating nuclear reactor. By signing and eventually ratifying the Tlatelolco Accord, Cuba would face no international restriction to importing a nuclear reactor. A preliminary analysis of these activities suggests that the efforts of the Cubans to keep their nuclear aspirations alive will be successful for the time being. The changes and developments in the peripheral areas of the civilian nuclear program complement its policy of simultaneously pursuing nuclear and alternative energy sources.

Future Scenarios

At the start of the program, the government attempted to emphasize the economic benefits. Yet Cuba's actions left little doubt as to the prime motivation for the venture. Two possible forms of nuclear cooperation were available to Cuba: (1) the construction of a turnkey project or (2) a development program emphasizing the provision of technical assistance, which would be less efficient.[88] Cuba opted for the latter, which was perceived to be "the most flattering for the political ambitions of the Cuban leadership."[89] Moreover, it was not clear that a nuclear energy program was even needed in Cuba. A 1970 monograph by Soviet geologist Boris Semevski did not even discuss nuclear power engineering as a possible alternative for overcoming Cuba's acute shortage of organic fossil fuel. Semevski concluded that the planned construction of two thermoelectric power stations of 1,200MW would "finally solve the shortage of energy and would make Cuba the Latin American leader in energy production per capita.[90] But only a short while later, Cuba launched its ambitious scheme to construct a network of nuclear power facilities on the island. Cuba's nationalism was an important motivation for the project. The country sought out a symbol to prove its increasing international stature and a means of exhibiting the capabilities of its model of revolution and development. Indeed, a nuclear power station built with Cuban hands would become a "brilliant propagandistic confirmation" of the success of the Cuban Revolution.[91] Three factors currently weigh heavily against the safety of Cuba's nuclear programs. First, no comprehensive technological and scientific assessment of the Cuba's nuclear facilities is readily available, a fact that gives rise to the uncertainty of the safety of its nuclear program. Second, claims and counterclaims about the shoddy construction and poor construction of the reactors at Juragua suggest that there is a reasonable doubt for concern. Finally, Russia's legacy in the nuclear industry leaves much to be desired. Its intimate cooperation with Cuba compounds the already existing fears of and opprobrium to the development of nuclear energy on the island.

Preliminary assessments of the reactor design, the safety record of other similarly designed reactors, and the ongoing development of Cuba's nuclear bureaucracy all suggest a positive movement toward a competent nuclear industry, but legitimate doubts remain. Here, in a passing nod to Ronald Reagan's position regarding Soviet compliance on disarmament measures, the world can trust the Cubans are doing the right thing, but someone must also verify that this is so.

Table 3.7: The State of Construction at the CEN Juragua-Reactor No. 1 (as of May 1996)

Type of Work (in tons)	*Volume of Project*	*Completed*	*Percentage*
Civil			
Movement of Earth	4,321,363	3,600,620	83
Concrete	354,023	270,268	76
Reinforced Steel	27, 053	23,396	86
Steel Inserts	4,870	4,461	92
Metallic Structures	9,967	7,799	78
Mechanical			
Thermo-Mechanical Equipment	2,031	1,174	44
Pressurized Steam Equipment	1, 039	655	63
Ventilation Equipment	990	241	24
Electrical Equipment	14,742	2,066	14

Source: M. Serradet Acosta, "Programa Nucleoenergetico Cubano," 12; and an interview by the author with Serradet-Acosta Havana, Cuba, Jan. 15, 1996.

The loss of Cuba's Soviet benefactor has rocked the Cuban economy. Moreover, it has forced the nuclear program to refocus its meager resources toward maintaining what facilities already existed and hoping to be able to conserve its partially constructed reactors until such time as it could secure financing for the completion of the projects at Juragua. The constraints are considerable enough to suggest that if Cuba intends to complete Juragua, many of the procedures associated with a safely operating nuclear facility will have to be compromised. This is a realistic suggestion when one sees how much difficulty Brazil, with its significantly larger economy, has had in completing its own civilian nuclear energy reactors. A strictly economic rationale for nuclear energy development in Cuba has always been questionable. In light of its recent economic difficulties and its growing inability to maintain energy sufficiency, its decision to continue this pursuit is understandable, yet it contains a high risk for completion. The resources that have applied to this pursuit might have been put to better use in the development of other sources of energy.

The assessment of Cuba's continued pursuit of nuclear energy must take into account how much political capital Cuba could earn by completing the project. Domestically, it would be a gold rush of sorts, the ultimate show of defiance in the backyard of *Los Señores Imperialistas.*[92] It would matter little how efficient the reactors would be. The idea of such a high technological accomplishment becomes the highlight of the success of the revolution.

Internationally, with the exception of the United States there is little opposition to Cuba's attempts to develop nuclear energy.

Resuming Construction

The potential for environmental disaster because of a nuclear incident exists, although minimally, but it would most likely be concentrated in Cuba, devastating the island. The $800 million estimate from the Ansaldo feasibility study is conservative because there remain unanswered concerns about nuclear safety and no means of independent verification of claims and counterclaims regarding the integrity of the CEN Juragua. It is important to remember that the IAEA is not a regulatory body in the strictest sense of the word. Although it provides services for operational safety and review assessments, its primary function is that of promoting nuclear power and providing monitoring and verification against proliferation of nuclear weapons capabilities. Moreover, despite the government's establishment of new agencies for the environment, nuclear safety, and material control and accounting, there remain questions regarding the competence of such agencies and their inherent ability to meet internationally recognized standards of environmental protection and nuclear safety. This is especially relevant in the wake of the Chernobyl experience and because of Cuba's close cooperation with Russia in the area of nuclear energy. Moreover, Espino, Díaz-Briquets, Perez-Lopez, and others assert that Cuba's overreliance on symbolic undertakings often negates the clearly definable environmental considerations and is, in essence, immune to them.

Continuing the "State of Suspension"

By continuing to keep the project in the state of "suspension" or "conservation," the Cubans keep open the possibility of finding a source of financing the completion of the nuclear project. The negative implication of this alternative is that it does little to assuage the concerns of the international community regarding the integrity of the Juragua construction site. Russia's renewed commitment without the requisite financial resources relegates its capacity to assist the Cubans to a symbolic gesture of friendship. This is by far the least costly of the options presently available to the Cubans. Choosing this option raises the specter that continues to be a source of much of the criticism related to Juragua and the possibilities of inadequate storage and deteriorating mechanical equipment. If Cuba finds the means to restart construction, then its engineers may find that the equipment has been irreparably damaged by the elements. Here the Cuban nuclear program may find that even with financing secured, the cost of repairing damaged equipment may place completion of the reactors at Juragua out of reach. Pursuing the option of continuing conservation also means that no comprehensive

technical assessment of the site will be forthcoming. In its absence, there can be no verifiable and internationally recognized nuclear safety regimen that adequately responds to all the concerns regarding CEN Juragua.

Yet the alternative of continued suspension remains the most acceptable to critics of the program for the time being because its signifies that there will be no movement toward completion of this venture. It remains a credible option for Cuban officials because it keeps open a window of opportunity for external financing. The Ansaldo feasibility study, while optimistic about completing the project, may have underestimated the costs of completing Juragua because of the potential for the unforeseen and hidden costs of backfitting, updating, and replacing weather damaged and poorly maintained equipment.[93] Maintaining the "state of conservation" does not allow observers of the Cuban nuclear program to get any closer to resolving the potential environmental problems, which remain a mystery. Cuba's efforts to institute bureaucratic mechanisms that address environmental concerns are laudable, but they are constrained in their ability to assiduously pursue and resolve environmental concerns because of limited resources.

Abandoning Juragua—Burying the "White Elephant"

Abandoning the pursuit of a nuclear energy capability may result in an overwhelming public relations disaster for the Cuban leadership. While failing to finish construction at the Juragua project would appear to be devastating setback for Cuba's economic recovery, continuing to pursue a project that may never come to fruition might prove to be costlier for Cuba's long-term hopes for economic and fiscal stability. Committing almost another billion dollars to a project of questionable return would lend added credibility to the suggestion that centrally directed economies place symbolic emphasis first before any sound economic rationale. In the case of the Juragua project, almost $2 billion will have to be committed by a rather weak and indebted economy before operation could conceivably begin. Even this aspect of Cuba's nuclear ambition is questionable. Still, the nagging criticisms regarding nuclear safety and the threat of environmental disaster remain. Addressing these criticisms might require Cuba (or a qualified proxy) to invest substantially more than the $800 million mentioned in the Ansaldo feasibility report. For critics of the program, abandoning Juragua would be the best alternative although it would essentially relegate the project to the dustbin of history, having been written off as a gross inefficiency and a poor option in energy policy. Abandonment would not in any way lessen Cuba's dependence on oil. For the time being, the recovery of the present economic system and introduction of a market or mixed economic liberalization still

Table 3.8: Outcomes Matrix

Policy Alternatives	*Environmental Risk*	*Economic Viability*	*Nuclear Status Safety*	*International Support*	*Need for Technical Assistance*
Resuming Construction	Uncertain	Low	Uncertain	Moderate	High
Abandonment of Project	Low	Neutral	High	High	Low
State of Suspension	Low	Neutral	High	High	Low
Pursuing Alternatives	Moderate	Moderate	High	High	Moderate

require fossil fuels. Cuba will still be forced to develop alternative sources of energy that could help it meet its energy demands with the least amount of environmental degradation.

Rather than hold out any policy option as best, the purpose of this chapter has been to weigh the risks and rewards of some of the potential policy alternatives presently available in the case of Cuba's nuclear energy policy. The overriding objective of this chapter has been to provide a clear exposition of the impact of developing nuclear energy in Cuba. What is readily apparent from this analysis is that it is not a simplistic choice of one option over another. There exist a multiplicity and overlapping of interests and imperatives that compound the decision-making process. Unfortunately these approaches are often at loggerheads and have had the effect of placing the issue into a zero-sum context. What has often been lost in this equation is the effect that all of these competing interests have on the Cuban population itself. The unreliable sources of energy have the most impact on Cuban society. The potential for an environmental cataclysm will effect this very same group the most. Presently, the inability of the Cuban government to resolve the energy crisis and to provide adequate and verifiable environmental protection for its people is justifiably reason enough for close scrutiny of its nuclear aspirations. The absence of the constructive confidence-building measures in the Caribbean Basin exacerbates the problematic relationships in place and only serves to place an adequate resolution of this situation beyond reach.

Although an immediate solution lies outside of the realm of political possibilities for the time being, a resumption of technological and scientific exchanges between the United States and Cuban nuclear communities

would provide the most tangible means to assuage fears, real or perceived, of a nuclear disaster in Cuba. This would not be something new. In the late 1980s, the Nuclear Regulatory Commission and officials from Cuba's Secretariado de Energia Atomica Nacional (SEAN) conducted exchanges and visits to facilities in both the United States and Cuba. The chief purpose of the visits was mostly for information exchange. Reinstitution of the exchange program could provide a means of conducting the proper scientific assessments of Cuba's nuclear facilities that are certainly of great importance to all interested parties. Such a program of education and consultation would seek to make individuals aware of problems and opportunities that lie outside of its sphere of presently available policy alternatives. It also serves to provide additional training and professional education in areas that demand a high level of competence and responsibility. The process involves a full assessment of the present state of affairs at the reactor sites and all associated bureaucracies. The most important products of such an undertaking would be twofold:

1. A clearly defined set of scientific analyses of Cuba's nuclear program that includes potential for reward and the potential for environmental risks and hazards from the exploitation of nuclear energy.
2. The potential for changing values about the integrity of nuclear energy, in general, and in the integrity of the reactors at Juragua. When provided with such information, all interested parties can openly discuss the true nature of Cuba's nuclear policy. Until such time, even under the most optimistic of political environments, the discussion of the subject will go no further than an exchange of partially substantiated claims and counterclaims, if that.

Commitment to a nuclear energy program may make long-term economic sense to national planners, but if outside observers regard it as an extravagant use of scarce resources in the short term, the country might have difficulty in obtaining bilateral and multilateral assistance. Alternatively, a program of civilian nuclear development undertaken by a country that is itself embroiled in regional conflict may prompt suspicious or apprehensive neighbors to suspect an ulterior and more nefarious military motive, a possibility given credence by several current cases.[94]

By subjecting the Cuban nuclear program to a cost-benefit analysis and possible outcomes we are provided with an effective means of determining how closely the actual case has adhered to the expectations of the three possible explanations offered thus far into this discussion. To this point, a preponderance of the evidence presented supports the economic and technological development model. Cuba has conceived and partially imple-

mented a nuclear energy program and bureaucracy that justifies, in economic terms, the Cuban decision to pursue this capability. Moreover, the analysis employed would provide a refutation of the Cuban policy were it not to conform to an economic rationale. Thus far the analysis has provided support for the contention that the Cuban program is based on sound economic principles. The economic and energy security model is also indirectly supported by the analysis, as one could argue that the case provides supporting evidence for this model because cost-benefit analyses by nature seek to strike a balance between economic growth and security concerns. The analysis also provides a means of assessing the long-term focus of the effects between the energy sector, the Cuban economy, and secure sources of energy for the island.

Although the Cuban nuclear program is often cast in terms of it being a confirmation of the politics of Cuba's nationalist/socialist development model, the strict economic terms in which its has been cast may be indicative of the inward focus of such statements. In other words, the Cuban nuclear program, while possibly providing a domestic rallying point for the regime, has been rationalized in terms of its economic viability. This is not suggest that all Cuban policy initiatives have been successful, but it suffices to say that with the evidence presented we can assume that in the realm of grand infrastructural programs, and specifically in this case, they will have undergone an economic evaluation. This does not speak to the rigor of such an analysis, but we can assume that economic viability comprises a portion of the decision-making process.

The External Factors of Influence on Cuba's Nuclear Ambitions

4

This chapter investigates the external factors of influence on Cuba's efforts to develop nuclear energy. This discussion will center on the bilateral, multilateral, and international aspects of Cuba's cooperation and interaction in the nuclear and energy fields. The first section on bilateral cooperation reviews Cuba's relations with its primary development partner as well as its burgeoning relations with partners in Europe, Canada, and Latin America. The section on multilateral and international cooperation focuses on Cuba's membership, role, and interaction with myriad international organizations, nuclear- and energy-related associations, in which it has participated in the period since the inception of the nuclear program. The last section will investigate the impact of the United States opprobrium to Cuban efforts in the energy sector with a specific emphasis on U.S. law and policy initiatives directed at undermining Cuba's nuclear ambition.

The social science modernization literature suggests that the source of the modernizing ideal will have a significant impact on the success and appropriateness of modernization schemes in developing states. Moreover, these schemes whether internal or external in nature will also carry significant implications for the trajectory of development within these states. On the one hand, modernization schemes that take into consideration states' human, technological, and scientific resource bases are more likely to be sustainable. This has been a major challenge to the proponents of modernization theory, where things solely Western are construed to be modern and vice versa, without consideration for their appropriateness to the society to

which they are being applied. On the other hand, development may be nearly impossible without the involvement of external forces, both positive and negative. From this paradox it becomes necessary to review and analyze the impact of these forces. This is an especially important component in the analysis of Cuba's nuclear ambition. This chapter seeks specifically to identify and explain the key external variables and influences that potentially impact and influence Cuban decision making in the energy sector. This is done to provide evidence in support for the three possible hypotheses offered in this book.

With the demise of the Soviet Union and the ending of the cold war in the early 1990s much attention was focused on the resulting impact of the Russian Federation's withdrawal of significant elements of assistance that it had been sending to Cuba. Moreover, the emerging "New World Order" now appeared to be democratically centered and market oriented. The Soviet denouement, the "democratic" renewal in Latin America, and the growing global economic interdependence signaled that cold war posturing and centrally planned economies would become a thing of the past. The overly dependent Cuban economy seemed ill equipped to manage this dramatic shift in world power, and for some, the days of the Castro regime certainly appeared numbered.[1]

Within this new environment analysts sought to predict, as it were, the future of Cuba and what this period of transition would mean for Cuba's foreign relations. They were especially concerned with identifying the key external variables that would most significantly influence Cuba's foreign relations. In the first place, there was a concern regarding how the evolution of Russian approaches to its Cuban partner would affect the old order of relations with the island nation. Would Russia, perhaps under nationalist pressure, expand its support of Cuba, particularly through economic assistance and the provision of military equipment? Or on the contrary, would Russia, experiencing serious economic difficulties, prefer to curtail its relations with Cuba even further, thus resulting in the "Cuban lobby" in the Russian Foreign and Defense Ministries being purged or ostracized?[2] Despite the problems that had arisen in the immediate aftermath of the ending of the cold war and in the economic relations between Russia and Cuba, cooperation between the two countries held the promise of potentially large benefits.[3] In broadening this inquiry the attitudes of other Latin American states toward Cuba would also play a significant role in the future. This included both trade and political relations, the readmission of Cuba into international organizations of the region, and the increased pressure on the United States to change its policies toward Cuba. Other external factors of influence could impact future Cuban development. The changing

attitudes of Western Europe (especially Spain) and Canada—in more general terms, changing positions of the "non-U.S." developed world—could under certain circumstances mitigate or undermine American policies.[4] Interestingly, Western European positions on Cuba have significantly deviated from the U.S. position, especially since the passage of the Helms-Burton Law of 1996. It was thought that there would be more rhetorical than practical opposition by the European Union countries to U.S. efforts.[5]

It is with these ideas in mind that we detail the relationships for the way in which they have influenced Cuban nuclear energy development policy, both positively and negatively. These relationships have evolved significantly in the period since 1991, and they continue to change in ways unforeseen by even the most keen observers and analysts of Cuban foreign relations.

Bilateral Nuclear Cooperation

Russian-Cuban Relations

The consideration of nuclear energy exploitation in Cuba would have been but impossible for Cuba without the Soviet Union (or another similarly equipped and willing benefactor). The case history suggests that Cuba's nuclear ambitions owe much credit to its relationship with the former Soviet Union. It is clear that in the initial stages of development, the nuclear program could be viewed as a "satellite" project of the overall program of nuclear energy expansion in the Soviet Union and Eastern Europe. During this period Cuba relied heavily on the Soviet Union for financing and assistance, the training of personnel, the provision of materials and equipment, and construction of facilities. An integral part of the relationship between the Soviet Union and Cuba was the design and implementation of a program for nuclear infrastructural development. This would include the creation of myriad support bureaucracies and the training of the personnel to work within these organizations.[6] From the period of 1982, when construction at the Juragua site began, until 1992, when the successor state, the Russian Federation, stopped providing assistance for the project, the Soviet Union poured more than $1 billion into the construction at the site alone. Because the figures are unavailable one can only conjecture as to how much assistance was provided to Cuba in the formation and operation of this bureaucracy.[7] This assistance, in addition to the capital outlays, included the provision of construction and training personnel and technical support in the design, construction, and operation of the research centers, facilities, and agencies within the nuclear energy sector. This is not to say that the Cubans were completely satisfied with the terms of this relationship. They were

certainly grateful for the assistance but were not always in agreement with the accounting practices, the schedule of delivery for key equipment and components, the chronic lack of spare parts, and the poor quality of those materials when finally delivered. Cuba's client status and its reliance on the Soviet Union made pursuit of the nuclear energy capability possible, but it also provided it with obstacles. These obstacles included debates over safety practices in the construction process, questions on reactor design, and the delays in the construction of the Juragua Unit-1. Nonetheless, by 1992, Cuba, together with the Soviet Union and then the Russian Federation, had between 75 and 80 percent of the base construction at Juragua Unit-1 completed, in addition to the creation of a vibrant nuclear scientific-technological infrastructure. This was a significant accomplishment for a developing state such as Cuba and by the early 1990s was suggestive of a bright future in the nuclear energy sector. Cuban officials, in part because of Russian patronage, enjoyed an elevated status among developing states. This elevated status was accorded to Cuba by virtue of its participation in international nuclear organizations, the renown of its nuclear medicine sector and the treatment of the victims of the Chernobyl accident, and the creation of highly trained cadres of nuclear engineers, specialists, and technicians.

The collapse of the Soviet Union in 1991 significantly affected the terms of the relationship between the now Russian Federation and the Republic of Cuba. It presented challenges of the kind that could relegate much of the Cuban economy to prerevolutionary levels. In a short time this did come to pass. At the closing session of the Cuban National Assembly in 1993, Fidel Castro stated, "We are facing a very, very great challenge. We have to be ready for greater difficulties than we can imagine."[8] This stark assessment was based on the fact that in 1993 oil imports and international trade had declined by more than half their previous levels, resulting in a severe energy crisis. In April 1992, Russia and Cuba concluded an agreement to continue funding for the Juragua. With the project more than three-fourths complete Cuba only needed to install the instrumentation and control systems for the reactor. Russian nuclear officials had contracted Siemens AG of Germany to install the systems. Unfortunately, Russia's own precarious economic situation precluded that they could pay for these services in hard currency as demanded by Siemens. Cuba was left to negotiate the $21 million payment with the German firm. Cuba, itself unable to generate the hard currency, could not complete the deal. In September 1992, Fidel Castro proclaimed during the "State of the Revolution" address that Cuba was placing the nuclear project into a state of "temporary suspension" because of Russia's demand of $200 million to continue work on the project. Yet, in November 1992, Russian and Cuban officials jointly announced that construction

would resume with French assistance. Contrary to the announcement in 1993, Russia advanced Cuba $30 million to mothball the construction. A letter from Secretary of State Warren Christopher to Senator Connie Mack of Florida stated: "The Russian government . . . has concluded that the completion of the project is not feasible under present circumstances."[9]

This began a cycle of announcements of the resumption of construction between Russia and Cuba and the search for a joint venture willing to underwrite the project. Since 1992, Cuba has concluded four major trade and economic agreements with Russia containing reference to the Juragua project and the resumption of activities at the construction site with no positive changes actually having occurred.[10] Little has come of these announcements, and it raises questions as to whether or not Russia maintains a legitimate interest in completing the Cuban venture.

Russia's Ministry of Atomic Energy (MINATOM) plans to export nuclear materials and technologies worth $3.5 to 4 billion by the year 2000. It currently has eight nuclear power units at different stages of construction in Iran, Slovakia, Ukraine, the Czech Republic, and Cuba.[11] In the post–cold war period, MINATOM has emerged as one of Russia's major currency earning exporters along with Gazprom and Rosvooruzheniye. With a workforce of two million, Russia's MINATOM-run empire earned $4.25 billion in exports in 1995 and 1996 with the annual projected growth of $3.5 billion by the year 2010.[12] Talks are underway for the construction of plants in India, Indonesia, and China. With Russia's announcement calling for the resumption of construction of the Cuban project in February 1998, the plans clearly illustrate the instrumental nature of its involvement in the Cuban project. Russia still needs to demonstrate to its potential suitors that it can successfully undertake and complete a nuclear reactor construction project far outside its borders. Moreover, this is one of the few instances where Russian work is being subjected to international scrutiny during the entire construction process. With the legacy of the Chernobyl accident and other nuclear incidents, the Cuban project has been vilified for poorly designed systems, safety practices, and the lack of adequate nuclear waste storage and disposal. Russians counter this claim with the "fact" that "foreigners are attracted by [*sic*] Russia's plants because, although cheap, their safety standards are comparatively high."[13] The safe and successful completion of a reactor in Cuba would go far in assuaging the suspicions of critics of the Russian nuclear industry. It would also present potential buyers of Russian nuclear reactors with an example of its ability to deliver the goods. This is the most important factor in attracting new buyers for Russian nuclear technology.

In 1997 the Russian Federation made no secret of its "desire" to return to cold war period trading levels with the Republic of Cuba. After a series of

high-level meetings on trade Russia and Cuba are once again seeking to increase trade and economic cooperation. This culminated in the negotiation of an oil-for-sugar swap and the expansion of Russian cooperation in the fields of nickel mining and once again on nuclear energy. Evgeniy Reshetnikov, deputy minister with MINATOM, announced that both countries needed this special agreement on the nuclear plant. "On the one hand Cuba is in desperate need of self-sufficiency in electrical supply, and on the other, the operation of the reactor will be the only way for Russia to get back from Cuba the enormous debts it owes our country."[14]

All reactor market considerations aside, the current status of the trade between the two countries belies these optimistic announcements and Russian critics of the post–cold war Cuba policy paint an unflattering picture of the Russian Federation's "ignominiously squandering [of] the legacy built by the selfless labor of several generations of our fellow countrymen."[15] The criticism is directed at the diminished arsenal of Russia's foreign policy assets and the blame lies with the leaders of the "young democratic Russia" and their decisions to reduce commercial contacts with the "ideologically foreign regime."[16] Bilateral trade between Russia and Cuba has steadily declined from $3.3 billion in 1991 to $550 million in 1996. The once wide assortment of goods exchanged has shrunk to a bare minimum. In effect, bilateral trade has been reduced to a single barter transaction, the exchange of raw Cuban sugar for Russian oil. For these critics, this state of affairs in bilateral trade relations results mainly from the actions of the Russian side, which abruptly altered its foreign economic orientation, often to the detriment of not only its foreign partners, but also itself.[17] In defense of the Russian position, nuclear officials with MINATOM maintain that the only reason for their withdrawal from the nuclear program stems from the economic considerations. The return on Russia's investment looks hardly profitable given the more than $1 billion dollars spent and the additional estimated $1 billion more that would have to be invested before construction is completed.[18]

As both countries enter the twenty-first century they are attempting to rekindle their trade relations and mutual cooperation. Together they have built an impressive nuclear program in Cuba that includes the cadres of highly trained personnel devoted to the peaceful exploitation of nuclear energy. Their failure to complete construction of the nuclear reactors at Juragua points to the now feeble economic foundation of the more than twenty-year nuclear cooperation relationship. It appears that the willingness remains firmly intact; it is just now that the limited economic capability of both states prohibits any significant advancement on the project. This has forced the Russian-Cuban partnership to look outside to attract potential partners to engage in a joint venture to complete the Juragua project. The

next section will detail Cuba's relations with other countries in the energy sector and will include a discussion of the efforts to elicit support from "tercer socios" in the nuclear project, but also with its relative success in attracting partners and investors for the conventional energy generation sector.

Initially, while both countries could "disregard" the economic elements of the decision to develop a nuclear energy capability in Cuba, it has become apparent that the Russian Federation could not afford to support Cuban ambitions in the post–cold war period. Moreover, the terms of trade are now cast in strictly economic terms eschewing any notion of the now moribund "socialist brotherhood." These factors indicate that Cuba's nuclear program most likely conforms to the expectations of the economic and technological modernization model of energy development. The evidence supports the contention of this model that would promote the nuclear program as long as it corresponds to the promotion of economic self-sufficiency. Given the overwhelming changes since 1991, it is hardly surprising that Russia has curtailed its activities because it could hardly justify the Cuban drain on its resources. Nor could the Cubans in an even more precarious economic state justify the expense of such a grandiose project when its ability to meet the basic needs of its population has been seriously compromised.

Cooperation with Other Countries

Until 1992, Cuba sought and received assistance for its nuclear program from the Soviet Union. The demise of the USSR and the COMECON states left Cuba, as well as those states, in a severe economic crisis.[19] Russia attempted to continue providing support for the Juragua construction, but its own economic travails at home left it with little recourse but to search out a partner to assist it in finishing construction at the Juragua site. Russia had successfully constructed a nuclear reactor through a joint venture in Finland. In constructing the VVER-1000 model reactor at Loviisa, the Russians were responsible for a majority of civil construction at the site and contracted the installation of the instrumentation and control (I&C) systems to the German engineering firm Siemens-Kraftwerk Union (KWU). This partnership was successful and as a result the Loviisa plant has been among the most efficiently operating facilities in the world.

The Russians felt strongly that this success could be replicated in Cuba and contacted the German firm. Siemens officials visited the Juragua site in early 1992 and agreed to move forward on the planned joint venture. Cuba only needed to pay the $21 million that Siemens was asking. It was $21 million dollars that the Cubans did not have. The project was soon scuttled and Cuba, with little prospect for continuing work on the project without external support, decided to place the project in a "temporary state of suspension."

This was not the first instance where Cuba had engaged in nuclear cooperation efforts with countries other than the Soviet Union. Dating back to 1986, Cuba has actively engaged other countries on two fronts. Initially, it sought nuclear cooperation agreements with other countries' governments. After the fall of the Soviet Union the rationale for seeking cooperation in this area became more instrumental to find willing partners (international commercial nuclear enterprises) to invest in the Juragua project.

In 1986 Cuba and Argentina signed a nuclear cooperation agreement under which both states would exchange technical information in a number of nuclear areas, including radiological safety, technical information, regulatory procedures, and safety practices. One suggestion for this cooperation would be that Argentina could somehow assist the Cubans with the construction of the reactors at Juragua. At that time the Cubans were reportedly short of funds to meet payments to the Russian contractor, Atomoenergoexport. Cuba was seeking assistance from Argentina on projects related to fuel fabrication and equipment supply.[20] On the heels of this agreement Argentina sought to expand its nuclear cooperation to land potential reactor contracts in Cuba for four VVER-440 model pressurized water reactors planned for 1995 to 2003. Brazil was also expanding its cooperation by training Cuban nuclear specialists and high-level technicians.[21]

At this time all three states were not signatories to the regional nuclear-free zone accord, the Tlatelolco Accord. In addition, all three were perceived to have nuclear weapons development programs and were the subject of much scrutiny from the international nonproliferation community. Shortly thereafter both Argentina and Brazil began to investigate the development of bilateral nuclear confidence building measures. This began with exchanges and information sharing, ending with a comprehensive regional nuclear cooperation organization linking both Argentina and Brazil with the IAEA and a new bilateral organization, the *Agencia Brasiliero-Argentino de Contabilidad y Control* (ABACC). This cooperation culminated with both countries signing the Tlatelolco Accord in the early 1990s.

In the immediate aftermath of the fall of the Berlin Wall, Cuba began to investigate alternate means of completing the Juragua project. By May 1991, at the behest of the Russian Federation, Siemens-KWU of Germany was nearing the end of negotiations to supply the I&C equipment for the Juragua units. Cuba was also discussing the I&C upgrade with two other nuclear firms, Cegelec of France and Skoda Works of Czechoslovakia. The work was valued at about $40 million. Cegelec and Siemens held discussions with the Cuban and Russian officials about the extent of work needed to upgrade the safety of the reactors. This bid was similar to the contract that Siemens won to upgrade the I&C systems at Mochovce-1 and -2 in Czechoslovakia. After

consultations with the United States Nuclear Regulatory Commission about the adequacy of I&C technology at the Cuban plants, Cuba approached Skoda. Skoda together with the Russians had supplied these systems for reactors throughout Eastern Europe. After Skoda told the Cubans that the work would cost around $300 million, Cuba sought more economical bids from Siemens and Cegelec. At that time the United States Department of State encouraged countries with advanced nuclear sectors such as France and Germany to become involved in improving the safety of the Cuban reactors. The United States Departments of Defense and Energy, however, were wary of any steps that would allow the reactors to go on-line.[22] Even with this flurry of activity the inability of the Cubans to provide the required financing for continued construction on the reactors effectively relegated these potential deals to the trash heap.

In 1995, after three years of inactivity and little interest in the nuclear program under the "temporary state of suspension," rumors started coming out of Havana that the Russians were prepared to begin construction once again. To revitalize the program, Cuba sought the assistance from Ansaldo SpA of Italy, National Nuclear Corporation (NNC) of the UK, Furnas of Brazil, and an unnamed British firm to conduct an economic and technological feasibility study. The long-term goal of this study was to establish a private multinational consortium to operate the plant and then sell the electricity to Cuba.[23] The cost to complete the project was estimated at $800 million.[24] The terms of the proposed multinational joint venture sought to attract a third partner (*tercer socio*) to join the Russians and the Cubans. This vaunted partner would invest $500 million and would receive a return on the investment before the Russians and the Cubans. During the period after these figures were released there was much speculation as to who the third partner might be. The Russians and Cubans concluded yet another intergovernmental agreement in June 1997, but as the year closed there was no indication that any of the firms mentioned was interested in investing the $500 million or anything remotely near that figure. A site visit by a group of American nuclear specialists to Juragua in October 1997 provided no indication that any work had been done at the site other than the installation of pressure vessels already at the site, structural reinforcement, and the painting of exposed piping. Rudimentary storage structures had been constructed to preserve material and equipment that had been in part exposed to the tropical elements.[25]

The efforts of Cuba to involve other states or multinational nuclear firms in the Juragua project have been largely unsuccessful. A number of these firms have visited the Juragua site and then opted not to participate in the venture. The reasons remain undisclosed and one can only conjecture

why there has been reluctance for involvement in this venture. Certainly, the economic difficulties that Cuba has experienced since the early 1990s have mitigated interest in the nuclear program. The potential for U.S. opprobrium to the Cuban venture has potentially lessened the desire of these firms to conclude any type of agreement with the Cubans, but this remains only as speculation. The impact of the "temporary state of suspension" has significantly effected Cuba, and because of its continuing reliance on a deteriorating energy infrastructure the energy sector was near collapse. Many of the existing thermoelectric generating facilities were old and in immediate need of major repair or outright replacement.

To address this chronic problem Fidel Castro announced in January 1997 that Cuba would seek alternative sources of energy to stave off the collapse of the energy sector and to maintain the economic growth trend of the mid-1990s. Remarkably, the response to this initiative was well received within and outside of Cuba. At the start of 1998, Cuba was negotiating or had concluded a number of deals to upgrade its existing thermoelectric facilities and to construct new facilities on the island. All of these projects were joint ventures between Cuban and foreign firms. Moreover, all of these projects were concluded with guaranteed sources of funding.

The Cuban government also announced a two-pronged strategy for boosting the cash-short energy sector that includes upgrading existing facilities while at the same time reducing domestic demand. Another component of this effort involves the upgrading of five 100MW of Czech and Soviet manufacture with foreign capital. This project includes the upgrade of two plants at the Antonio Maceo-Rente complex in Santiago de Cuba, two units at the Mariel facility near Havana, and one unit Nuevitas facility in Camaguey Province. Two French engineering companies, Babcock and Gemco International, have agreed to supply the equipment for the Antonio Maceo facility under a deal that is unwritten by a $15 million short-term credit from the French export insurance agency Coface. The French government also reportedly has given the Cuban government a $5.7 million grant to help improve efficiency at the island's heavy oil-burning units near the Varadero-Boca oilfields.[26]

Cuba by 1999 also plans to build a 250MW thermal unit in Holguin Province to serve its vibrant nickel-mining sector. It has not been revealed where the $250 million needed for financing the projects will come from.

The government is also planning an ambitious plan to increase overall generating capacity through a $500 million program to upgrade three 100MW units at the Santa Cruz del Norte generating complex and build an additional 350MW unit over the next three years. The Canadian firm First Key Project Technologies will carry out the work. The project will involve the

creation of a joint venture between First Key, the Chilean firm Santa Ana, and the Cuban state-owned power company Union Electrica. The venture will sell the power for hard currency to mining interests and other companies doing business in Cuba. It is also expected to be the first project to date in Cuba to be run by an external enterprise. The leading candidates for the project are Spain's Endesa and Electricite de France (EdF). Funding for this venture is expected to come from the Canadian Export Development Corporation and other lenders.

Additionally, the Canadian firm Sherritt International has completed talks with the Cuban state oil company, CUPET, regarding a joint venture to build 135MW of new thermal generating capacity that will be fired by the natural gas from the CUPET wells in the Varadero and Boca de Jaruco oilfields. Sherritt established a new subsidiary, Sherritt Power Corporation, to hold its electricity-generating business in Cuba. As things currently stand the joint venture, Energogas, plans to have two 50MW units running by mid-1999 and a 33MW unit running by the end of 1998.[27] The total generating output of the units will amount to 206MW. The cost of the planned works has been pegged at $150 million and the Canadian company is expected to earn 100 percent of the generated cash flow until the capital costs are repaid.

Sherritt Power is using proceeds from an initial stock offering to finance the Varadero-Boca gas and electricity project.[28] The project will upgrade the existing Antonio Guiteras Thermoelectric Plant and the José Martí Thermoelectric Plant, and once the Energogas project (150MW) starts to operate, electricity production will increase to more than 500MW.[29] The new facility will de-sulphurize petroleum gas from the Varadero oilfields for energy.

All told, the rapid expansion of projects in the thermoelectric generation sector is remarkable given the static nature of investment and activity in the nuclear energy sector during the past six years. As of 1999 plans are underway to upgrade the generating capacity of eight existing units with the potential of 800MW. The investment for these units totals $315 million completely underwritten by foreign firms. Meanwhile, Cuba has plans to expand this sector by 600MW generating capacity over the next three years. $350 million of the $600 million required for the projects has already been secured. The additional 600MW generating capacity will in increase Cuba's total capacity by 16 percent. This will be bolstered by Cuba's efforts to conserve and reduce domestic energy demand and increase the efficiency of existing facilities.

The decision to de-emphasize the nuclear program has opened the possibility of expanding the thermoelectric sector. Foreign firms have wasted little time in seeking out investments in this area, and for the time being, it appears that these projects will help Cuba to address its chronic energy problem. But the movement toward this type of energy generation raises other

questions. Will Cuba's oil imports increase as a result of this expansion? Will this consume an even larger portion of Cuba's export earnings in the short-term period? And does this signal a return to the foreign-dominated concerns to Cuba?

The terms and conditions of these projects seek to reward the investor first and the Cubans last. Moreover, these projects are directed at supplying energy and services for firms doing business in Cuba. It appears outwardly, at least in the short term, that the lot of the Cuban society will improve little as a result of these projects. Moreover, it appears that the focus of Cuba's foreign relations in the energy sector has shifted from government-to-government nuclear cooperation and development agreements to joint-venture projects involving Cuban state firms and foreign energy concerns. This shift also reflects the movement away from a reliance on a single source of materials, assistance, equipment, and financing for Cuban energy ventures. Unfortunately, for Cuba this has not included participation by these firms in the nuclear energy development program (see Table 4.1).

As mentioned, numerous foreign firms have exhibited an interest in the Cuban project and have visited the facility at Juragua. In each instance the prospective suitor has declined to invest or participate in the venture. This surely prompted the shift in policy by the Castro regime. A cursory examination of the change in policy orientation has been moderately successful and lessens the disappointment of maintaining the "temporary state of suspension" for Cuba's nuclear ambitions.

Table 4.1: Current Cuban Energy Projects and Joint Ventures

Facility	*Type*	*Location*	*Units*	*MW*	*Firm*	*$*	*Financing*	*Completion Date*
Antonio Maceo	Thermo	Santiago	2	200	Babcock	15m	Coface (France)	1998
Mariel	Thermo	Havana	2	200	Babcock	15m	Coface (France)	1998
Nuevitas	Thermo	Camaguey	1	100	Babcock	15m	Coface (France)	1998
Santa Cruz del Norte	Thermo	Santa Cruz del Norte	3	300	First Key	150m	Canadian Export Dev.	1999
Antonio Guiteras	Thermo	Varadero	2	100	Sherritt	150m	Sherritt	1999
José Marti	Thermo	Varadero	1	30	Sherritt	150m	Sherritt	1998
Unnamed	Thermo	Holguin	1	250	Unnamed	250m	Un-named	1999
Unnamed	Thermo	Santa Cruz del Norte	1	350	First Key	350m	Canadian Export Dev	2001
Juragua 1	Nuclear	Cienfuegos	1	417	Russian-Cuban JV	800m	TBD	2002
Juragua 2	Nuclear	Cienfuegos	1	417	Russian-Cuban JV	TBD	TBD	TBD

As with the previous section on Cuban relations with the Russian Federation, this section offers evidence supporting the economic and technological modernization model. All of the bilateral activities are consistent with this approach by seeking to expand Cuba's technical and scientific capability, as well as corresponding to the expectation of promoting economic self-sufficiency. The bilateral energy initiatives selected have been oriented toward the modernization of the existing energy infrastructure or expansion of the energy sector's generating capacity. Moreover, investment by external actors in Cuba's energy sector is indicative of the economic viability of these projects.

Unlike the previous analyses offered where the evidence presented supported the economic and technological modernization model as well as the economic and energy security model, Cuba's efforts to increase its thermoelectric capability significantly deviates from the expectations of the economic and energy security model. Whereas the model focuses on the maintenance of access to secure sources of energy, the Cuban bilateral activities indicate a shift away from this priority. Cuba by increasing its thermoelectric capability also increases its dependence on external sources of fossil fuel. In addition this increases Cuba's exposure to the vagaries of the world energy markets, of which the implications are the increased possibil- of an imbalance between economic growth and security planning. From ..is point forward the economic and energy security modernization model loses much of its explanatory value because it can no longer account for the priorities or the trajectory of the Cuban energy sector.

Multilateral Nuclear Cooperation

This section of the chapter looks at the cooperative efforts by the Cubans with multilateral organizations in the field of nuclear energy development. This includes a discussion of Cuba's relations and involvement with the International Atomic Energy Agency (IAEA), the United Nations Development Programme, and the Organizacion por la Proscripcion de Armas Nucleares en America Latina (OPANAL). In addition, it will touch upon the other nuclear related international organizations of which Cuba is a member or participant. Moreover, this section will detail how these efforts have assisted Cuba in advancing its nuclear energy policy.

International Atomic Energy Agency

Cuba has been a member of the International Atomic Energy Agency since its inception in the 1960s. From that period through the present Cuba has maintained a positive relationship with the multilateral organization. It has received assistance in the form of training of personnel in specialized fields

of nuclear science and technology, laboratory equipment, grants and fellowships for study and training abroad, and consultation on aspects of nuclear safety, materials handling, quality assurance, and regulatory and licensing procedures. In addition, Cuban representatives have served the IAEA in a number of capacities, including safeguarding inspection team members, resident technicians, international civil servants, and as a member of the agency's board of governors. Cuba for its part has had an active role in the IAEA. In 1983, it was elected for the first time to the board of governors; this was repeated in 1987. Fidel Castro Díaz-Balart, the Executive Director of CEAC, served as the Cuban representative to the board.[30] The relationship has been fruitful and beneficial for Cuba and until recently was viewed as a means of monitoring the development of the nuclear program and of proliferation risks. There is presently debate over the nature of assistance be provided from the IAEA to Cuba by the U.S. Congress, yet the positive relationship continues. Supporters of this relationship between the IAEA and Cuba contend that it serves the interests of all parties directly and indirectly involved.

During the 1970s Cuba signed, at the insistence of the Soviets, three safeguard agreements with the IAEA, which currently apply to all nuclear facilities on the island, including the nuclear facilities, a nuclear research reactor, and a zero power reactor.[31] The IAEA spent about $12 million on nuclear technical assistance projects for Cuba since 1963—when Cuba began receiving nuclear technical assistance from the international agency—through 1996. About three-fourths of the assistance Cuba received through these projects consisted of equipment such as computer systems and radiation monitoring and laboratory equipment. The IAEA's nuclear technical assistance was given primarily in the areas of general atomic energy development and in the application of isotopes and radiation in agriculture. In 1997, the IAEA approved an additional $1.7 million for nuclear technical assistance for projects in Cuba for 1997 through 1999.[32] In addition the IAEA spent about $2.8 million on training for Cubans and research contracts for Cuba that were not part of the specific nuclear technical assistance projects.[33] Of the total dollar value of all nuclear technical assistance that the IAEA has provided to Cuba, about $680,000 was approved for nuclear safety assistance for the nuclear reactors under construction at Juragua for 1991 through 1998, of which about $313,000 has been spent. The IAEA is assisting Cuba in developing the ability to conduct a safety assessment of the nuclear power reactors and in preserving, or "mothballing," the reactors while construction remains suspended. The IAEA is also implementing a training program for personnel involved in the operational safety and maintenance of all nuclear installations in Cuba, including the reactors[34] (see Table 4.2).

The agency's technical cooperation fund has been the primary source of funding for the nuclear assistance projects provided for Cuba. Specifically, the IAEA has provided four major nuclear assistance programs for the Cubans. Of the $680,000 that has been approved for the nuclear technical assistance programs, $313,364 had been spent on two of these projects as of January 1997. Here is a description of the IAEA assistance programs currently underway in Cuba:

- Since 1991, the IAEA has assisted Cuba in undertaking a safety assessment of the reactor's ability to respond to accidents and in conserving the nuclear reactors under construction. The agency has spent three-fourths of the $396,000 approved for the project. Spain has provided about $159,000 in extrabudgetary funds. This project is designed to develop proper safety and emergency systems and to preserve the plant's emergency work and infrastructure in order to facilitate the resumption of the plant's activities.[35]
- Since 1995, the IAEA has assisted Cuba in designing and implementing a training program for personnel involved in the operational safety and maintenance of nuclear facilities and installations. The IAEA has spent $31,000 of the $74,000 allotted for these activities.
- For 1997 and 1998, the technical assistance program will focus on two new projects to assist in licensing the reactors and establishing quality assurance programs for them. The purpose of these activities is to strengthen the ability of the Cuban nuclear regulatory body, CNSN, to carry out the process of licensing the reactors.[36] The quality assurance project will assist the Cuban nuclear officials at the nuclear power plant in developing an effective program that will improve safety practices and lower construction costs.[37]

Table 4.2: Dollar Value and Type of All Nuclear Technical Assistance Projects the IAEA Provided for Cuba, 1962–1996

Type	*$ in millions*	*Percentage*
Equipment	$8.72	73%
Fellowships/Scientific Visits	$1.92	16%
Expert Services	$1.25	10%
Subcontracts	$0.11	1%
Total	$12.0	100%

Source: IAEA (1997).

Cuba has also served as a regional actor on behalf of the IAEA by hosting various conferences and meetings in Havana. Most notable have been two meetings. In May 1995, Cuba hosted a regional seminar on public information in Havana where there were representatives from the Caribbean basin states, Mexico, and Central America. The purpose of this meeting was to disseminate information regarding the exploitation of nuclear energy in the region and the social and environmental implications of those actions. In October 1997, Cuba again was the host for two IAEA-sponsored meetings. The meetings focused on the practical applications of nuclear technologies in fields of agriculture, industry, health, environment, and science. These meetings were organized by a committee of representatives from the IAEA, Cuba, and other Latin American countries and were part of Cuba's commemorative activities marking the IAEA's fortieth anniversary year[38] (see Table 4.3).

Cuba's thirty-five-year history of participation and cooperation with the IAEA has been impressive. As a developing country, Cuba has served as a leader in the advancement of nuclear science and technology and has played a significant role in the administration and leadership of the IAEA. It has relied heavily on the agency for financial and technical support in areas of nuclear science. In the period since the end of the cold war, the IAEA has become one of the few reliable supporters of Cuba's nuclear program. The IAEA's dual objectives of promoting the peaceful exploitation of nuclear energy and monitoring proliferation threats in the world have served the Cubans' own ambitions well. Cuba enjoys an elevated status in the region because of its involvement with the IAEA and in turn continues to be an ardent supporter of the agency and its objectives. Cuba's president of the Agencia de Energia Nuclear, Daniel Codorníu Pujals, coherently summarized the impact of the relationship between Cuba and the IAEA in a speech before the 38th Session of the General Conference of the IAEA:

> In this manner, we have worked intensely with the regulating agency in the perfection of a legal and standardized system, as well as in the preparation of personnel to guarantee that the evaluation of security of the nuclear energy facility is correct and integrated in all stages of licensing. It is necessary to recognize the understanding and support of the secretariat of the IAEA of our determination to complete the nuclear energy facility and to guarantee the ongoing preparation of our nuclear security system, which has contributed to the development of experts and support in other countries.[39]

Table 4.3: Sources of Funding for IAEA Nuclear Technical Assistance Projects, 1963–1996

Source	*$ in millions*	*Percentage*
Technical Cooperation Fund	$9.38	78%
UNDP	$2.26	19%
In-kind	$0.20	2%
Member States	$0.15	1%
Total	$12.0	100%

Source: GAO (1997).

OPANAL and the Tlatelolco Accord

In December 1995, Cuba formally signed the Latin American nuclear-weapon-free-zone accord, the Tlatelolco Accord, in Mexico City. Cuba was the last country in Latin America to sign the accord.[40] A preliminary assessment of the proliferation risks emanating from Cuba suggests that the Cuban government, by virtue of its "positive" movement in nonproliferation matters, has embarked on a course favorable to the international community that would be difficult, if not impossible, to reverse. Cuba, upon ratification of this regional accord by its National Assembly, agrees not to introduce nuclear weapons of any kind into the region. It also agrees that the IAEA, with which it already has favorable relations, will be allowed to inspect all Cuban nuclear facilities. Upon ratification Cuba must submit a full inventory of all nuclear materials and technologies to the accord's organizing body, the Organizacion por la Proscripcion de Armas Nucleares in America Latina (OPANAL), and also conclude full-scope safeguard agreements for all these materials with the IAEA.

Given the growing cooperation in nuclear affairs and sense of unity in Latin American relations, the Castro government has astutely engaged its Latin American partners in regional and bilateral security and nuclear cooperation arrangements to garner much-needed closer economic ties. The signing of the Tlatelolco Accord attests to this aspect of Cuba's burgeoning cooperative resolve. The present regime has placed its credibility in the post–cold war period on being a "good neighbor," one that is willing to engage in international cooperative efforts. This activity may also serve an instrumental function. It is possible that Cuba is using this movement to attract a potential investor for its moribund nuclear reactors in Juragua. Be that as it may, Cuba has taken a significant step away from its cold war posture

in relation to such nuclear nonproliferation and security arrangements. Throughout the cold war period it maintained that the nuclear nonproliferation regime was discriminatory against those states that did not possess nuclear weapons and favored those that did. Cuba also maintained that it was not going to sign any such accord until all other states in the region did so as well. With the accession of both Argentina and Brazil into the Tlatelolco regime in the early 1990s, Cuba remained the only holdout. Cuba's intransigence in this area was also inconsistent with its participation in other similar nonnuclear arrangements (see Table 4.4).

As of yet, Cuba has not ratified the Tlatelolco Accord, and it remains a nonvoting observer in the proceedings of OPANAL. Cuba also has not signed, nor has it expressed in interest in signing, the Nuclear Nonproliferation Treaty.

Other International Organizations

Cuba has not limited its international cooperation with the IAEA alone. It received financing and support from the United Nations Development Program (UNDP) in the initial development stages of the nuclear program.[41] In the period from 1980 until 1988, Cuba received approximately $1.66 million in assistance from the UNDP. Most of this aid was in the form of equipment for research laboratories and facilities employing nuclear applications.[42] Seeking to expand its cooperation in the nuclear sphere with other countries in the region, Cuba in 1988 began to cooperate in the Arreglos Regionales Cooperativos para la Promocion de la Ciencia y Tecnologia Nucleares (ARCAL). Cuba is involved in a majority of the projects undertaken by the group.

As Cuba's close nuclear cooperation with the Russians has waned, its international cooperation and participation in multilateral organizations

Table 4.4: Cuba's Participation in Major Multilateral Arms Control Agreements (1998)

Agreement	*Year*
Geneva Protocol	1966
Antarctic Treaty	1984
Outer Space Treaty	1977
Tlatelolco Accord[43]	1995
Seabed Treaty	1977
Biological Weapons Convention	1976
Inhumane Weapons Convention	1987
Chemical Weapons Convention	1993
Nuclear Nonproliferation Treaty	Nonsignatory

have increased appreciably. Cuban nuclear agencies have now established cooperative arrangements with the following international and regional nuclear related organizations: the World Association of Nuclear Operators (WANO); World Health Organization (WHO); Food and Agriculture Organization (FAO); Pan-American Health Organization (PAHO); Organizacíon Latino Americano de Energia (OLADE); Agencia Brasileiro-Argentino de Contabilidad y Control (ABACC); and the American Nuclear Society (ANS).[44]

Involvement in these organizations further enhances Cuba's ties within the epistemic communities served by these organizations. But it is difficult to assess the benefits that would accrue directly to the nuclear program through these organizations. With the exception of UNDP assistance, Cuba is not likely to receive assistance significant enough to aid it in advancing the nuclear program. As the focus of these organizations is the promotion and dissemination of information and research to their constituent members, these activities can be viewed as contributing positively to the scientific development in Cuba and elsewhere.

Cuba's cooperation with multilateral organizations has ostensibly served two purposes. First, it has garnered Cuba a modicum of international political support in its effort to develop a nuclear energy capability. Second, and more importantly, its has provided Cuban nuclear officials with a means of advancing its scientific and technical base through its involvement with specialized multilateral organizations and, in particular, the IAEA. This evidence coincides with the expectations of the economic and technological modernization model. Moreover, Cuba's specific efforts to expand the scientific and technological base through IAEA-sponsored training programs in such critical areas as licensing and regulatory procedures, nuclear safety controls, and quality assurance can be viewed as a part of its program to expand its knowledge in technical matters. This factor, coupled with the overarching objective of modernization through advanced technological capability, clearly supports the expected behavior of actors pursuing modernization under the economic and technological model.

The Impact of U.S. Opprobrium

> Our entire political system for the moment is one in which domestic concerns have taken complete priority. . . . [There] is a sense of denial that the rest of the world is even out there.
>
> —Senator Richard Lugar[45]

In 1992, Fidel Castro announced to the Cuban people that construction at the much-vaunted nuclear reactor site at Juragua in Cienfuegos was being suspended because of the loss of funding from the Russian Federation. In

the six years since, we have witnessed a steady stream of predictions: a potential "Chernobyl" ready to contaminate the southeastern United States; a secret nuclear weapons program underway; and reports of a reactor so poorly constructed that it might never see a day of operation. In response, all recent U.S. legislation regarding Cuba has prominently contained provisions to nail the coffin shut on Castro's "Project of the Century." This is puzzling for a number of reasons. First, the nuclear program in Cuba is far, very far, from completion. In interviews over the past two years with Cuban nuclear officials, the most optimistic estimate for a completion date would be thirty-six to forty-two months from the restart of construction. That would place the first day of operation at late 2003 at the absolute earliest. Moreover, since the original deal for construction at Juragua was consummated between the Cubans and the Soviet Union, the project experienced one setback after another until it reached its present stoppage. Even if construction were to resume at the Juragua site, the Russian Federation and Cuba would still have work out the details of transporting the nuclear fuel to Cuba and the arrangements for spent fuel disposal. Thus far in this discussion, there has been little mention of the potential for costs and delays from backfitting of poorly constructed systems at the site. Furthermore, few have explored the possibility of who will pay for any of this work should some international nuclear firm deem the project worthy of a nearly $1 billion investment.

Given the above-mentioned facts, one should pause to wonder how this small agenda item, in all seriousness, has been elevated to a United States policy concern *writ large* with the disproportionate fixation of many legislators, policy advocates, and analysts in Washington and beyond. The answer for the transformation lies in part with the misappropriation of what is mostly a scientific and technical matter by political elements singularly and wholly unprepared to analyze, let alone discuss, any of the merits of such a grand undertaking by the government of Cuba. This is not to disparage the legitimate concerns of some of these parties, but the current effort to cut funding to the United States's contribution to the International Atomic Energy Agency (IAEA) for quality assurance and nuclear safety training and cooperation programs defies rationality. Even more perplexing is the inclusion on a provision to the 1997 Defense Appropriations Bill to construct a network of early warning radiation detectors along the Gulf Coast of southern Florida at a cost of $3.2 million. The detection system would purportedly provide warning of radioactive fallout emanating from a nuclear reactor accident at the yet-to-be completed power generation facility at Juragua.

The Cubans may not ever operate a nuclear reactor at Juragua. But it would be a strong bet that many of the officials currently enduring the

"Special Period in a Time of Peace" will still be occupying positions of importance with the various energy-related bureaucracies within the post-transition Cuban government. The Cuba of the twenty-first century will most likely still be a resource-poor country. Furthermore, many of the imperatives that presently support Cuba's nuclear ambitions will remain firmly in place in the twenty-first century Cuba. Given that Cuba continues to entertain the nuclear option in its energy future, it is incumbent upon the international community to insist that Cuban officials become intimately familiar with the requirements and standards for the same operation of nuclear installations now and for the future. As it stands, proposed legislation like the Menendez Bill, aimed at reducing the U.S. contribution to the IAEA's technical assistance fund for the amount targeted to nuclear safety, quality assurance, and other technical programs in Cuba, is an impediment to that goal and ultimately undermines the regional and multilateral efforts to ensure that this is so.

This section is an attempt to clarify an issue area that to this point has been mired in the intransigent domestic debates over what is to be done regarding Cuba and to assess the impact of U.S. opposition on the Cuban nuclear program. The spate of legislation emanating from Washington has been long on bold predictions of the demise of the Castro regime and what should occur in its aftermath. But it has also been short on any practical means to affect these desires short of undermining international legal structures. This section also focuses on the problems with the present policy and the logic that undergirds it. The following section appraises the direct influence of these policies to Cuban nuclear energy development activities. It considers what possible effects continued pursuit of the U.S. policy might engender, including recent proposals to cut funding dollar for dollar to the IAEA for training activities now underway in Cuba. Finally, the section closes with a call to return the issue to its proper place in the pantheon of America's policy concerns and to acknowledge that Cuba's energy policy is presently being redirected to take into consideration the post–cold war political and economic realities.

Even if Cuba were to find a funding source today, we can conservatively place the start-up date at the latter part of the year 2003. Cuba's "Project of the Century" has become a project for the next. It would appear from the perspective of a policy analyst familiar with the issue, yet not a nuclear engineer, that this is all much ado about very little. The decision of Cuba to pursue a nuclear option can be viewed as admirable or foolhardy depending on the perspective taken, but nuclear energy development in Cuba bears little on the future of U.S. national security, or of real issues confounding U.S.-Cuban relations. If anything, these issues should be the concern of the

American counterparts of the Cuban nuclear policy specialists. This issue, by virtue of its elevated status of importance and consideration of its potentially harmful implications by being included in the recent Cuba legislation, demands closer attention. The present handling of this issue also potentially undermines some of the efforts employed to widen regional and hemispheric participation in nuclear policy and nonproliferation arrangements. The following section investigates some of the implications of U.S. legislation (proposed and enacted) in this area.

U.S. Policy and the Cuban Nuclear Program

During the time that Cuba has been trying to keep its nuclear aspirations alive, the United States policy toward the Cuban project has been one of general opposition. Given doubts regarding safety issues U.S. officials would prefer that the nuclear reactors never see a day of operation. Augmenting this opprobrium, the Congress of the United States has set forth provisions in the Helms-Burton Law that conditions the normalization of relations with Cuba on the abandonment of the Juragua project. Moreover, Helms-Burton specifically sanctions any country providing assistance to the nuclear project with a dollar-for-dollar reduction of foreign aid. This is targeted at the Russian Federation, as it remains Cuba's primary partner in the nuclear field and would most likely be the only country in question who receives significant foreign aid from the United States. But these laws have done little to stem the Russia Federation and MINATOM in their interest in Cuba or in their quest to sell Russian-designed and -built nuclear reactors in the international market. Recently, Russian officials have concluded nuclear reactor deals with a number of nations, including Egypt, India, and Iran. Furthermore, Russian officials have continually insisted that the Juragua project remains a viable venture. This section will briefly discuss the possible implications of enforcing Helms-Burton in the area of nuclear trade; the impact of this legislation on Cuba's nuclear activities; and the wider implications of staying this course as it relates to international nonproliferation and nuclear policy.

After the downing of the Hermanos al Rescate planes off the Cuban coast, the pending Helms-Burton legislation swept through both houses of Congress and was quickly signed into law by President Clinton. It signaled the United States's revulsion at the Cuban decision to shoot down civilian aircraft. Even if previous Hermanos missions had violated Cuban airspace, the Cuban choice of a military response was inappropriate and ultimately regrettable for a number of reasons. The Clinton administration had pursued a policy of calibrated responses to Cuban initiatives. It was firmly opposed to the Helms-Burton legislation for being wildly speculative in its

objectives and hard-fisted in its handling of issues such as the settlement of claims and the "trafficking in stolen property." Moreover, it would once and for all codify the embargo and make it impossible for the president to lift the embargo unless Congress approves it. It clearly labeled the Castro brothers as imminent threats to humanity and stated as one of its provisions that they both must be removed from power before a talk of normalizing relations can be considered. Here the Cubans miscalculated the American response. It also reflects the rise of "international political provincialism" in the foreign-policy-making process, where foreign-policy issues are subordinated to internal and political party concerns. It also indicates to some degree the lack of interest by American legislators for contractual obligations, sometimes out of ignorance and sometimes out of indifference.

The downing of two U.S. civilian aircraft over international waters propelled the legislation from Capitol Hill to the White House in record time, and in short order, Cuba, at the behest of the anti-Castro interests, was saddled with yet another American sanction aimed at bringing down the regime.

Prominently displayed in the Helms-Burton legislation are provisions that set out to limit Cuba's ability to complete its nuclear policy objectives of completing construction of the nuclear reactors at Juragua. Specifically, these provisions aim to reduce the desire of Cuba's would-be nuclear trading partners, most notably the Russian Federation, from engaging the Cubans in any meaningful way. This law calls for the "withholding from assistance allocated for any country an amount equal to the sum of assistance or credits . . . in support of the completion of the Cuban nuclear facility at Juragua" (Title 1, Sec. 111). One could argue that the mostly symbolic nature of Cuban-Russian nuclear cooperation in the post–cold war period is indicative of the success of this approach. A much more reasonable appraisal would point to the chronic shortages of hard currency for both partners that have brought this project to a standstill. Yet, these provisions aim to limit the possibilities of this cooperation with the threat of a reduction in foreign aid to the Russians. Ironically enough, this law contains exemptions for the most significant area of assistance effecting Russia's nuclear industry, that pertaining to the stabilization of its nuclear arsenal. Under the 1993 Comprehensive Threat Reduction Act, or "Nunn-Lugar Act" (Public Law 103–160), Russia's nuclear infrastructure has been earmarked to receive assistance to stabilize its nuclear assets. Moreover, assistance to Russia and other states of the former Soviet Union are exempted from these sanctions in the areas of political, economic, and humanitarian aid. This has the effect of allowing Russia's MINATOM a free hand to continue cooperating with Cuba and pursue reactor sales in the international nuclear markets should it choose to do so. Furthermore, under the provisions of international nuclear accords and as a member of the

IAEA, Cuba is entitled to pursue a nuclear energy capability so long as it adheres to provisions of full safeguards and nuclear safety protocols.

In February 1997, *NBC Nightly News* reported that funds contributed by the United States to the IAEA were being used to fund training programs for the nuclear program in Cuba. A subsequent GAO study of the issue indicated that indeed a portion of the voluntary contribution by the United States was earmarked for technical assistance programs for the Cubans.[46] But a closer inspection of the figures behind this "news story" indicates that there is more smoke than substance in relation to this issue. In 1996, the United States contributed $16 million (about 30 percent) to the IAEA's technical cooperation fund. Cuba for its part contributed $45,150 (or 0.7 percent) to this fund. The IAEA has approved $1.7 million in technical assistance for projects for Cuba for 1997 through 1999. By extrapolation the United States contribution to the fund over this same period of time would be around $48 million of the $159 million total. The amount of technical assistance for Cuba, $1.7 million, is 3.5 percent of the total U.S. contribution. That assistance from the IAEA coffers to Cuba represents 1.06 percent of the total contributions to the fund for 1997 through 1999. The reduction of the 3.5 percent that goes to Cuba from the U.S. contribution to the fund would only amount to a paltry $59,500. This would not disable Cuban cooperation with the IAEA, nor could it be conceived as an impediment to the provision of assistance to Cuba from the agency. Symbolically, opponents of the Cuban program could point to the noninvolvement of the United States for assistance programs from the IAEA. Whether it is $59,500 or $1.7 million matters little. The IAEA will most likely push forward with the assistance and training programs that ultimately benefit the United States as well as Cuba.

This has not gone unnoticed by Cuban official representatives for the IAEA in Vienna. Following is an excerpt of an official protest to the IAEA from Cuba regarding actions set in motion by the Congress of the United States. In direct reference to the Helms-Burton Law, it states:

> These arrogant statements raise a number of questions, all of which necessarily ask what right the United States, as a Member State of the IAEA and a leading nuclear power, has to try to crush the Cuban nuclear program and thus prevent access to the benefits of the peaceful applications of nuclear energy in the country's socio-economic development programs, which are of considerable importance to the well-being to the Cuban people.[47]

Yet in July 1997 a bill was introduced in the House of Representatives by Congressman Robert Menendez to withhold U.S. assistance for programs and projects of the IAEA in Cuba. H.R. 2092, known as the IAEA Account-

ability and Safety Act of 1997, is clearly designed to wash American hands clean of any involvement in Cuba's nuclear program. A similarly worded amendment was included in the 1997 Foreign Relations Authorization Act for 1998 and 1999. But short of painting a self-congratulatory and triumphalist picture of uncompromising opposition to the Castro regime, these bills are essentially toothless and clawless tigers and would violate the spirit of international nonproliferation cooperation. Like the Helms-Burton law, these proposed pieces of legislation render themselves moot by the nature of the exceptions to their provisions. Sec. 2 (2)(B)(I) states that the law would not apply to IAEA programs for "safety inspection of nuclear facilities or related materials, or for inspections and similar activities designed to prevent the development of nuclear weapons" by Cuba. This sounds very much like the mission of the international organization under which all these activities would take place.

The restrictions specific to the Juragua facility and the nuclear research center at Pedro Pi would be lifted by the United States if Cuba: (1) ratifies the Tlatelolco Accord or the Nuclear Nonproliferation Treaty; (2) negotiates full-scope safeguards with the IAEA not later than two years after ratification of the accord; and (3) incorporates internationally accepted nuclear safety standards into practice. Interestingly enough this has been the focus of Cuba's nuclear activities for the past year. In 1996, the Cubans embarked on a new nuclear law project to compliment the passage of Decreto-Ley No. 208—Regarding the National System of Accounting and Control of Nuclear Materials. Cuban nuclear officials have indicated that the reason for delay in the ratification stems from the need to alter the existing legal basis of nuclear law so that it will more easily comply with the provisions of agreements with which they fully intend to comply. Decreto-Ley No. 208 represents part of that effort. Cuban nuclear officials are clearly cognizant of the shortcomings of the Soviet-based systems of accounting, control, and materials handling. They have sought to design legislation that conforms to internationally recognized standards and norms of nuclear materials handling and storage. They have modeled the system in spirit to the scope and objectives contained in U.S. Nuclear Regulatory Commission standards. Reaching that standard is another question altogether. But they have sought to make this system amenable to the requirements of the full-scope safeguard agreements that Cuba intends to sign when the treaty comes into force. On a larger scale the new nuclear law project, under the direction of the Agencia de Energia Nuclear and the Centro Nacional de Seguridad Nuclear seeks to place all of Cuba's nuclear activities under a system of laws and practices that correspond to existing and future international nuclear standards.[48] Given the present environment for U.S.-Cuban relations, one could imagine that if

Cuba were to finally ratify the Tlatelolco Accord and consummate a nuclear cooperation deal with another country to complete Juragua or some other facility, the call for action would be immediate. Given the present policy environment it would not be too far-fetched to imagine the introduction of legislation that would call for the removal of the United States from certain international or regional organizations because those organizations would treat Cuba as a sovereign and independent nation. Moreover, if Cuba, in compliance with those agreements, were able to move forward with its nuclear program, the idea of imposing unilateral sanctions against any of the states cooperating with Cuba would not be out of the question. We have seen elements of the more radicalized opposition to the Castro regime call for "surgical strikes" against Cuban nuclear installations, and in a major U.S. newspaper no less.[49]

There can be no argument that the Cuban nuclear program does raise some questions regarding the safety and integrity of a Cuban- and Russian-built installation. This is especially so when one considers the significant resource constraints that the project has faced during the past six years. As a close neighbor, the United States, in addition to Cuba, has a responsibility to be sure that the nuclear facility at Juragua would pose no threat to the environment. The United States has and continues to coordinate and consult with the other national civilian nuclear agencies in the region. By consistently threatening would-be participants in the Cuban program, the United States is treading on thin international legal ice. The United States has in the past two decades expended vast amounts of diplomatic capital in garnering support for international agreements on all aspects of the exploitation of nuclear energy. Many of these agreements were the result of measured confidence-building initiatives and based on the promise of reciprocity. The United States is now fairly confident that these agreements provide a stable base for peaceful nuclear commerce and a reduced threat of weapons of mass destruction. The notion of scuttling the basis of these agreements and the resulting norms over its domestic imperatives of combating a flailing attempt to develop a nuclear energy capability in Cuba is less than compelling. Moreover, these actions imperil these same international and regional nuclear cooperation agreements. Cuba, like any other state in the international system, is entitled to develop a peaceful nuclear energy capability, whether Americans like it or not. Enacting domestic legislation that ostensibly diminishes that ability is in all likelihood a violation of the international accords the United States has worked hard to obtain.

There are already well-established international protocols for review and oversight of civilian nuclear installations and programs. This project in particular is in need of direct U.S. cooperation in all areas of the program. What

would be required is the insertion or reinsertion of the American scientific and technical community in this discussion. Given that Cuba is a member in good standing of the international nonproliferation community by virtue of its de facto participation and progress in the activities of that community, there should be direct contact between American and Cuban officials at this level. Cuba, unlike its other regional partners, will not receive any of the rewards commonly associated with the accession to regional and international nonproliferation accords. Argentina and Brazil, for instance, were the recipients of nuclear cooperation agreements and commercial contracts as a result of it accession to the Tlatelolco Accord. Cuba is already a member of the IAEA, the American Nuclear Society, the World Association of Nuclear Operators, and numerous other international nuclear organizations. Moreover, it continues making progress toward ratification and compliance with the Tlatelolco Accord, as evidenced by the passage of Decreto-Ley No. 208 of 1996 and the new nuclear law project. American nuclear cooperation in this area wouldn't be something new. In fact during the 1980s Cuban and American officials conducted informational and technical exchanges on the nuclear program. Duke Power of North Carolina, under the leadership of William Lee, hosted a delegation of Cuban nuclear officials at McGuire Nuclear Power Station outside of Charlotte, North Carolina. Both sides viewed these visits and exchanges as essential components for assuring that Cuba could successfully and safely exploit nuclear energy. Moreover, the 1997 GAO study affirmed that safety and technical cooperation with Cuban nuclear officials should continue for the time being. Therefore it is puzzling why, in the face of progress in these areas and with the legitimate concerns regarding the development of nuclear energy in Cuba, U.S. legislators would seek to limit Cuban access to advancement in these areas. It is safe to say that most of the officials seated in positions of importance within Cuba's nuclear bureaucracies will in all likelihood remain in place after a transition in leadership. It is incumbent upon the United States to ensure that these officials know we are legitimately concerned and prepared to discuss these matters in a sober and objective manner. Perhaps this type of cooperation could convince Cuba to consider other alternatives for resolving its lingering energy problems.

Cuba will remain largely dependent on external sources of oil to satisfy its energy demands. The nuclear option thus remains for the near to long-term future of energy development in Cuba. The past six years have witnessed a sea change in Cuba's energy priorities as it has de-emphasized the nuclear option to explore modernization of the existing energy generating capability and new means of energy generation such as wind and solar power. As a future political, commercial, and environmental consideration, it is in the

interest of the United States to establish scientific and technical ties within Cuba's nuclear and energy community. Casting aspersions and the speculating about threat of impending nuclear disaster across the Straits of Florida provide no real means of prudently addressing those concerns.

The opposition to Cuba's nuclear program has almost been overtly expressed in political terms, with a passing albeit insignificant acknowledgment to the scientific-technical issues underlying the "concerns" of U.S. policymakers. Moreover, these efforts have had little effect on the scope or objectives of the Cuban program. If anything the U.S. opprobrium to the Cuban program has strengthened Cuba's political resolve in pursuing nuclear power. This phenomenon also lends credibility to the assertion that Cuba's nuclear program is primarily a political ploy at garnering propagandistic support for a weak and ill-conceived project. From the perspective of the politically motivated explanation for Cuba's effort to develop the nuclear program, the opposition to the program by the United States indirectly serves the interests and objectives of the Cuban ruling elite. It provides the Castro regime with a convenient scapegoat for the continuing underdevelopment and chronic economic problems it is experiencing.

But this explanation minimizes the fit between the broad expanse of the Cuban program to the economic and technological modernization model with its corresponding support for the programs' objectives. While the value-added of political arguments is desirable, it does not provide a full justification of the economic rationale and technological modernization imperatives of developing a nuclear energy capability in Cuba.

Summary

This chapter sought to detail Cuba's external nuclear cooperative efforts and the impact of these efforts on the Cuban nuclear energy development policy. The impact has been overwhelmingly favorable during the cold war period and in the face of Cuba's economic troubles during the period since the end of the cold war. The first section focused on Cuba's bilateral relations with the Russian Federation and then with Cuba's Western European and Latin American partners. The second section was a review of Cuba's participation and cooperative projects in multilateral, international, and regional nuclear-related organizations. This section focused on nuclear assistance agreements established by Cuban and the IAEA. The section also touched on Cuba's participation in other regional nonproliferation and nuclear cooperation regimes. The last section dealt with the U.S. policy to close down or limit nuclear assistance to Cuba from states in the international system.

The purpose of this analysis centers on the impact and influence of

these international interactions on the choice, implementation, and successful accomplishment of Cuban nuclear policy objectives. The modernization literature has suggested that the impact of these influences is highly determinate of the appropriateness and success of modernization schemes in developing states. Moreover, these influences will carry significant implications for the trajectory of development within these states. In relation to these influences, developing states find themselves in a paradoxical situation. For development to be sustainable, the development scheme must take into consideration that country's resource base. Unfortunately, states often disregard the appropriateness or an advanced technology such as nuclear energy for a developing state. But development may be nearly impossible without the involvement and assistance from external sources and the imperatives they bring to bear in the situation.

Foreign policy and development analysts have tried to forecast what Cuba's external trade policies would look like in the aftermath of the Soviet demise. How would Cuba respond to the new nature of relations with the former Soviet Union? What role would Western Europeans and Latin Americans play in Cuba's attempt to keep the nuclear program alive? And would the IAEA continue to be willing to promote simultaneously the development of, and assist Cuba in, the peaceful exploitation of nuclear energy, especially now with intense pressure being applied by the United States to terminate these activities?

The following discussion addresses those questions and other issues germane to the Cuban attempts to keep its nuclear aspirations afloat.

- The loss of Cuba's primary nuclear trade partner has devastated the nuclear program. While the Russian Federation has attempted to keep the Juragua project alive, the fact remains that the numerous trade agreements concluded between Cuba and Russia to complete construction have been mostly symbolic in nature. The search for the third partner in the joint venture to complete the reactors has been fruitless. The Soviet Union made Cuba's nuclear ambition a reality. The Soviet-successor state has had neither the desire nor the wherewithal to support such a venture so far from home. The suspect investment prospects for the project have limited Russian and Cuban efforts to maintaining a mothballed program until the time when the interest and financing for completing the reactors become tangible. Some critics in Russia now blame the short-sighted leaders of the newly democratic state for losing the Cuba that everyone else in the world is now finding. But to limit the discussion to the failures of post–cold war policy between Russia and Cuba would minimize the significant advances made in the creation and development of a well-

conceived and vibrant nuclear infrastructure. While it is true that Cuba's nuclear reactors are moribund, there now exists a resource base that enables Cuba to tackle easily the nuclear option when the circumstances warrant it. Russia must still demonstrate to its potential nuclear clients throughout the world that it can successfully complete a nuclear reactor outside of its borders and under international scrutiny. For this reason, there is little reason to suggest that either Cuba or Russia will terminate their nuclear cooperation relationship anytime soon.

- While a number of other countries have expressed an interest in the Cuban nuclear program, not one has concluded an agreement to work on the program. In the early 1990s representatives from Germany, Spain, Brazil, Italy, and Argentina visited the Juragua site and walked away. This inability to attract a project partner has been disheartening to the Cubans. Yet the nature of relationships between Cuba and other countries in the energy sector has evolved appreciably since 1991. The change has been especially significant since Fidel Castro announced in 1997 that the nuclear program would no longer be the sole focus of Cuba's energy development program. In fact, it has opened the door to a flurry of joint venture activity to upgrade and construct new thermoelectric facilities throughout the island. The promotion of a national energy efficiency program has accompanied these overtures and promises to more than compensate for the inability to complete the Juragua project. One issue is raised by the nature of these activities. Cuba has concluded these deals with guaranteed financing from external sources. In one case, the foreign firm will receive all proceeds from the operation of this new facility until such time as it receives its capital investment in full. Moreover, the joint venture with the Cuban state will be seeking to sell electricity to foreign firms for hard currency payments. The arrangement potentially could dampen the investment environment in Cuba, and it eerily resembles the economic arrangements of the prerevolutionary period. While states other than the Russian Federation have not stepped up to assume the mantle of primary nuclear trading partners, the activities of countries like Canada, France, and others in the nonnuclear energy generation sector have revitalized Cuban energy policy.
- Cuba's nuclear infrastructure has prospered because of its participation in international and multilateral organizations. The interaction between Cuba and the IAEA has been an essential component in the development of Cuba's nuclear infrastructure. Since 1963, Cuba has

received technical assistance from the IAEA to develop nuclear technical capabilities in a number of sectors across the Cuban economy. While Cuba has not received any direct funding from the agency in the construction of the nuclear reactors at Juragua, IAEA assistance has helped Cuba to expand its nuclear program capabilities in the areas of quality assurance, nuclear safety, materials handling, command, and control. The assistance has also provided the Cuban nuclear infrastructure with a model for the creation and development of the requisite agencies to carry out these tasks. Cuba has also benefited from its participation in the administration of the agency's activities by serving on the IAEA Board of Governors, as well as placing Cubans on the nuclear safeguards inspection teams. In other instances, states have used the placement of their nationals on these inspection teams to later circumvent IAEA safeguards from revealing elements of nuclear weapons development programs. Cuba's active participation and mostly transparent activities suggest that the trajectory of its nuclear program is entirely peaceful in nature. Cuba has concluded safeguard agreements with the IAEA, and by all indications it appears that it will continue to follow through with its commitments to these agreements for the foreseeable future. Cuba has recently signed the Tlatelolco Accord, and upon ratification it will more fully integrate its nuclear-related activities to international accountability and scrutiny. This dispels any suggestion of a nefarious rationale to Cuba's nuclear ambition. Cuba's participation in the myriad international organizations devoted to the advancement of nuclear applications bolsters its own technical capacity but also enhances it ties outside of the island. All told, the cooperative activities undertaken by Cuba have greatly increased its nuclear capabilities, as well as positively influencing the direction of nuclear energy development. Rather than constructing impassable obstacles to its nuclear ascendancy, Cuba has astutely utilized its participation to support and advance its nuclear program.

- The United States's opposition to the Cuban nuclear program has had little effect on its prosperity or privations. A majority of the legislative and policy positions taken by the United States has done little other than mollify criticism from the Cuban-American and anti-Castroites who regularly decry the looming Cuban Chernobyl. Moreover, the attempts to halt assistance to the Cuban program from the IAEA and other sources has verged on meddling in matters that are in reality of little concern and are certainly not national security interests. The best that can be said about the United States's position on the issue is

> that it serves no one's interest to lambaste the Cuban nuclear program from afar when the means of assessing such a threat exist. The United States can and has cooperated with the Cubans on the nuclear issue. When scientific and technical analysis replaces the casting of aspersions across the Straits of Florida, then the United States may be able to construct a policy regarding Cuba's nuclear program that conforms to reality, not myth. The impact of the U.S. opposition limits legitimate and desirable contact between the American and Cuban scientific communities. Moreover, it places U.S. commercial interests at a disadvantage in investing in the Cuban energy sector, while the rest of the world is engaging in joint ventures with Cuban state enterprises in Cuba's energy sector.

The survival of Cuba's nuclear aspiration remains assured for the short term. The influence of external forces in the nuclear program has been overwhelmingly positive. Cuba has advanced its nuclear potential in all areas because of the interaction with foreign states, international organizations, and multinational firms. Cuba's nuclear program has floundered primarily because of one reason: lack of financing. For Cubans and Russians the loss of the financial wherewithal to construct the reactors was, as of the end of the cold war, completely unforeseen.

Frankly, no one could have predicted that the Soviets or the Russians would not have completed the venture in Cuba. Yet, as this came to pass, Cuba has found it difficult, if not impossible, to continue its pursuit of nuclear power. The failure to attract project partners stems from both Russia and Cuba's inefficient scheme to build the reactors. No prudent investor would entertain participating in the nuclear construction venture as long as there is no tangible means to recoup the investment. The attraction of investment in the thermoelectric sector reflects a fundamental shift in the creation of joint ventures that favors the foreign enterprise.

This chapter demonstrated that Cuba was cognizant of its domestic energy resource constraints and logically and rationally sought and secured external assistance to advance its energy policy. It has been successful in the creation and development of a vibrant nuclear energy sector, short of completing the construction on the nuclear reactors. This is a remarkable accomplishment for any developing state, but especially for one such as Cuba, which has promoted the creation of knowledge and expertise matched by few countries in the developing world.

On Cuba's Decision to Pursue a Nuclear Energy Capability

5

This chapter analyzes the Cuban nuclear program by utilizing the process-tracing methodology. The analysis can be broken down into three distinct sections. The first section contains the identification of specific energy development policies and instruments, in relation to the requirements of process tracing of Cuban nuclear policy implementation. In addition, an assessment of the Cuban model of energy development utilized to achieve those objectives is included, as detailed in the cost-benefit analysis. The next section examines the plausibility of the three approaches employed in this examination; it is accomplished by comparing the expectations of each approach against the actual behaviors and actions exhibited in the case study. The final section ties together the analyses of the practical and hypothetical actions in this case in a set of findings that speak directly to the original research questions posed.

This book began with two basic research questions related to the development of a nuclear energy capability in Cuba. Why did Cuba choose to pursue a nuclear energy capability, and why has Cuba persisted in its nuclear energy development program?

The first question was the primary focus of the book at the initial analysis of the case. We cannot answer the second question until we fully explain the sources, justifications, influences, and practical actions undertaken in the pursuit of nuclear power. The questions posed are puzzling for two major reasons: first, there are environmental and nuclear safety concerns raised by critics that seriously question the capabilities of the

Cubans to manage nuclear energy. Safety is a concern of mostly American critics who assert that the Cubans under Castro are incapable of meeting requisite thresholds of environmental protection and safety in the operation of a nuclear power station, which leads to the perception of a "Cuban Chernobyl." Second, there are also serious economic factors that preclude Cuba from ever being able to complete a nuclear reactor at Juragua. To reiterate one of the initial questions of this inquiry: Why is a developing state, which is strapped for cash, in serious debt, and almost completely dependent on external sources of capital, seeking to develop a highly capital-intensive form of energy generation that may lie outside the reach of its national capabilities?

This case is important because of the future domestic considerations regarding the maintenance and management of the existing energy generation capability that are significant in the case of Cuba's attempt to develop a nuclear energy capability and of its overall economic development. Moreover, the international scope of Cuba's efforts to develop nuclear energy informs our understanding of the paths that might be employed by other developing states with similar energy demands, capabilities, and shortcomings. States rarely, if ever, develop nuclear energy capabilities in isolation. There are myriad complex relationships that are both necessary and sufficient for the undertaking of such a grand infrastructural project. Adding to the relevance of Cuba's attempt to develop a nuclear energy capability is the relationship to inquiries regarding nonproliferation matters, along with related questions of export controls, the supply of nuclear fuels, and the storage and disposal of nuclear waste.

Historical Process Tracing of Policy Implementation

How does one confirm or disconfirm which, if any, of the three plausible approaches applied to this case more fully explains Cuba's initial decision to develop nuclear power capability? And which, if any, of these can provide an explanation for the persistence of Cuba to complete its nuclear energy objectives in the face of daunting obstacles? The case evidence identified nuclear energy policy objectives, along with the selection of policy instruments to achieve those objectives. This case study was an exploratory analysis of the Cuban nuclear energy development program and policies from the late 1970s to the present by using process tracing of Cuba's nuclear policy and competing approaches to the development of a nuclear energy capability and modernization in a developing state.[1] The criteria for the selection of this case is justified for the following reasons:

1. This is a case with large within-case variance in the value on the independent variable, dependent variable, or conditional variable across time or space. In other words, the historical trajectory of Cuba's efforts to develop a nuclear energy capability has been fraught with obstacles, such as perceived safety deficiencies, construction delays, and the loss of financing, which has forced Cuba to alter or reevaluate its policy objectives. Additionally, the end of the cold war with the accompanying losses of Soviet-bloc trading partners and aid donors have significantly altered Cuba's nuclear aspirations. For these two reasons we can suggest that the impact to the variables being employed in this investigation has caused them to be altered to incorporate these changes over time.
2. This is a case about which the competing approaches make opposite and unique predictions. The different approaches to the development of nuclear energy make competing predictions about what we can expect from the decisions and actions of Cuba and other developing states to pursue a nuclear energy capability.
3. This is a case that resembles current situations of policy concern. Cuba's decision to exploit nuclear energy is certainly not a unique phenomenon. Nevertheless, it does hold a special place within the spectrum of international policy analysis, given the fact that it is the last "socialist" state in the Western Hemisphere. Cuba is attempting to develop a nuclear energy capability in contradistinction to U.S. policy, and Cuba maintains a significant, albeit disproportionate, hold on the fixations of the U.S. policy community. Cuba also presents a significant case study of a developing state attempting to develop an advanced technological expertise under adverse conditions. All these reasons make the Cuban case, and the analysis of competing approaches of nuclear energy development, worthy of study.

Within this context, to examine and analyze the expectations highlighted, this investigation employed the case study method. This method is most suitable for this kind of investigation where the researcher (1) asks "how" and "why" questions, (2) does not and cannot control the actions of the subjects and/or events being studied, and (3) focuses on contemporary events in their natural context.[2] Moreover, the case study method is useful when the researcher attempts to shed light on particular decisions, processes, institutions, and events; why and how each of these events operated and were made; and what resulted. This investigation offers this case study in which the expected behaviors are compared against Cuba's empirical record in nuclear energy development. The objective is to determine which, if any, of

these approaches best explains the efforts of Cuba to develop a nuclear energy capability.

The tracing of the trajectory of energy development policy identifies its objectives and implementation to see if policy objectives and implementation correspond to the propositions advanced by a specific model of nuclear energy development, or if another model of energy development provides a fuller explanation of this path to development. Process tracing is also a useful method for clarifying alternative definitions of causality. It has been defined as terms of causal effect, the mean causal effect being the difference between the systematic component of a dependent variable (completion of the nuclear energy capability) when the causal variable (the energy development approach) takes on two different values. The clarification between alternative definitions of causality can be expressed as the difference in industrialization processes when the source of the modernization project has been internal, on the one hand, or external, on the other. The investigator explored the chain of events in the decision-making process by translating the initial case conditions into case outcomes. The cause-effect links that connected the independent variable and outcome were unraveled and divided into smaller steps; then we looked at observable evidence of each step. Did this chain of events or the decision-making process unfold in the manner predicted by the theory? Specifically, did actors speak and behave as the theory predicts? Did they perceive and respond to stimuli in the manner predicted? Did the timing and details of their behavior match predictions? Did the timing and details of other events, those that comprise the process of developing a nuclear energy capability that translates initial conditions into outcomes, match the theory or approach predictions? The tighter the fit between the theoretical predictions about that process and the actual details of process, the stronger the validity of that theory or approach.

Most theories and analytical approaches make many predictions about causal process. Hence, process tracing allows the investigator to test many propositions within a single case observation. For this investigation, the traceable process of causation for the plausible hypothesis is that "politically motivated models of modernization eschew economic performance for symbolic gestures." This might be stated as follows: as states attempt to develop large infrastructure projects, the concern for political consolidation causes a lower priority for economic factors in development and thus lower and less efficient economic performance. Here we have one theory but many predictions. Moreover, process propositions are often unique—i.e., no other known theories or approaches predict the same patterns. Hence, process tracing often offers strong tests of a theory or an analytical approach. If a case supplies abundant and reliable data that bear upon unique process

predictions of this sort, then a single case as in the case of Cuba can provide a very strong test of a theory. The investigator began unsure of what antecedent conditions the approaches required to operate, and the discovery of these conditions was an important task. They were found by exploring bureaucratic and demand structures required in all cases where states seek to develop a nuclear energy capability. In this vein, the study of nuclear energy and development in Cuba is not a unique phenomenon. However, the validity of an approach and its ability to explain the Cuban case has the potential to be strongly confirmed. Yet this is not the overriding concern of this investigation. Theory testing comprises only a small area of the available objectives within the spectra of social science inquiry.

The Plausibility of the Three Approaches to Nuclear Energy Development

The case study analysis consists of the application of the three approaches introduced in chapter 1 on the development of nuclear energy capabilities in Cuba. The three approaches were detailed, and the expectations for the development of nuclear energy capabilities in Cuba were derived from each approach to provide a template for this analysis. All three approaches are directed to forecasting the path to nuclear energy development, and each offers distinct expectations by which to measure the correspondence of Cuba's nuclear energy policy and activities in the period since the late 1970s. Moreover, this is an investigation of the development of national nuclear development policy in a developing state. There is a general set of considerations applicable to most cases of nuclear energy development in developing states.[3] They may not be seen in all cases of nuclear energy development in developing states, but most are usually present or expected to be so in these cases. These considerations have provided the basis for analyzing the nuclear energy policy decision-making process. It is important to link these considerations to the domestic circumstances underlying Cuba's attempt to develop a nuclear energy potential. This serves two purposes: first, to provide a better basis of understanding the actions that are particular to the Cuban case; and, second, to determine which if any of these actions or considerations in the decision-making process is generalizable. Cuba's decision to pursue a nuclear energy capability can be viewed as a part of a grander scheme of modernization and industrialization. Within the "grand theories" of modernization and developmentalism there are three specific approaches that potentially provide a firmer basis for analyzing and explaining Cuba's nuclear energy policies and activities.

The first approach employed in this inquiry, *politically motivated modernization*, argues that states utilizing politically motivated models of devel-

opment and modernization (nationalist and ideologically based models) are more likely to choose projects that are symbolically more flattering to the political ambitions of the standing regimes. Under this approach, the choice of projects is highly determinate of the selection and subsequent completion of large infrastructural and industrial projects in developing states such as Cuba. The second approach, *economic and technological modernization,* asserts that Cuba chose to develop nuclear energy to achieve technological modernization, scientific expertise, and the resulting domestic energy self-sufficiency. The final approach derived from this body of literature is the *energy and economic security approach.* It suggests that Cuba chose to develop a nuclear energy capability to specifically address its chronic energy dependency, to develop a civilian nuclear industry, and to inure itself from the detrimental impact of a potential loss of energy sources.[4]

In relation to the case of Cuba's nuclear program the debate over cause and effect endures as one of the salient inquiries regarding Cuba's decision to pursue this capability. In the employment of a politically charged modernization scheme, is it political change that has directed the trajectory of economic and technological changes in Cuban society? Or, as the above-mentioned question suggests, does this process work in the opposite direction, from the economic to the political, and what are the implications for Cuban society if this is the direction of change? If so, will the change under the guise of economic and technological advancement be coherent and predictable and be ultimately successful as has been suggested?

In all cases we would expect that the policy choices will be typified by, but not limited to, the selection of grand infrastructure, highly visible, and high technology projects such as the development of nuclear energy capabilities. Additionally, the decision-making process will be an almost exclusively elite oriented and highly centralized.

In all three cases we should bear in mind that not one of the policymakers or national leaders in Cuba could have foreseen the demise of the Soviet Union in 1991. This seminal event clearly impacted the trajectory of Cuban nuclear energy policy. But it also provides an additional indicator by which to assess the relative strength of an approach to development, both before and after this watershed in the Cuban attempt to develop nuclear energy.

Politically Motivated Modernization

The approach of politically motivated modernization asserts that the process of modernization is guided by ideological and political motivations, and all resulting policy objectives and their implementation are reflections of this underlying logic. Moreover, rather than being a post hoc justification of an observed political phenomena, this approach retains a highly predictive

value inasmuch as it provides a template of the trajectory of the drive toward and the persistence of Cuba's objective of developing domestic nuclear energy competence. What differentiates this approach from the others is that it centers on the political objectives of a regime as opposed to any material, economic, and socially efficacious ones. This approach also maintains that there are limits to economic rationality in choosing the nuclear option, especially when the perceived political rewards, such as prestige, propagandistic value, and symbolic accomplishment, are more highly regarded than any of the material and economic rewards associated with the attainment of a nuclear energy capability. Under this approach, the economic and social benefits associated with the development of a nuclear energy capability are considered by-products of the political rationale that guides these activities. The specific expectations for this case are:

- The selection of policy choices reflect the overarching political (nationalist and ideological) objectives and possibly minimize economic rationality.
- The political objectives of states employing this approach are national prestige, increased international status, and the symbolic and propagandistic capital that can be garnered for domestic and international consumption.
- The material objectives are secondary in nature to the political ones, and any benefits that can accrue to the regime and society are viewed as by-products of political objectives.

This approach is rendered inoperative when support for a nuclear energy development program is withdrawn at the highest level of government. All nuclear energy development activities need not be terminated when the reorientation of priorities is sufficient to signal the shift away from this model of modernization and development. Such a shift is manifested in the prioritization of modernization being contingent upon sound underlying economic and environmental rationale. As was previously mentioned, economic rationality is often eschewed when decisions are made under the politically motivated approach to modernization. Although one could argue that political motivation is always in place, by carefully evaluating the implementation of policy one may be able to determine a shift away from the nationalistic and ideological foundations of a policy to other priorities.

In direct relation to this case, one could argue that Cuba's nuclear energy development program was primarily focused on the politically motivated imperatives of the Republic of Cuba's nationalist and socialist ideals. Under this approach we could expect that Cuba would select such a large infrastructural project like the nuclear program to pursue. We could also expect

that the decisions made in this pursuit were initiated and made at the highest levels of the Cuban government with little external policy inputs and with a minimum of opposition within the ruling elite. For the Cuban government, as with all other developing states, this part of the program is simple and straightforward.

From the detailed discussion of the case it was also very clear that the Cuban elite attached significant political and symbolic value to the prospect of developing a nuclear energy capability. Yet a preponderance of evidence has been presented to suggest that under no circumstances did the Cuban policy in its creation and implementation intentionally minimize or disregard the economic impact or the secondary material considerations of developing a nuclear capability. In fact, this aspect of the nuclear energy development program was a central tenet of the Cuban decision to pursue such an advanced technological capability. The Cuban decision to refocus the objectives of the policy away from nuclear energy development to alternative sources of energy when it became painfully aware that, in the absence of a Soviet-like benefactor, it could not proceed alone, points to the underlying economic basis of decision making. Without the Soviet partner the Cubans have been forced to consider the loss of the benefactor in strictly economic terms. The notion of any socialist brotherhood was rendered bankrupt in the post–cold war milieu.

From these points we can ascertain that the trajectory of Cuban nuclear energy policy did not completely adhere to the politically motivated model of modernization or in the manner expected by this approach. Moreover, the assigning of symbolic value to the nuclear program by the Cubans is common in most countries and was not sufficient enough cause to compel Cuba to pursue its nuclear ambition. Although the political and symbolic justification of Cuba's revolutionary model of development could have been significantly boosted by the successful completion of a nuclear power program, the evidence strongly suggests that it was a secondary consideration in the nuclear development scheme. The fit between the expectations of the politically motivated modernization approach and the actual details of the Cuban case was not sufficient enough to qualify this approach as the best explanation for the trajectory of Cuban nuclear policy. Although the politics of modernization are strong and could potentially influence the trajectory of a large infrastructural development program, in this case it clearly was secondary and instrumental to the other policy imperatives.

Economic and Technological Modernization

The economical and technological approach to modernization is defined as access to the advanced technology and industrial skills needed in a nuclear

power program. The approach may be seen in a wider context as a means of raising the level of scientific and technological development, just as electrification based on nuclear power generation may be seen as an optimal path to economic development based on electrification.[3] Additionally, the education, training, and development of cadres of engineers, scientists, and technicians may be viewed as important by-products of this process, which is viewed as a logical and necessary component of the overarching modernization process, with special attention to the ability of a society to create knowledge and technical expertise. Under this approach we would expect several things:

- The policy objectives of projects selected under this approach are technological modernization, the expansion of technical capability, and the promotion of economic self-sufficiency.
- The important by-products of this approach are the training and development of cadres of scientists, engineers, and technicians and the creation of knowledge and technical expertise.

This approach is undermined when it becomes apparent that sound economic decision making is disregarded for other, less tangible rationalizations and objectives. It is often argued that developing states are more prone to adopt developmental schemes that are more symbolically than materially rewarding. It may also be the case that the nuclear energy development activities are couched in terms and objectives germane to this approach but are lacking in the underlying rationality. This is especially important to note in the case of economic and technological approach because the ultimate goal of these developmental schemes is the same, that being the successful and peaceful exploitation of nuclear energy. The key indicator for assessing if the nuclear energy development schemes adhere to this approach is whether or not they are economically feasible. This was assessed only after a cost-benefit analysis of the Cuban nuclear program.

Like the previous approach discussed, the economic and technological approach to nuclear energy development assumes that the decision to pursue this capability is initiated at the highest level of government. What qualitatively differentiates this approach from the other approaches in this investigation is the focus on technological advancement and the benefits to be derived from the training and development of Cuban scientists and engineers as a by-product of this process. The evidence presented in this case overwhelmingly points to the specificity of these concerns within the foundational objectives of developing nuclear energy in Cuba. The Cuban development scheme centered on development of human capital as a motivating force for policy. Here it matters little if those individuals are identified as Che Guevara's

conception of the "New Cuban Man" or anything else. The overriding rationale of the policy can be identified as the design and implementation of a nuclear capability, with the complimentary development of highly trained cadres of engineers, scientists, and technicians required to staff the research centers and facilities in Cuba. This is a remarkable accomplishment for any developing state, socialist or otherwise, and the impact is enduring and has a significant and positive spin-off to all sectors of Cuban society.

In addressing the concerns for an economically sound basis for pursuing nuclear energy, the Cuban program was consistent with those concerns. Initially, with assistance from the Soviet Union, Cuban policymakers pursued a course of development that was rational, as long as the Soviets were prepared to assume the costs of financing the program and its policy. It was only after ten years of work had been completed on the program that the Cubans' benefactors decided not to continue assisting in the financing of the project. This did not make the program any less economically tenable. It was simply that there was no longer sufficient financing to continue the venture. It might be surprising that the Cubans took so long in changing their focus from nuclear energy development to the search for alternative forms of energy generation. But it is more likely that the Cubans first exhausted every contingency in their attempt to resume construction at the nuclear reactors, before deciding to pursue another course of policy.

The application of the economic and technological model of nuclear energy development provided a strong explanation of the trajectory of the policy and their objectives. The Cuban concern for the development of advanced technology and the accompanying human capital points to a well-conceived and highly rational means of addressing Cuba's long-term energy needs and the promotion of energy efficiency through the exploitation of nuclear energy. We should not confuse the failure to complete the nuclear reactors at Juragua with a failure of the larger policy. The creation and development of a highly integrated nuclear infrastructure staffed by highly trained personnel corresponded to the overarching aims of the Cuban nuclear program. Moreover, when the deconstruction of the Cuban notion of and interpretation of modernization is incorporated into the analysis it becomes abundantly clear that technology transfer and acquisition in Cuba corresponds to a deeper historical current that predates the specifics of nuclear cooperation with the former Soviet Union. Modernization when viewed explicitly through the employment of advanced technologies and implicitly through the adoption of external modalities and orientations provides an understanding and context for the development of a nuclear energy capability. More than a product of Cuba's cold war relationships, the employment of advanced technologies is completely consis-

tent with historical trajectories that at one time helped to keep Cuba on par with the latest technological advances available in the developing world.

Furthermore, in order to understand why Cuba has sought to expand its technological and scientific capabilities we must look beyond the obvious implications of Cuba's Soviet influences to the more deeply seeded thinking that has been generated throughout the past 150 years through Cuba's relationship with the United States. Because of proximity and intense interaction with its neighbor to the north, we begin to understand that although generous and deeply involved, the Soviet Union was a poor substitute for the United States on a number of fronts.

Because Cuba had unabashedly adopted distinctly American modalities in education, scientific technique, and application (and in business practices), socialist modalities were neither sufficient nor capable of replacing the American variants. Although some may argue that the relationship between the United States and Cuba was based on colonial resource extraction and clientelistic practices, in the above-mentioned areas Cuba directly benefited from the relationship.

When viewed from this vantage point there is a sense that Cuba, because of this self-selected historical trajectory, would have selected to develop a Cuban nuclear energy capability. Even though Fidel Castro's regime can lay claim that the program is a success of the Cuban revolution, he cannot erase the impact and influence of the vestiges of preexisting Cuban thought and modalities as they apply to these realms. As a function of the prerevolutionary economy the employment of these resources did serve less than egalitarian purposes, but the fact is that Cubans enjoyed, if only in reserve domains, access to technology and scientific techniques enjoyed by few if any developing countries in the 1950s. By extension, it can be added that the socialist regime has astutely and assiduously appropriated these modalities and attempted to extend them to the whole of Cuban society. This notion represents the essence of Cuba's scientific and technological policy since 1960—the exploitation and employment of advanced technology in everyday Cuban life.

Additionally, the Cuban case history indicates that we should also view the subsequent shifts in priority of energy policy to be completely consistent with this approach, as they remain economically rational and continue to point to the advancement of technology, the expansion of domestic technical capabilities, and the promotion of Cuban self-sufficiency.

The timing and detail of the whole of Cuba's nuclear energy development program and the decision-making processes observed unfolded closely in the manner expected by the economic and technological modernization approach. Moreover, the actors involved in the nuclear program responded

to stimuli in the manner predicted by continuing to adhere to economically feasible practices and changing the policy when it was no longer economically feasible to do so. In some respects, the utilization of this logic points to the practical manner in which nuclear energy policy has been created, implemented, and readjusted to fit Cuba's reality.

This approach provided the most powerful explanation of the three approaches employed in this investigation. The evidence strongly suggests that the trajectory of the nuclear energy development process adhered closely to the expectations of the economic and technological modernization approach. Moreover it lends credibility to the idea that economic change and stimuli directed the trajectory of the program, which in turn provided the basis for the political optimism evidenced in the ambitious tone in which the program was being promoted by the Castro regime. Outwardly, the program with all of its changes and shifts in priority, in reality, reflected coherent and predictable patterns of events when bound to the expectations of the approach. Unfortunately for Cuba's nuclear ambitions, the process up until the present has not culminated in success.

Energy and Energy Security

The development of centrally generated electricity may offer unique economic advantages, and after careful analysis, nuclear fission may emerge as a means of generating electricity at the lowest real cost. The introduction of nuclear power may help to diversify and augment the domestic supplies of energy in general, and electricity in particular, thereby diminishing dependence on any one source of supply and reducing the dependence on imported energy sources.[6] In particular circumstances, centrally generated electricity offers unique economic advantages in comparison to other sources of energy generation, and after the cost-benefit analysis, nuclear energy emerged as the means for Cuba to produce energy at the lowest real cost.[7]

There is an underlying relationship between (1) a nation's energy needs and external dependence or exposure, (2) economic and political stability, and (3) broader security concerns. The intensity of these relationships will, of course, vary from country to country in the developed and developing world, and within a country over time. When dealing with security in the context of energy, we are concerned with the broad and unavoidably subjective connotation of the term. Such a grand interpretation encompasses economic, political, strategic, and military aspects of security, as opposed to the more minimalist interpretation that focuses on specific military threats and defense programs.

Economic security focuses on national resource sufficiency and, in particular, access to goods and services in world markets in affordable terms.

Political security suggests the maintenance of domestic stability, whether it is based on rule by the consent of the governed or on varying degrees of authoritarian measures. Either way, law and order prevail, and economic political and social activities are conducted with little or no hindrance. Strategic and military security is partly outward looking and may be gauged by the degree and intensity of perceived external threats and the military capability that can be marshaled to meet those threats. It is also inward looking in that it involves the diversion of domestic resources and services to meet those threats. Under this approach the expectations are as follow:

- The choices of policy objectives focus on maintaining access to secure sources of energy; in some cases the choices involve the development of stand-alone energy sources such as nuclear energy.
- The choices of policy seek to limit a state's external dependence on, and exposure to, world energy markets.
- The implications of energy development under this approach are a long-term focus on the effects and interactions between energy, the economy, and security in a given state, resulting in a balance between economic growth and security planning.

It should be clear that a nation's energy policy and its management carry significant implications for both the security and economic domains. Energy shortages at home require adept diplomacy and adequate bargaining power to fill the breaches. External and internal security, as well as external trade policies and economic development plans, have their roots in the successful or unsuccessful management of energy policy. Energy policy management must aim at maintaining the present equilibrium (if satisfactory) or advancing the policy to safer and more secure levels.

In some respects this approach was the most difficult to assess. With the energy and economic security approach, as with the other two, there is a correspondence to the expectations of a high-level decision to pursue a large infrastructural development program. Within the framework of this approach, Cuba was clearly cognizant of the need to provide secure sources of energy and seek to limit its external dependence on others for its energy. The Cubans consistently trumpeted the lessened dependence on imported oil as one of the chief motivations for pursuing nuclear energy. But it is unclear how two nuclear reactors were going to help it lessen its dependence when clearly 90 percent of its oil had to be imported, and the reactors would only reduce that dependency by a mere 15 percent. Any disruption in service from the nuclear energy sources would leave Cuba similarly exposed to the external energy dependency. Moreover, any loss of oil would be devastating to the Cuban economy

especially while the reactors were under construction. This is in fact what occurred in 1992. With the cutback in the amount of oil imported from the former Soviet Union, Cuba watched helplessly as the economy tumbled and eventually was reduced by almost 40 percent.

Throughout their thirty-year relationship with the Soviets, the Cubans had failed to acquire truly secure sources of energy to support its economy. Although the nuclear program could provide Cuba with some relief in the case where it lost its oil supply, it would have been inadequate in providing Cuba with economic or energy security. If the energy and economic security approach were to hold, we would expect to see Cuba continue pursuit of nuclear and alternative sources of energy generation. One could argue that Fidel Castro's 1997 change in policy is consistent with the underlying rationale of the approach. But if one considers the increased activity in the thermoelectric sector in Cuba, any hope for approaching energy equilibrium is fundamentally lost. The increased activity is important for two reasons. By updating and increasing the thermoelectric generation capability, Cuba correspondingly must increase its dependence on imported oil to fuel these facilities. This may make sense in the short term, but Cuba will still be similarly exposed to a significant economic downturn should its access to oil imports be compromised at any time in the future. Moreover, it inextricably ties the Cuban economy to the world energy markets, thus subjecting its economy to the vagaries of that market. Cuba was effectively shielded from the world market by virtue of its relationship with the Soviets, who granted Cuba favorable and at-below-world-market prices for imported oil while paying it higher-than-market prices for its sugar exports. In the post–cold war environment, no such set of favorable terms is in the offing for Cuba.

The case study corresponded to the expectations of the economic and energy security model of nuclear energy development at the inception of the nuclear program in the late 1970s. The correspondence to Cuba's nuclear policy ended with the end of the cold war. One would have expected Cuba to continue to search for the means of providing a balance between Cuba's energy needs, its economic stability, and its broader security concerns. Yet in the period since 1991, Cuba's energy policy, although de-emphasizing nuclear energy in pursuit of alternative sources, has actually increased its external exposure as it has attempted to respond to its short-term economic needs. Although this makes sense in 1999, this disequalibrium potentially undermines the long-term domestic stability and increases Cuba's exposure in the economic and security arenas. One should bear in mind that the economic and energy security approach is a cold war period theoretical construct. As such it was included to assess whether this approach retained its

salience after the end of the cold war. In one respect it still does. Cuba, for all intents and purposes, must maintain equilibrium between these competing interests, and it would be wise to do so. Yet the case history compellingly points out why Cuba cannot. The energy shortages, internal security, and need to shore up its almost moribund economy forced Cuba to shift away from these well-conceived and vital concerns. It may be that the present-day policy exigencies have caused Cuba to defer to the immediate needs of its economy at the expense of the long-term energy and security imperatives. It also suggests that the Cuban cold war energy policy assumed too much in the way of secure sources of oil, and it minimized the potential for overexposure to outside sources. In part, this policy mismanagement, which offers little in the way of providing an explanation of Cuba's nuclear pursuit, provides a compelling macroview of Cuba's current dilemma.

Major Findings

Rather than attempting to prove or falsify the approaches, this investigation sought to evaluate the validity of the approaches through application as opposed to theory testing. Moreover, theory application has been an underutilized method of conducting social science research but it is no less important in assisting researchers to investigate the appropriateness of theories and approaches constructed to provide fuller explanations of complex realities.

Of the three plausible approaches presented in this investigation, the economic and technological modernization approach provides the best fit of the three approaches offered between the expectations of the approach and the actual details of the process of conceiving and implementing a nuclear energy development program.

The energy and economic security approach to nuclear energy development initially provided a good fit between the trajectory of the development of Cuba's nuclear energy policy and the expectations of the approach as the events unfolded. The approach became less valid when Cuban actors and policymakers responded to the loss of their Soviet benefactors by increasing Cuba's external dependence for energy sources and further concentrating domestic energy sources in the thermoelectric generation sector. These events are contradictory to the expectations of the otherwise well-conceived approach to the development of a nuclear energy capability in Cuba. In addition, the actors continue to act in a manner that contradicts the expectations of the approach as well by seeking more joint ventures to upgrade and construct new thermoelectric facilities. The perceptions of the

actors have been altered significantly with the ending of the cold war, and the correspondence of their actions to the expectations of this approach has been similarly undermined.

The politically motivated modernization approach to nuclear energy development, like the economic and energy security approach, was relevant during the cold war. Cuba could afford to extol the virtues of the "revolutionary model of development," especially when there were few economic constraints on its ambitious nuclear development schemes. The loss of the Soviet benefactor fundamentally rendered the approach bankrupt. The bankruptcy results from the minimization of politics in the formulation of policy in the post–cold war period. One may grant that Cuba still heavily relies on the political aspects of everyday "revolutionary" life to keep the regime alive, but this has been significantly altered by a heavy dose of economic reality.

In fact, almost all of Cuba's post–cold war nuclear policy has been couched in strictly economic terms. While the ruling elite remains firmly pledged to advancing the revolutionary nature of the regime, it is clear that in the case of the nuclear program, the decision-making process has unfolded in a contradictory fashion to that suggested by the politically motivated modernization approach. In the period since 1991 Cuba has backed away from the political objectives of acquiring a nuclear energy capability. The evidence strongly shows that the political imperatives such as prestige, status, and propagandistic value have been minimized to a point where most public announcements and energy policy initiatives are related in terms of their economic benefits. As has been suggested by William Potter and others, some nuclear development programs eschew economic

Table 5.1: Correspondence of the Three Approaches to the Expectations

Expectations	*Politically Motivated*	*Economic and Technological*	*Energy and Economic Security*
Minimized Economic Rationale	No		
Symbolic Value	Yes/No		
Secondary Material Objectives	No		
Technological Advancement		Yes	
Training and Development		Yes	
Source Security			Yes/No
Limit External Dependence			Yes/No
Long-term Focus			Yes/No

rationality in pursuit of advanced nuclear capabilities. In the case of Cuba, this rationale has strengthened over the course of the energy development program. Moreover, as Cuba continues to seek joint venture projects with international firms, one should expect a continuing diminution of the political rhetoric of the past. In its place one can expect that Cuban policymakers will continue to base their energy policy decision making on the sound economic rationale.

Summary

The book and this chapter in particular set out to bring together the objectives and implementation of nuclear energy development policy to see if Cuba's nuclear energy development program corresponded to the approaches advanced by this investigation. This was accomplished by establishing the cause-and-effect links that connect the independent variable (Cuba's model of nuclear energy development) and outcome (a Cuban nuclear energy capability). This investigation has established that the economic and technological modernization approach best explains the trajectory of Cuba's nuclear energy policy during the past twenty years. True to form, Cuba's decision-making process unfolded as predicted by the approach. The fit between the approaches' expectations and the process and actual details of the process was extremely close. The approach was further validated after the fundamental shift in policy objectives with the loss of Soviet and then Russian assistance to the nuclear program. Cuba continued to base its nuclear aspirations on sound economic reasoning and the objective of developing the entirety of the nuclear infrastructure.

During the initial period of the development program, and until 1991, the primary actors and the policy objectives of the program conformed neatly to the energy and economic security approach, as well as the politically motivated modernization approach. Neither of the two approaches' expectations held in the wake of Cuba's decision to suspend the nuclear program and pursue other options. Their initial correspondence to the activities undertaken by Cuba may speak to the rather ambitious nature of the program, and the programs' steady narrowing of objectives until the suspension of construction, clearly signal the weakening explanatory values of these two approaches.

The failure to complete construction of the nuclear reactors at Juragua does not necessarily signal the death knell for the Cuban nuclear program. Cuba remains firmly committed to pursuing its nuclear energy development policy, only now somewhat trimmed around the edges. This is not to suggest

that Cuba acted irrationally in conceiving and embarking on the nuclear development program. At this point one can safely return to the initial two research questions posed at the beginning of this investigation.

Why Did Cuba Choose to Pursue a Nuclear Energy Capability?

Cuba initiated a nuclear energy development program with completing nuclear energy generation facilities as its primary objective. The objective was part of a larger program of modernization and expansion of the scientific and technological infrastructure by the Castro regime in Cuba. Initially, the expansion program sought to assimilate nuclear techniques into all sectors of the Cuban economy. This included the creation of research facilities and institutions through the island. Most, if not all, of these enterprises were underwritten by Cuba's primary trade partner, the Soviet Union.

Because of Soviet assistance Cuba confidently sought to expand the exploitation of nuclear techniques into the field of energy generation. The reasons for pursuing the nuclear energy were numerous and varied. First and foremost, Cuba was completely dependent upon oil exports to fuel its economy. Cuba's thinking at this time was conditioned by the impact on the world economy of the oil shocks of the early 1970s. Cuba was seeking to minimize its exposure to the vagaries of the world market. By developing a nuclear energy generation capability Cuba could provide a buffer against the external impact of world oil shortages as well as lessening its dependence on the Soviet Union. In addition, acquiring advanced nuclear energy capabilities was entirely consistent with the overall scientific expansion program already underway in Cuba.

Cuba also sought to create a diverse and well-orchestrated nuclear infrastructure to support its pursuit of nuclear energy. Eventually, Cuba successfully put into place agencies for the administration, regulation, research, and construction of nuclear reactor facilities. Cuba also created nuclear-related agencies in the fields of agriculture, medicine, physics, and the environment. At that time the ambitious plans called for the construction of a network of a dozen reactors dispersed throughout the island. When these reactors were completed and operating Cuba would be virtually self-sufficient in energy supply and could lessen its dependency on the Soviet Union in this area once and for all. As we have seen, such was not the case. Cuba and the Soviet Union were continuously confronted with obstacles in design and construction of the first two planned reactors and by the late 1980s, together they had pared back the ambitions and were focusing on merely completing the reactors at the Juragua construction site.

The Soviet resolve in completing the projects was being undermined by

the economic and political collapse of the Soviet Union, and Cuba, having no other source of assistance for its nuclear program, was forced to curtail its activities and construction plans. By 1991, it was clear to the Cubans that, short of a miracle, it had no choice but to suspend construction and place the reactor construction into mothballs.

Why Has Cuba Persisted in Its Nuclear Energy Development Program?

In the period immediately after the collapse of the Soviet Union, Cuba became keenly aware that all of its fears of overreliance and dependency on the Soviet Union in the area of energy, and of its economy for that matter, had become painfully true. The Soviet successor state, the Russian Federation, was mired in its own internal crisis and was inherently unable to give the Cubans the support that they desperately needed to keep any hopes for the nuclear program alive. To address this setback the Cubans sought assistance from countries other than the Russian Federation and in short order firms from Western Europe were lined up and ready to embark on a joint venture with the Cubans to complete the reactors.

Just as quickly, all of these firms walked away from the project unconvinced that they could ever realize a profit from the venture. The case history strongly suggests that the estimated $800 million price tag to complete the reactors was far too high for these firms. This suggestion is especially important with the understanding that Cuba had no domestic sources of capital to pay for the project, little or no credit available in the international markets, and few if any prospects to generate income from the facilities. This perception was informed by the Russian experience where the privatization of the domestic energy sector had resulted in complete failure. Yet Cuba continues to entertain the possibility (although reluctantly) of completing the reactors that have now been in a state of suspension for more than seven years. On five separate occasions since 1992, and most recently in April 1999, Cuba and the Russian Federation have announced agreements to complete the reactors as a part of larger assistance and trade agreements.

These announcements contradict a shift in energy policy declared by Fidel Castro that de-emphasized the nuclear option and opened up the possibility of other sources of energy generation to meet Cuba's demand requirements. In the period since the declaration Cuba has seen a flurry of activity in the conventional energy sector that includes plans for the upgrading of existing facilities and the construction of new facilities, all completely financed by foreign enterprises.

The new thermoelectric investment and development activities do not signal the demise of the nuclear program. Clearly, the Cuban government

has devoted a vast amount of scarce resources to the development of a nuclear support infrastructure. Although Cuba has veered away from lessening its dependence on imported oil by expanding the conventional energy sector, it is clear that this is only a short-term measure to keep the economy afloat it is not a long-term solution to Cuba's chronic energy problems. For that reason nuclear energy generation remains a viable option for Cuba, although muted for the time being.

Postscript 6

When measured in terms of absolute dollars and potential megawatts of electricity generation, the Cuban nuclear program represents a small but important role in the spectrum of grand infrastructural modernization schemes in the developing world. In concluding this case study it is important that one carefully consider what this examination adds to the existing social science literature on modernization, energy development, and the nature of progress in developing societies at the end of the twentieth century. This concluding chapter looks at the findings and implications of the study at two levels. First, it will expound on the macrotheoretical inferences that can be drawn from the study of nuclear energy development in Cuba. The linkage of the Cuban case to the modernization literature is relevant, as it has served to validate the expectations of modernization theory by the application of a case study. This type of analysis makes use of the case history through tracing the policy process across time. Second, it looks at the case-specific implications of the Cuban nuclear program, including the prospects for the energy sector in Cuba and the wider development schemes of the socialist regime.

This chapter will also investigate the trajectory this type of case study might engender as a result. This includes the suggestion that this kind of study might be appropriate for expanded regional and global comparative studies on energy development schemes. The chapter closes with final comments on the Cuban nuclear energy program and energy development in developing states.

Macrotheoretical Implications

The discussion of the theoretical implications of this case center on the relationship of the expectations of three approaches derived from the modernization literature to the actual events of a modernization scheme. Rather than testing any of these approaches, this investigation has sought to apply these approaches to the Cuban case to assess their correspondence to the trajectory of policy objectives and their implementation during the almost twenty-year period that Cuba has attempted to develop a nuclear energy capability.

The discussion of modernization began with a focus on the apparent inadequacies of the macrotheoretical constructs to explain the consistent failure of these schemes in developing states. This is especially pertinent when one considers that a major assertion of modernization theory, as it was initially conceived, was a direct linkage between modernization, i.e., economic development, and the expansion of democratic governance through political development. The prevailing critique of modernization theory was that modernizing societies often found it difficult to translate economic development into effective democratic governance. Moreover, in some cases, economic development could be linked to the breakdown of political systems, as witnessed by the proliferation of bureaucratic authoritarian regimes in Latin America. This often was a result of the failure of these modernizing societies to provide effective political institutions to meet the demands of rapidly mobilizing social forces unleashed because of the economic development. The modernization theorists were also accused of being far too prescriptive in their approaches as these policies were duplicated in some developing states with less than favorable results. Yet these arguments, although apparently discredited, have found a renewed salience in the post–cold war period. As a result, the implications of successful economic development and modernization in Cuba could be significant.

Revisited modernization, or neomodernization theory as it is now known, suggests that the link between economic development and political development was not nearly as strong as previously argued. The reformulation of modernization theory asserts that the economic development is now only a necessary but not sufficient stimulus for political development to occur. In addition, the overly prescriptive nature of modernization theory could now be validated with the number of actual cases available for study by social scientists. With these two ideas in mind the Cuban case study was undertaken. This was important for two reasons. Cuban efforts to develop nuclear energy were never geared toward the expansion of politics in Cuba. They were certainly oriented toward providing an increased standard of liv-

ing for Cubans, but the idea of increasing political involvement of the population did not enter the realm of potential or desired objectives. As such Cuba's efforts to develop place it outside of "normal" development studies, especially now after the end of the cold war.

The Cuban case also provided an excellent opportunity to investigate the claims made by the different modernization approaches selected for the development of nuclear energy and its exploitation in Cuba. As most of these schemes were developed prior to 1991, it bears to reason that the "new world order" directly challenges many of the justifications and arguments supporting those approaches to modernization.

Energy development in Cuba has been both a success and a failure. The implications of this case study for the modernization and development literature have been mostly positive. In many respects the case confirmed many of the expectations of the modernization approaches. The Cuban case was unique in the respect that it was buffered from the vagaries of the world market by virtue of its relationship with the Soviet Union. In the absence of that benefactor, Cuba has found it difficult to continue pursuit of energy without such a buffer. The resulting outcomes closely adhere to expectations offered by modernization theory and strongly endorse the notion that theory application can be a useful research tool in validating the utility of pproaches employed to explain energy development in a state such as Cuba. Interestingly, the current economic reversal of some of the development success stories of the 1980s in East Asia and elsewhere casts some doubt on the enduring validity of these schemes for developing states. While the expansion of economic activity may provide a developing state with increased opportunities to interact with the global market, it is now uncertain as to whether this interaction is a positive for these states in the long run. There are now a number of examples where the development of economies in some states has been either co-opted or manipulated by less than democratic regimes to promote growth without a complimentary expansion of autonomous political activity. In fact some of the most successful economic development cases have occurred in the least democratic states or under outright dictatorships.

Case-Specific Implications

In the modern period Cuba has consistently aimed to place its mark on the modernization and development schemes that it has literally imported from abroad. This feature of the Cuban modernization process was especially apparent in Cuba's attempt to develop a nuclear energy capability. Cuba, with the ample assistance of the Soviet Union, was able to initiate a

program that distinctly bore the influence of the revolutionary regime's larger development imperatives. It also reflected a larger historical trajectory of technology transfer and the adoption of external modalities that extend back to the nineteenth century. Cuba eschewed the short course to modernization by opting for a much grander technological and scientific development program that could result in a nuclear energy capability. This refrained from the swifter path to nuclear energy development available to Cuba through a turnkey project. By selecting an alternative path of development, Cuba elected to delay acquiring the nuclear capability in the short run. Because of the unforeseen demise of the Soviet Union, it turned out to be the wrong choice. But one should not be so quick to label the effort a failure. As the twentieth century closes, Cuba has in place a well-conceived and operating nuclear bureaucracy. It may come to pass that the reactors at Juragua never see a day of operation. For many critics of the Cuban nuclear program this would be most welcome news. But Cuba has in place the scientific and technological infrastructure to successfully exploit nuclear power for electricity should its financial position improve in the future.

Should Cuba find the nuclear option no longer attractive, the diversity of knowledge, expertise, and creativity inherent in the nuclear sector could still serve Cuban society for generations to come. It is apparent now that the Castro regime understands the implications of large infrastructural undertakings for sustainable development. The inability to maintain a secure energy source in Cuba has devastated its economy and society. The recent turn to conventional and alternative forms of energy generation also reflect the growing global trend of turning to energy sources other than nuclear power. With the exception of the Russian Federation, few if any industrialized states are actively constructing and bringing on-line nuclear power stations. With the current oversupply and low prices of fossil fuels, countries are turning to the traditional forms of energy generation to sustain development and economic growth. Cuba has attracted investment in the thermo-electric generation projects, as opposed to the Juragua nuclear project, where not one firm has considered assisting Cuba in completing construction of the nuclear reactor. This attraction may be shortsighted, however. Growing efficiencies in the extraction, refining, and delivery of oil supplies have made conventional energy generation the most cost effective form of generation at this time. These growing efficiencies imply that it may be so for some time to come. And for the enterprises involved in energy generation it may make for a sound investment policy. But few if any analysts correctly predicted the oil crisis of the 1970s, and even fewer predicted the sudden end of the cold war. It may be this very reasoning that has prompted Cuban policymakers to keep the nuclear option alive in its energy policy.

The possibility of an interrupted oil supply is always a reality for a developing state like Cuba, whose ability to generate capital and borrow loans is less than guaranteed. This is a dilemma for all similarly overexposed developing countries that are ill equipped to deal with the sudden shifts in the international system or the vagaries of the world market. For these reasons, the development of a nuclear energy capability retains it attractiveness and remains within the realm of policy solutions for Cuba's chronic energy dilemma.

In the late 1990s, Cuba is seeking to replicate the Chinese model of economic development and expansion. This model seeks growth under an authoritarian regime with limited economic liberalization measures. The specific measures include attracting foreign investment in different sectors of the economy, engaging in joint ventures with foreign firms, and implementing limited market reforms to promote economic activity. The Cuban experience in this economic opening has been met with mixed results. Cuba has attracted investment in tourism, mining, and to some extent in the energy sector. This has created income disparities that potentially could undermine some of the tenets of the socialist regime. Moreover, if Cuba is to continue along this trajectory of economic liberalization it may present the gime with its greatest challenge to date. The experience common to all developing states has been the challenge of providing adequate political institutions to deal with the rapid mobilization of domestic social forces unleashed by economic development. In the cases where the political system has not provided adequate institutions and mechanisms to meet the growing demands of these social forces, conflict has often resulted.

In the recent cases of democratic renewal in Latin America, Eastern Europe, and elsewhere the transition to democracy and market economies has been less than stable. For some of these states the transition has been one of chaos and growing inequalities that democracy and capitalism promised to eradicate. There have been no keener observers of the democratic transition process than the Cubans. Cuba is well aware that its present path of economic and social development may not be enough to sustain the present regime, but they are also cognizant that a rush to a democratic political system and a market economy may not be the answer.

Future Considerations

The obvious question generated by this analysis is: Can it be extended to and replicated in other cases? The answer is an emphatic yes. The analysis of nuclear energy development schemes, in particular, and of energy development programs, in general, can be and should be expanded to incorporate

other developing states. This can be accomplished by constructing regional assessments and cross-case and cross-national studies. The most logical step would be to conduct a case study survey of energy development in Latin America. Three Latin American countries—Argentina, Brazil, and Mexico—already possess operating nuclear energy generation facilities. A number of others have investigated pursuing the nuclear option. By employing the economic and technological model of energy development, one could analyze these programs to see how well the policies pursued and implemented adhere to the approach. This in turn could bolster the validity of this approach.

As a policy issue of concern in both the United States and Cuba, the domestication and politicization of international scientific and technical matters only serve to cloud the reality of what is occurring in Cuba in this area. This has forced individuals within this country to rely on secondary interpretations of the facts of this matter. The only way one can know what is really going on in Cuba is to directly engage Cuban officials. In its place we have vengeful politicos playing with elements of our national security policy about which they are mostly uninformed and less than qualified to understand in their complexity. As a result we rely on mostly symbolic measures to address what are legitimate, but ultimately overexaggerated, concerns. Allowed to continue unimpeded the result of this course of action could be problematic. One or more of our partners might be swayed sufficiently to follow, but it is an educated guess that the majority, as in the case of Helms-Burton Amendment, would resist any attempts to have the United States dictate the terms of trade as they relate to Cuba. This book has sought to provide a beachhead against the tide of less-than-informed discussions and sought to amplify the dialogue to include the officials, specialists, and policy analysts equipped to initiate sound and rational policy responses to an issue of concern.

Finally, the prospect of a democratic Cuba is one that would be welcomed by most everyone. The actions of the American policy and academic communities today are setting the course of how smoothly the transition in Cuba might be. Cuba for its all its apparent shortcomings is attempting to deal with the its future by putting in place a reliable source of energy and electricity to fuel its continuing development. Nuclear energy, for all of its inherent failings, is a still legitimate option for the Cubans. Cuba also needs to explore other "viable" alternatives that correspond to its economic reality.

The future of Cuba, the Castro-less Cuba, the Cuba of the twenty-first century, desperately needs energy. The United States can play a part in ensuring that it can and will develop its energy sector and corresponding infrastructure for its future. Without such assistance, the notion of a demo-

cratic life will ring hollow, and industrial expansion will be a mostly empty project without power. Promoting an immoral policy of the "economic asphyxiation" of Cuba in the hopes that democracy rises to assume its proper place may guarantee that this so.

One final consideration: The revitalization of Cuba's energy sector will most likely be delayed until after a "normalization" of United States-Cuban relations. This means that little or no effort will be undertaken to address assiduously the present energy concerns. Moreover, as the infrastructure in Cuba is in some places nearly one hundred years old and continues to deteriorate, it bears to reason that the cost of replacing these systems will soar into the billions. The implications of these problems are that any immediate hopes for the economic revitalization and readjustment in Cuba must wait until the supporting infrastructure is replaced. The expectations of U.S. business interests may go unsatisfied, and more importantly, the everyday quality of life in Cuba will be diminished. It also bears to reason that without direct multilateral assistance from institutions such as the Inter-American Development Bank, the World Bank, and the International Monetary Fund, Cuba faces a dour future in the area of energy development. U.S. government institutions, banks, and corporations will also play an important role in shaping the future of redevelopment and revitalization of

and in the next century. Unfortunately, the longer the wait to initiate work, the higher the cost in terms of investment dollars, and more importantly, the higher the human costs.

Notes

Chapter 1: Contextualizing Cuba's Nuclear Program

1. Jonathan Benjamin-Alvarado and Alexander Belkin, "Cuba's Nuclear Power Program and Post-Cold War Pressures," *The Nonproliferation Review*, 1, no. 2 (winter 1994): 18.
2. José De Cordoba, "Some See Castro Regime Coming to End in Violence as Economy Worsens," *Wall Street Journal*, Sept. 10, 1993, A10.
3. Cuba's GDP rate of growth has averaged about 4 percent over the period of 1995–1997; the growth rate for 1998 is estimated at 4.0 percent and 5.0 percent for 1999. See *EIU Country Report: Cuba, 4th Quarter 1997* (Dec. 1997), 9.
4. John Shanahan, "Cuba's Potential Chernobyls," *Wall Street Journal*, Apr. 5, 1992, A14.

   Miguel Serradet Acosta, *Programa Nucleoenergetico Cubano* (paper presented at the Regional Seminar on Public Information, Havana, Cuba, May 17–19, 1995), 11.
6. Jonathan Benjamin-Alvarado, "The Quest for Power: Analyzing the Costs and Benefits of Cuba's Nuclear Energy Program," *Cuba In Transition, Volume 6*, Papers and Proceedings of the Sixth Annual Meeting of the Association for the Study of the Cuban Economy (ASCE) (Miami: ASCE, 1997), 442.
7. Juan del Aguila, *Cuba: Dilemmas of a Revolution*, 3rd ed. (Boulder: Westview Press, 1994), 84.
8. Brazil's Angra 1 and Angra 2 nuclear reactors have faced construction delays and financial setbacks similar to those experienced by the Cubans in the construction of the Juragua reactors.
9. Even with the Juragua-1 unit on line, and even assuming that the reactor could operate at near 100 percent capacity, the additional electrical output of 440 megawatts would add only 10 percent to Cuba's generating capacity. Cuba would still require about an additional 30 to 40 percent to meet its estimated demand. See Benjamin-Alvarado and Belkin, "Cuba's Nuclear Power" (1994).
10. Mark Falcoff, "Castro in Our Mind," *The National Interest*, no. 40 (summer 1995): 89.
11. For a discussion of these approaches, see Peter H. Smith, "The Changing Agenda for Social Science Research on Latin America" in *Theoretical Debates in Social Science on Latin America*, Peter H. Smith (Boulder: Westview Press, 1995); Samuel P. Huntington, *Political Order in Changing Societies* (New Haven, Conn.: Yale University Press, 1968); Cyril E. Black, *The Dynamics of Modernization* (New York: Harper and Row Publishers, 1966); Cyril E. Black, ed., *Comparative Modernization: A Reader* (New York: Free Press; London: Collier, 1976); John H. Kautsky, *The Political Consequences of Modernization* (New York: John Wiley and Sons, 1971).

12. See James Everett Katz and Onkar S. Marwah, eds., *Nuclear Power in Developing Countries: An Analysis of Decision Making* (Lexington, Mass.: Lexington Books, 1982).
13. According to these hypotheses, economically based models of modernization and development, while more rational and efficient, are less likely to be employed by developing states that are driven primarily by political and ideological imperatives. See Huntington, *Political Order in Changing Societies* (1968); and Kautsky, *The Political Consequences of Modernization* (1971).
14. See Ian Smart, "The Consideration of Nuclear Power," in *Nuclear Power in Developing Countries*, ed. Katz and Marwah (1982), 19–41.
15. Raju G. C. Thomas, "The Relationships among Energy, Security and the Economy" in *Energy and Security in the Industrializing World*, ed. Thomas and Ramberg (1990), 1–12.
16. See Ronald Inglehart, *Modernization and Postmodernization: Cultural, Economic and Political Change in 43 Societies* (Princeton, N.J.: Princeton University Press, 1997), 5–6.
17. Max Weber, *The Protestant Ethic and the Spirit of Capitalism* (New York: Scribner's, 1958 [1904–5]).
18. Inglehart, *Modernization*, 9.
19. Huntington, *Political Order in Changing Societies*, 17.
20. See William C. Potter, *Nuclear Power and Nonproliferation: An Interdisciplinary Perspective* (Cambridge, Mass.: Oelschlager, Gunn and Hain, 1984).
21. Smart, "Consideration," 21.
22. David Landes, "The Creation of Knowledge and Technique," *Comparative Politics: Notes and Readings*, 8th ed., ed. Bernard E. Brown and Ray C. Macridis (New York: Harcourt Brace, 1996), 361.
23. R. Thomas, "Relationships," 2–3.
24. Ibid., 3.
25. Stephen Van Evera, *Guide to Methodology for Students of Political Science* (Cambridge, Mass.: DACS/MIT, 1997), 42.
26. Robert Yin, *Case Study Research: Design and Methods* (Newbury Park, Calif.: Sage Publications, Inc., 1989), 4–5. See also Harry Eckstein, "Case Study and Theory in Political Science," in *Handbook of Political Science, Volume 7: Strategies of Inquiry*, ed. Fred Greenstein and Nelson W. Polsby (Reading, Mass.: Addison-Wesley Publishing Co., 1975), pp. 79–137; Alexander L. George, "Case Studies and Theory Development: The Method of Focused and Structured Comparison," in *Diplomacy: New Approaches in History, Theory and Policy*, Paul Gordon Lauren (New York: The Free Press, 1979), pp. 43–68; Van Evera, *Guide to Methodology for Students of Political Science*, 25–42; Ole R. Holsti, *Turning Undergraduate Students into Case Writers*, Course Teaching Notes, Pew Case Studies in International Affairs (Washington, D.C.: Institute for the Study of Diplomacy, 1997), 9.
27. Joe R. Feagin, Anthony M. Orum, and Gideon Sjoberg, eds., *A Case for Case Study* (Chapel Hill: University of North Carolina, 1991).
28. Process tracing is also a useful method for clarifying alternative definitions of causality. It has been defined as terms of causal effect, the mean causal effect being the difference between the systematic component of a dependent variable when the causal variable takes on two different values. The clarification between alternative definitions of causality can be expressed as the difference in industrialization processes when the source of the modernization project has been internal, on the one hand, or external, on the other. See Gary King, Robert O. Keohane, and Sidney Verba, *Designing Social Inquiry: Scientific Inference in Qualitative Research* (Princeton, N.J.: Princeton University Press, 1994), 85–87.
29. This is a database service provided by the Monterey Institute of International

Studies to officials, researchers, and journalists interested in nonproliferation studies. It is a collection of articles and reports from journals, newspapers, and industry publications not usually available in libraries.

Chapter 2: Theoretical and Substantive Dimensions of Modernization and Development in Cuba

1. An example of a significant contribution in this area can be found in Julie M. Feinsilver, "Cuban Biotechnology: The Strategic Success and Commercial Limits of a First World Approach to Development," in *Biotechnology in Latin America: Politics, Impacts and Risks*, ed. N. Patrick Peritore and Ana-Karina Galve-Peritore (Wilmington, Del.: SR Books, 1995). Although Katz and Marwah, as well as Thomas and Ramberg, have sought to analyze nuclear policy decision making in developing states, the examination of specific cases has been limited to the application of one approach. This analysis seeks to analyze the Cuban case comparative to three different hypotheses relevant to the pursuit of a national nuclear energy capability. See James Everett Katz and Onkar S. Marwah, *Nuclear Power in Developing Countries: An Analysis of Decision Making* (Lexington, Mass.: Lexington Books, 1982); and Raju G. C. Thomas and Bennett Ramberg, ed., *Energy and Security in the Industrializing World* (Lexington: University of Kentucky Press, 1990).
2. See Etel Solingen, *Industrial Policy: Technology and International Bargaining* (Stanford, Calif.: Stanford University Press, 1996).
3. See William C. Potter, *Nuclear Power and Nonproliferation: An Interdisciplinary Perspective* (Cambridge, Mass.: Oelschlager, Gunn and Hain, 1984).
4. John H. Kautsky, *The Political Consequences of Modernization* (New York: John Wiley and Sons), 17.
5. Peter H. Smith, "The Changing Agenda for Social Science Research on Latin America," in *Theoretical Debates in Social Science on Latin America*, ed. Peter H. Smith (Boulder: Westview Press. 1995), 8.
6. Ronald Chilcote argues that the experience of Western Europe has suggested a linear path toward modern development. Nineteenth-century theories of evolution asserted that the Western world had pursued a path through successive stages of development. Implied in this view of "progress" was the belief that the Western world could in turn civilize less-developed areas, and conquest and expansion would combine with the spread of European or Western values to these areas. See Ronald Chilcote, *Theories of Comparative Politics: The Search for a Paradigm Reconsidered* (Boulder: Westview Press, 1994), 222. For examples of social science treatments of modernization, see S. N. Eisenstadt, "Modernization and Conditions of Sustained Growth," *World Politics* 16 (Jul. 1964): 576–94; Marion J. Levy, *Modernization and the Structure of Societies* (1966). For treatments of stage theory and modernization, see Walt W. Rostow, *Stages of Economic Growth: A Non-Communist Manifesto* (Cambridge: Cambridge University Press, 1960); Walt W. Rostow, *Politics and the Stages of Growth* (Cambridge: Cambridge University Press, 1971); A. F. K. Organski, *Stages of Political Development* (New York: Alfred A. Knopf, 1965); Cyril E. Black, *The Dynamics of Modernization* (New York: Harper and Row, 1966).
7. Counterting this approach is the seminal treatment of Cuban development by Francisco Lopez Segrera. He combined underdevelopment, dependency, and imperialism in formulating a Marxian historical analysis of the Cuban political economy. He argues that socialism is possible in a country dominated by imperialism no matter what the force of its dependent ties. The essential purpose of the study was to examine the conditions of dependency and the consequences of

imperialism that brought capitalism to prerevolution Cuba. In López Segrera's estimation, Cuban underdevelopment was a consequence of international capitalism and constituted a particular form—that of dependent capitalism. See Francisco Lopez Segrera, *Cuba: capitalismo, dependiente y subdesarrollo* (Havana: Casa de las Americas, 1972).

8. Weber, 21–23.
9. Black, *The Dynamics of Modernization*, 7.
10. See Samuel P. Huntington, *Political Order in Changing Societies* (New Haven, Conn.: Yale University Press, 1968), 17; see also G. Almond and S. Verba, *The Civic Culture*.
11. David Landes, "The Creation of Knowledge and Technique," in *Comparative Politics: Notes and Readings*, 8th ed., ed. Bernard E. Brown and Ray C. Macridis (New York: Harcourt Brace, 1996), 361.
12. Theories of development generally relate to the experience of advanced nations. Thus traditional perspectives of development in less-developed nations usually assume the possibility of development everywhere; capital and technology might "trickle down" from the advanced nations to the less-developed nations. It was believed that diffusion of capital would resolve the problems of hunger, poverty, health, education, and the like. By the 1960s it was apparent that this was not the case. This approach was not solving the problems of the less-developed countries. The intellectual reaction to this failure is embodied in the work of Andre Gunder Frank in *Capitalism and Underdevelopment in Latin America: Historical Studies of Chile and Brazil* (New York: Monthly Review Press, 1967). For a critique emanating from the Raul Prebisch/Economic Commission in Latin America (ECLA) school of dependent development, see Celso Furtado, *Development and Underdevelopment*, translated by Ricardo W. de Aguilar and Eric Charles Drysdale (Berkeley and Los Angeles: University of California Press, 1964).
13. Ronald Inglehart, *Modernization*, 8–9.
14. Ibid. It is interesting to note that Lenin rather ingeniously co-opted an element of Weber's conceptualization of modernization by incorporating and emphasizing the impact of culture, not as Inglehart asserts as an epiphenomenon of the economic system, but as a causal agent.
15. D. Landes, "The Creation of Knowledge," 361.
16. Ibid.
17. Huntington, *Political Order in Changing Societies*, 264
18. Ibid., 5–6.
19. Ibid.
20. Ibid., 265.
21. Ibid., 304.
22. In Cuba in the 1950s American investment totaled just under a billion dollars. Americans owned 90 percent of the telephone and electric power systems, 50 percent of the railways, and 40 percent of the raw sugar production, and U.S. banks held 25 percent of Cuban deposits. On a per capita basis, American investments in Cuba were three times as large as they were in the rest of Latin America. More than 70 percent of Cuban exports went to the United States, and more than 75 percent of imports came from the United States. Ironically, at the closing of the cold war Cuba was in a similarly overdependent and difficult situation. In the late 1980s at least 80 percent of Cuba's import and export trade was with the Comecon states of the Eastern Bloc.
23. Huntington, *Political Order in Changing Societies*, 309–10; see also Juan Del Aguila for a description of this phenomenon in Cuba after the 1959 revolution, *Cuba: Dilemmas of a Revolution* (1994), Chapter 8: "The Politics of Stable Rule: Government, Institutions, and Crisis," 151–84.

24. Ibid., 310–12.
25. A recent paper by Andreas Pickel points to many of these conditions in post–cold war Cuba. Giving the example of the Eastern European experience, he argues specifically against the application of shock therapy and the adoption of liberal democratic practices to Cuba. The developing gradualist approach to reform in the post–cold war period, he claims, is responsible for the survival of the Castro regime. See Andreas Pickel, "Is Cuba Different? Regime Stability, Social Change and the Problems of Reform Strategy," unpublished manuscript, Trent University, Apr. 1997).
26. The seminal work in this area of modernization literature is David Apter's *The Politics of Modernization* (Chicago: University of Chicago Press, 1965). Apter emphasizes two models of modernization—the Western democratic and the sacred collectivity models. He also examines characteristics of modernization and tradition within a structural-functional framework. See also Apter, *Rethinking Development* (1987).
27. Kautsky, *Political Consequences*, 17.
28. Ibid. One could add that this strikes at the core of many of our debates over the expansion of the liberal democratic notion to all states in the international system. Criticism is often leveled at Western scholars and policymakers for their insistence that democracy is both a process and a functional orientation to governance. This insistence eschews any substantive identification with democracy that might manifest itself in another part of the world and, as such, is labeled as something other than "democratic."
29. Ibid., 45.
30. Ibid., 48.
31. Ibid., 160.
32. Kautsky adds that one must keep in mind that the process of industrialization itself changes over time. Thus a society like Cuba, incapable of industrialization with the technology available or chosen today, may be able in the future to industrialize when that process involves new techniques and advances within its grasp. Ibid., 168.
33. Inglehart, *Modernization*, 10.
34. Inglehart elaborates: "A standard criticism of modernization theories is that they are either ethnocentric, teleological or both. Some early modernization theory did simplistically equate modernization with becoming (1) morally superior, and (2) like the West. The flaws in this perspective are pretty obvious. Few people would attribute moral superiority to Western society today, and it is evident that East Asia (until very recently) was the cutting edge of modernization in many respects." Ibid., 17.
35. Ibid., 10–11. See also Barrington Moore, *The Social Origins of Dictatorship and Democracy* (Boston: Beacon Press, 1966).
36. Some of the more impressive critiques of the failures and shortcomings of modernization theory include Douglas A. Chalmers, "The Demystification of Development," in *Changing Latin America: New Interpretations of Its Politics and Society*, ed. Douglas A. Chalmers (New York: Columbia University, 1972), 109–22; Phillipe A. Schmitter, "Paths to Political Development in Latin America," ibid.; Dean C. Tipps, "Modernization Theory and the Comparative Study of Societies: A Critical Perspective," *Comparative Studies in Society and History* 15 (Mar. 1973): 199–226; Ignacy Sachs, "The Logic of Development," *International Social Science Journal* 24, no. 1 (1972): 37–43; and Phillip Coulter, "Political Development and Political Theory: Methodological and Technological Problems in the Comparative Study of Political Development," *Polity* 5 (winter 1972): 233–42.
37. See Immanuel Wallerstein, *The Modern World System, Vol. 1* (New York: Academic

Press, 1974); and Fernanado Henrique Cardoso and Enzo Falletto, *Dependency and Development* (Berkeley and Los Angeles: University of California Press, 1979) for the prime examples of these fields of inquiry.

38. For significant treatments of this phenomenon, see Douglas A. Chalmers, Carlos M. Vilas, Katherine Hite, Scott B. Martin, Kerianne Piester, and Monique Segarra, *The New Politics of Inequality in Latin America: Rethinking Participation and Representation* (Oxford, England: Oxford University Press, 1997); and Dietrich Rueschemeyer, Marilyn Rueschemeyer, and Bjorn Wittrock, eds., *Participation and Democracy East and West: Comparisons and Interpretations* (New York: M. E. Sharpe, 1998).
39. See P. Smith, "Changing Agenda," 9–10.
40. Potter, *Nuclear Power and Nonproliferation*, 9–10.
41. Examples of this type of analysis are found in The Commission of the European Communities, Directorate-General for Energy and Development, *Energy and Development, What Challenges? Which Methods?: Synthesis and Conclusions* (Paris: Lavoisier Publishing, 1984); United Nations, Division of Natural Resources and Energy, Technical Co-operation for Development, *Energy Planning in Developing Countries* (Oxford, England: Oxford University Press, 1984); and Jose Goldemberg, Thomas B. Johansson, Amulya K. N. Reddy, and Robert H. Williams, *Energy for Development* (Washington, D.C.: World Resources Institute, 1987).
42. Ian Smart, "The Consideration of Nuclear Power," in *Nuclear Power in Developing Countries*, James Everett Karz and Onkar S. Marwah, eds., 20.
43. Smart asserts that no general discussion of costs and benefits can pretend to be universally applicable. They can only point to broad categories of factors (which are numerous) that should be considered in every instance, but that should also be assessed individually by the government of each country as to their relative importance (p. 21).
44. Ibid. For a fuller discussion of the dynamics of the process of technological advancement and economic development, see Edward J. Malecki, *Technology and Economic Development: The Dynamics of Local, Regional, and National Change* (New York: Longman Scientific and Technical, 1991); see also the Organisation for Economic Co-operation and Development (OECD), *Impacts of National Technology Programmes* (Paris: OECD, 1995); Gerald Silverberg and Luc Soete, eds., *The Economics of Growth and Technical Change* (Brookfield, Vt.: Edward Elgar Publishing, 1994); and Pradip K. Ghosh, ed., *Energy Policy and Third World Development* (Westport, Conn.: Greenwood Press, 1984).
45. Jose Goldemberg, "Communication: A Note on the Energy Intensity of Developing Countries," *Energy Policy* 24, no. 8 (1996): 759–61.
46. For example, in the OECD countries, GDP has grown 3.7 percent per annum (pa) in the period of 1981–1991, and energy consumption grew on 1.4 percent pa since the energy intensity has been decreasing 2.3 percent pa. In contrast Latin America has grown only 1.8 percent pa but energy growth was 2.9 percent pa because the energy intensity increased 1.1 percent pa. See Goldemberg, "Communication," 759. See also L. Nielsson, "Energy Intensity in 31 Industrial and Developing Countries, 1950–1988," *Energy* 18, no. 4 (1993) 309–22.
47. Smart, "The Consideration of Nuclear Power," 22.
48. See Jorge Sabato and Natalio Botana, "La ciencia y la technologia en desarrollo futuro de America Latina," *Arbor: ciencia, pensamiento y cultura* 146, no. 575 (Nov. 1993): 21–43; Jorge Sabato, *Ciencia, desarrollo y dependencia* (San Miguel de Tucuman, Argentina: Imprenta de la Universidad de Tucuman, 1971); and Fidel Castro Diaz-Balart, *Energia Nuclear y Desarrollo: Realidades y Desafios en los Umbrales del Siglo XXI* (Havana: Editorial de Ciencias Sociales, 1990).
49. I. Smart, "The Consideration of Nuclear Power," 22.

50. Ibid., 23
51. Ibid.
52. This specifically requires that national planners have constructed a picture of expected geographical and sectoral incidence of demand. The next step must be to examine how energy demand can be satisfied most economically in terms of distribution as well as generation capacity. Answers to questions of how much, where, and when will depend not only on the plotted incidence of demand but also on the relative costs of generation and distribution. Some preliminary chart of size, location, and timing of desirable additions to the electric supply system is nevertheless an essential part of the preamble. See Smart, "The Consideration of Nuclear Power," 25. See also Mudassar Imran and Philip Barnes, *Energy Demand in Developing Countries: Prospects for the Future, A World Bank Staff Commodity Working Paper, No. 23* (Washington, D.C.: World Bank, 1990); International Energy Agency (IEA), *Energy in Developing Countries: A Sectoral Analysis* (Paris: OECD, IEA, 1994).
53. See Maarten Wolsink, "Dutch Wind Power Policy: Stagnating Implementation of Renewables," *Energy Policy* 24, no. 12 (Dec. 1996):1079–88; Penny Street and Ian Miles, "Transition to Alternative Energy Supply Technologies: The Case of Wind Power," *Energy Policy* 24, no. 5 (May 1996): 413–26; Thomas Drennen, Jon D. Erickson, and Duane Chapman, "Solar Power and Climate Change Policy in Developing Countries," *Energy Policy* 24, 1 (Jan. 1996): 9–16.
54. See *Energy Efficiency and Conservation in the Developing World: The World Bank's Role—A World Bank Policy Paper* (Washington, D.C.: World Bank, 1993).
55. For a discussion of the social implications of energy development in developing countries, see Goldemberg et al., *Energy*, 9–57.
56. Thomas, in Thomas and Ramberg, *Energy and Security*, 2–3. Much of the evidence in support of Thomas's analysis is now dated, and many of the factors that informed his conclusions have changed dramatically in the post–cold war period. What remains significant about his analysis is that the notion of nuclear ambition in developing states remains a fluid concept. Since his book was published in 1990, South Africa, Argentina, and Brazil have renounced their nuclear weapons programs. But in that same period of time, the proliferation concerns in the Persian Gulf region have been magnified, South Asia remains a region of significant proliferation concern, and the security of the vast nuclear stockpiles of the former Soviet republics is questionable and subject to diversion, smuggling, and theft. For an analysis of the proliferation issue in the late 1990s, see Graham T. Allison, Steven E. Miller, Richard A. Falkenrath, and Owen R. Cote, *Avoiding Nuclear Anarchy: Containing the Threat of Loose Russian Nuclear Weapons and Fissile Material* (Cambridge, Mass.: MIT Press, 1996).
57. R. Thomas, in Thomas and Ramberg, *Energy and Security*, 2–3.
58. Ibid., 9. Thomas looks at eight such states: South Korea, Taiwan, India, Pakistan, South Africa, Cuba, Brazil, and Argentina. They represent varying levels of economic development but are typified as middle- or low-income countries. All were severely dependent on external sources of oil during the oil crises of the 1970s and have nuclear energy development programs at home.
59. "The significant question is what defense or deterrent purpose a South African nuclear weapons program would serve even if the country were to divert its nuclear energy program in that direction. Unlike, Pakistan, which faces the potential of a nuclear India . . . the regime of South Africa need fear no such threat." Ibid., 10. For an excellent analysis of recent nuclear developments in South Asia, see Stephen P. Cohen, ed., *Nuclear Proliferation in South Asia: The Prospects for Arms Control* (Boulder: Westview Press, 1991).
60. Ibid., 11. For an analysis of the Argentina-Brazil case, see John R. Redick, "Latin-

America's Emerging Non-Proliferation Consensus," *Arms Control Today* 24, 1 (Mar. 1994): 3.

61. See Jonathan Benjamin-Alvarado, "The Quest for Power: A Cost-Benefit Analysis of Cuba's Nuclear Energy Policy," in *Cuba in Transition*, vol. 6, 417–29 (Miami: ASCE, 1997).
62. Etel Solingen argues that in the case of designing civilian nuclear industries in Argentina and Brazil, focus should be concentrated on domestic political structures and institutions, rather than on market structures, international regimes, and the political power of private enterprises or ideology. Whereas most analyses in this area have been geostrategically focused, Solingen investigates nuclear programs in the context of industrial policy. The development of an industrial capacity in designing a nuclear power reactor and its components does not invariably signal nefarious military objectives, although embracing such capability lowers technical barriers. A comprehensive nuclear energy program is not necessary if military applications are the leading objective because nuclear weapons can be obtained from a smaller dedicated program. Neither is the existence of a large-scale industrial program sufficient to impute strategic intentions to the state that develops it. See Solingen, *Industrial Policy, Technology, and International Bargaining: Designing Nuclear Industries in Argentina and Brazil* (Stanford, Calif.: Stanford University Press, 1996).
63. Potter, *Nuclear Power and Nonproliferation*, 7.
64. Ibid., 8. Potter adds, "It is appropriate here simply to note that psychological factors can override strict economic analyses of the costs and benefits of nuclear power. Such factors are, for example, 'the need' to share advanced nuclear technology, the fear of missing the nuclear revolution, an unwillingness to accept a 'have not' status in an openly discriminatory nuclear world order, and in the case of the more economically advanced states, the desire to be a leader in the development of a new technology."
65. See, for example, Francisco Lopez Segrera, *Cuba: capitalismo, dependiente y subdesarrollo (1510–1959)* (Havana: Casa de las Americas, 1972); Julia Feinsilver, *Healing the Masses: Cuban Health Politics at Home and Abroad* (Berkeley and Los Angeles: University of California Press, 1993); Susan Eva Eckstein, *Back to the Future: Cuba under Castro* (Princeton, N.J.: Princeton University Press, 1994); Juan M. Del Aguila, *Cuba, Dilemmas of a Revolution* (Boulder, Colo.: Westview Press, 1994); and Jorge I. Dominguez, *To Make the World Safe for Revolution: Cuba's Foreign Policy* (Cambridge: Harvard University Press, 1989).
66. See Konstantin Zhukovsky, "Cuban Foreign Trade Minister to Discuss Cooperation Matters," *ITAR-TASS* (Jun. 2, 1997); and Veronika Romanenkova, "Russia May Construct Nuke Plant in Cuba in 1998," *ITAR-TASS* (Jun. 5, 1997).
67. See GAO reports, Nuclear Safety: International Atomic Energy Agency's Nuclear Technical Assistancefor Cuba GAO/RCED–97-72 (Mar. 1997); Nuclear Safety: Concerns with the Nuclear Power Reactors in Cuba GAO/RCED-95-236 (Aug. 1, 1995); and GAO/RCED-92-262). See also Jerome L. Heffter and Barbara J. B. Stunder, "Transport and Dispersion for the Potential Accidental Release of Radioactive Pollutants from the Nuclear Reactor at Cienfuegos, Cuba. NOAA, Air Resources Laboratory (Aug. 1992). For examples of similar reports from the Cuban government, see Dario Gandarias Cruz and Daniel Codorniu, El Programa Nuclear Cubano Y Su Infraestructura Cientifico-Tecnico (1995), Agencia de Energia Nuclear, La Habana; and Miguel Serradet Acosta, Programa Nucleoenergetico Cubano (a paper presented at the Regional Seminar of Public Information, hosted by the Agencía de Energia Nuclear, La Habana), May 19, 1995. For an academic treatment of the possible environmental problems in Cuba, see Barbaro Quintero-Leyva, A Preliminary Assessment of Nuclear Radiation Dose in the Case of a Hypothetical-Severe Accident Scenario Involving Breach of Containment at

the Cuban VVER-440 (v213) Type Nuclear Reactor, master's thesis, Department of Nuclear Engineering, University of Florida, 1996.

68. For a recent example, see Frank J. Gaffney and Roger W. Robinson Jr., "Stop the 'Cuban Chernobyl,'" *Wall Street Journal* (Jan. 21, 1997), A1–9; Frank Gaffney, "'Useful Idiots': Why Would Any American Help Fidel Castro Bring His Cuban Chernobyl On-Line?" Center for Security Policy, Decision Brief No. 96-D 1 3 (Feb. 10, 1996). See also Juan O. Tamayo, "Cuba Exagera Inversíon Extranjera, Segun Perito (Cuba Exaggerates Foreign Investment According to Expert)," *El Nuevo Herald-Miami* (Aug. 11, 1996), 1 A, 1 4A. The dissident press in Cuba has also contributed in bringing attention of the environmental ramifications of nuclear energy development on the island. For example, see Olance Nogueras Rofes, "Llevan Autoridades a Leonel Morejon Almagro Visitar Juragua," Buro de la Prensa Independente Cubano (BPIC) distributed on the Internet via cubanet.org (Mar. 26, 1997).
69. Jorge Perez-López, "Nuclear Power in Cuba After Chernobyl," *Journal of Inter-american Studies and World Affairs* (summer 1987): 79–117. See also Jorge Perez-Lopez, "Nuclear Power in Cuba: Opportunities and Challenges," *Orbis* 26, no. 2 (summer 1982).
70. Ibid., 79.
71. Jorge Perez-Lopez, "Cuba," in *Energy & Security in the Industrializing World,* Raju G. C. Thomas and Bennett Ramberg, eds. (Lexington: University of Kentucky Press, 1990), 153–81.
72. Fidel Castro Díaz-Balart, *La Energia Nuclear en La Economia Nacional de La Republica de Cuba* (Moscow: COMECON, 1986).
73. See Foreign Policy Association, Commission on Cuban Affairs, "Chapter XVII: Public Utilities," in *Problems of a New Cuba* (New York: Foreign Policy Association, 1935), 397–442.
74. Fidel Castro Diaz-Balart, *Energia Nuclear y Desarrollo: Realidades y Desafios en los Umbrales del Siglo XXI* (La Habana: Editorial de Ciencias Sociales, 1990). Castro Díaz-Balart subsequently published *Energia Nuclear: Peligro Ambiental o Solución para el Siglo XXI?* (Torino, Italy: Ediciones Mec Grafic S.A., 1997) The central thesis of this book is that nuclear energy development is not only an indispensable requirement for Cuba's future but also that it is a right to which it is entitled. Cuba will ultimately seek to peacefully and safely exploit this alternative source with the idea that it will become a "conventional" form of energy generation.
75. See José R. Oro, "Part Two: The Cuban Nuclear Program and Its Ecological Impact," in *The Poisoning of Paradise: Environmental Pollution in the Republic of Cuba* (Miami: The Endowment for Cuban American Studies, 1992), 15–39.
76. In separate instances congressional hearings have been convened to provide information on the safety of the nuclear reactors under construction at Cienfuegos. See the proceedings of the 1991 hearing, "International Commercial Reactor Safety," by the Subcommittee on Nuclear Regulation of the House Committee on the Environment and Public Works, July 25, 1991; and the proceedings from the 1995 hearings, "Nuclear Safety: Concerns with the Nuclear Power Reactors in Cuba," by the Subcommittee on the Western Hemisphere, House Committee on International Relations, August 1, 1995.
77. See Jonathan Benjamin-Alvarado and Alexander Belkin, "The Cuban Nuclear Program and Post–Cold War Pressures," *The Nonproliferation Review* 1, no. 2 (winter 1994): 18–26; Jonathan Benjamin-Alvarado, "Proliferation Risks and Nonproliferation Opportunities in Cuba: An Assessment of Nuclear, Biological and Chemical Weapons Capabilities," *The Military and Transition in Cuba: A Reference Guide for Policy and Crisis Management* (Washington, D.C.: International Research 2000, 1995), Sec. 111.2, 1–8; "The Quest for Power: A Cost-Benefit

Analysis of Cuba's Nuclear Energy Policy," *Cuba in Transition,* vol. 6 (Miami: ASCE, 1997), 417–29; and *Non-Issue: Cuba's Mothballed Nuclear Power Plant,* An International Policy Report (Washington, D.C.: Center for International Policy, July 1998).

78. María Dolores Espino clearly elucidates the reasons for concern over environmental deterioration in Cuba. Among the reasons listed are: production maximization without consideration of costs, an inadequate regulatory environment, and the absence of pressure groups. Additionally, Cuba suffers from many of the same factors that also affect "developing" countries, such as: chronic external trade imbalances and debt burdens; the use of inefficient, inappropriate, and obsolete technologies; and a lack of adequate financing for infrastructure. See Espino, "Environmental Deterioration and Protection in Socialist Cuba," in *Cuba in Transition, vol. 2* (Washington, D.C.: ASCE, 1992); see also Sergio Diaz-Briquets and Jorge Perez-Lopez, "Water, Development, and Environment in Cuba: A First Look," in *Cuba in Transition,* vol. 5 (Washington, D.C.: Association for the Study of the Cuban Economy, 1995).

Chapter 3: The Quest for Power

1. Díaz subsequently became a Commissioner with the United States Nuclear Regulatory Commission in Washington, D.C.
2. As previously mentioned, Cuba has long been attempting to alleviate its dependence on external sources of fossil fuels to supply its domestic industrial and developmental demands for energy.
3. For an example, see Sergio Díaz-Briquets and Jorge F. Perez-López, "Water, Development, and Environment in Cuba: A First Look," in *Cuba in Transition* Vol. V (Washington, D.C.: Association for the Study of the Cuban Economy, 1995).
4. Gene Bardach, *Analysis: A Handbook for Practice* (Part 1), (Seattle: University of Washington Institute for Public Policy and Management, Public Service Curriculum Exchange, 1995).
5. Fidel Castro Díaz-Balart, *Energía Nuclear y Desarrollo: Realidades y Desafíos en los Umbrales del Siglo XXI* (Havana: Editorial de Ciencias Sociales, 1990), 352–53.
6. Ibid., 334.
7. From 1956 to 1959, the United States concluded such agreements with some forty "friendly states." See Bertram Goldschmidt, *The Atomic Complex: A Worldwide Political History of Nuclear Energy* (Le Grange Park, Ill.: American Nuclear Society, 1982), 303–306.
8. This can be translated as follows: "Even though it was evident that under those similar circumstances it could only be considered under a metaphysical hallucination or a mid-summers night dream." Castro Díaz-Balart, *Energía,* 335 (author's translation).
9. See Benjamin-Alvarado and Belkin, "Cuba's Nucelar Power Program," 20.
10. Castro Díaz-Balart argues that the Cuban government was neither interested in nuclear development nor could it conceive of the conditions to make it possible. His view is, in part, postrevolutionary revisionism that seeks to diminish all accomplishments on the part of Cuba's ruling regime prior to 1959. It is best reflected in the in the statement, "All efforts before that date were nothing more than nuclear fiction." Castro Díaz-Balart, *Energía,* 336.
11. Ibid., 354.
12. Alexander Belkin, "Cuba's Nuclear Program" (unpublished paper, April 1992), 12.
13. "Agreement between the USSR and the Republic of Cuba in the Use of Atomic Energy for Peaceful Uses of September 15, 1967," in *The Compilation of Active*

Treaties, Agreements and Conventions signed by the USSR with Foreign States vol. 25. (Moscow: IMO, 1972), 225.

14. Castro Díaz-Balart comments, "Without a doubt, this was the stage where distinct limitations ruled, and the absence of a clear perspective of the objectives and priorities for development, and the scattering of human resources and materials, did not permit the integration of a national nuclear program," 353.
15. Castro Díaz-Balart, *Energía*, 353.
16. Pedro Abigantus Leon, Sub-Director for Development, CEN Juragua, Cuba. "Panoramic (*sic*) of Juragua Nucleo-electric Programme" (a paper presented at the 1995 American Nuclear Society Winter Meeting, October 1995, T26/A19).
17. In 1980, the total amount of economic assistance to Cuba from the Soviet Union was $3.2 billion. Most of this assistance (72 percent) consisted of trade subsidies for sugar and petroleum. In 1983, the total amount of Soviet economic assistance had increased by 65 percent to $4.9 billion. In 1983, 70 percent of all Soviet economic aid extended to communist countries was going to Cuba. For more detailed information, see Central Intelligence Agency, Directorate of Intelligence, *Handbook of Economic Statistics 1990,* CPAS 90–10001 (Washington, D.C.: GPO, 1990), 178–79.
18. From 1977 to 1980, all nuclear activities were placed under the auspices of the Comisíon Nacional de los Usos Pacificos de Energía Atomica (CNUPEA).
19. Castro Díaz-Balart, *Energia*, 354.
20. Ibid.
21. Ivan M. Schulman, "Void and Renewal: Modernity," in *José Martí: Revolutionary Democrat*, ed. Christopher Abel and Nissa Torrents (Durham, N.C.: Duke University Press, 1986), 154.
22. John M. Kirk, "The 'Intelectual comprometido,'" in Abel and Torrents, *José Martí*, 119. Original source: Jose Martí, *Obras Completas*, Vol. VII, 425.
23. Alan Dye, *Cuban Sugar in the Age of Mass Production: Technology and Economics of the Sugar 'Central,' 1899–1929* (Stanford, Calif.: Stanford University Press, 1998), 73.
24. Louis A. Perez Jr., *On Becoming Cuban: Identity, Nationality and Culture* (Chapel Hill: University of North Carolina Press, 1999), 61.
25. Ibid.
26. Tirso Saenz and Emilio G. Capote, *Ciencia y Tecnologia en Cuba: Antecendentes y Desarrollo* (Havana: Editorial de Ciencias Sociales, 1989), 8.
27. Perez, *On Becoming Cuban*, 329.
28. Ibid. Over time this inherent connection became more pronounced as those commercial firms began to view Cuba in a familiar albeit different role. Perez states, "No less important, Cuba's primary industry—sugar production—was seasonal and could not generate adequate profits for electric companies. The success of electricity as a commercial venture was thus conceived from the outset as dependent primarily on the creation of a market for electrical appliances."
29. Fidel Castro Díaz-Balart, *La Energia Nuclear en la Economia Nacional de la Republica de Cuba* (Moscow: COMECON, 1986), 9. Castro Díaz-Balart adds ambiguously, "If all four units were operating the savings would be 2.4 annually." He may have been referring to two more units in addition to the Units 1 and 2 at Juragua, but his reference is unclear.
30. Interview by author with Arnaldo Coro Antich, Chief Science and Technology correspondent, Radio Habana, Havana, Cuba, June 6, 1993.
31. During the 1980s, Cuba consumed on average 10.83 million tons of oil. For the 1990s the figure dropped 8.7 percent to 9.88 million tons annually. See *Energy Statistics and Balances of Non-OECD Countries, 1994–1995,* 142–43.

32. Ibid. In 1993, Cuba was only able to generate approximately 11,000 gwh (a loss of 27 percent from 1990); by 1997 Cuba had rebounded and was able to consistently produce 14,000 gwh (90 percent of the 1990 production figures). See EIU Country Report, 2nd Quarter—Cuba. Economist Intelligence Unit, 1999, 18.
33. Castro Díaz-Balart, *La Energia Nuclear,* 346.
34. Jose Goldemberg, "Communication: A Note on the Energy Intensity of Developing Countries," *Energy Policy* 24, no. 8 (1996): 759–61.
35. For example, in the OECD countries, GDP has grown 3.7 percent per annum (pa) in the period of 1981–1991, and energy consumption has grown 1.4 percent pa, since the energy intensity has been decreasing 2.3 percent pa. In contrast in Latin America has grown only 1.8 percent pa but energy growth was 2.9 percent pa since the energy intensity increased 1.1 percent pa. See Goldemberg, "Communication," 759. See also L. Nielsson, "Energy Intensity in 31 Industrial and Developing Countries, 1950–1988," *Energy* 18, no. 4 (1993): 309–22.
36. Ibid.
37. Jose Goldemberg, Thomas B. Johansson, Amulya K. N. Reddy, and Robert H. Williams, *Energy for Development* (Washington: World Policy Institute, 1987), 1.
38. This will be discussed in the cost-benefit section of this chapter.
39. *Statistical Abstract of Latin America* (Los Angeles: UCLA Latin American Center Publications, 1996), Table 3407—Cuba Comparative PC of Real Product (1947-89); OECD, *Energy Statistics and Balances of Non-OECD Countries,* 1994–1995 (Paris: OECD, IEA, 1997), 116–17.
40. *Cuba, EIU Country Report, 4th Quarter 1997,* The Economist Intelligence Unit Ltd. (1997), 6; and *Energy Statistics and Balances of Non-OECD Countries 1994–1995* (Paris: OECD/IEA, 1997), 116–17.
41. "Foreign Capital to Fund Expansion of Cuban Capacity," *Latin American Power Watch* via Lexis-Nexis (Feb. 1, 1998).
42. "Energy Conservation Programme Extended Nationwide," Radio Rebelde, Havana, Cuba (Feb. 5, 1998), transcript via BBC Summary of World Broadcasts, Feb. 17, 1998.
43. "Need for Energy Savings Stressed at Basic Industry Meeting," Cuba Vision, Havana, Cuba (February 9, 1998) transcript via BBC Summary of World Broadcasts, February 24, 1998.
44. *Energy Statistics and Balances of Non-OECD Countries 1994–1996* (Paris: OECD, 1997), 296–97.
45. An excellent source on the Cuban nuclear infrastructure can be found in Dario Gandarias Cruz and Daniel Codorniu Pujals, "El Programa Nuclear y Su Infraestructura Cientifico-Tecnico (paper presented at Regional Seminar on Public Information, Havana, Cuba, May 19, 1995).
46. A visit to the ISCTN by the author in January 1996 revealed a vibrant educational institution with an outstanding curriculum including advanced engineering and physics courses being taught in English. The laboratories were indeed fully stocked with electronic measuring instrumentation and a research reactor. But much of the facility was in need of maintenance, and some equipment was not operable because of a lack of replacement parts.
47. In 1996, an estimated 1,500 Cubans had passed through these programs and were deployed throughout the island in different sectors of the economy. Interview by author with Antonio Bolufe Gutierrez, Director, Consultoria Delfos, Havana, Cuba, Jan. 9, 1996.
48. Ibid.
49. Ibid., 361.
50. Interview by author with Dr. Luis Desdin Garcia, Director of CEADEN, Havana, Cuba, October 27, 1997.

51. In 1997 the agency changed its name to the Centro de Informacion de la Energia. The change reflected the new direction in the priorities of Cuba's energy development policy. In January 1997, Fidel Castro announced that while Cuba was still interested in developing a nuclear energy capability, it would now explore other alternatives in energy development. See, "Castro Freezes Plans for Russian-Tech Nuke Plant U.S. Sought to Stop," Agence France Presse, Jan. 17, 1997, via Lexis-Nexis.
52. See Jorge Petinaud Martinez, "El Centro de Informacion de la Energia Nuclear y la Informacion Publica en Cuba" (paper presented at the Regional Seminar, May 1995).
53. Interview by author with Jorge Petinaud Martinez, Chief of Public Relations, Centro de Informacion de la Energia, Havana, Cuba, Jan. 11, 1996.
54. Castro Díaz-Balart, *La Energia Nuclear*, 366.
55. For an analysis of this new decree, see Jonathan Benjamin-Alvarado, "The Cuban New Nuclear Law Project: Commentary on Cuba's Decreto #208," *The Monitor: Nonproliferation, Demilitarization and Arm Control* 3, no. 3 (summer 1997): 40–45.
56. Interviews by author with Fidel Illizástigui Pérez, Nuclear Safety and Export Control Specialist, CNSN, Havana, Cuba, Jan. 9, 1996, and May 27, 1997; and Jorge Paredes Gilismán, Safeguards Specialist, CNSN, Havana, Cuba, May 27, 1997.
57. Economist Intelligence Unit, *Cuba, EIU Country Report, 2th Quarter 1999*, 5.
58. Interview by author with Antonio Bolufe Gutierrez, Director, Consultoría Delfos, Havana, Cuba, Jan. 9, 1996.
59. See *1997 UNESCO Statistical Yearbook* (Lanham, Md.: UNESCO and Bernan Press, 1997), 5.2–5.8.
60. Castro Díaz-Balart, *La Energia Nuclear*, 353–54.
61. Boris N. Semevski, *Economicheskaya geographiya Kuby*, trans. Alexander Belkin (Leningrad: Nauka, 1970), 67.
62. Robert Collier, "Cuba Turns to Mother Earth: With Fertilizers and Fuel Scarce, Organic Farming Is In," *San Francisco Chronicle*, Feb. 21, 1998, A1, A23.
63. Interview by author with Osvaldo Juvier, Vice President, Operations, Duke Energy Corporation, Charlotte, North Carolina, Nov. 15, 1996.
64. Interview by author with Miguel Serradet Acosta, Director, Nuclear Energy Facilities, Ministerio de Industria Basica, Havana, Cuba, Jan. 15, 1996.
65. Interview with Russian Ministry of Atomic Energy official, Athens, Georgia, Nov. 15, 1997. This official intimated that the only barrier to the Russian Federation's participation in the Juragua project is economic viability. Russia still maintains an interest in completing the Juragua project with the Cubans, but its own economic considerations and requirements make any additional commitments to the project unlikely for the time being.
66. In late 1997, Cuba and Russia concluded a trade protocol in which Moscow agreed to extend Havana a credit of $350 million. Currently the two countries exchange 3 tons of Russian oil for 1 ton of Cuban sugar. See "Cuba, Russia promise to reach deal soon on US-feared nuclear plant," Agence France Press (via ClariNet), Feb. 21, 1998.
67. Thomas Cochran, "A Chernobyl in Cuba," *America's Defense Monitor*, television program transcript (Feb. 15, 1998), 8.
68. The technology in this area has advanced sufficiently in the past few years so that biomass-burning electrical generators can be shifted to coal-burning during the nonharvest months.
69. Interview by author with Osvaldo Juvier (Nov. 15, 1996).
70. Benjamin-Alvarado and Belkin, "The Cuban Nuclear Program," 22.

71. "Industrial Analysis—Oceanography: Critical to Economic Development," *CUBANEWS* 2, no. 8 (Aug. 1995): 9.
72. John Shanahan, "Cuba's Potential Chernobyl," *Wall Street Journal*, Aug. 5, 1992, A14.
73. Ibid.
74. "Cuban warns of risky reactors," Editorial, *The Washington Times*, May 6, 1992, A1. See also José R. Oro, "Some Aspects About Environmental Pollution and Protection of Ecological Systems in Cuba and Its Surroundings," unpublished manuscript, Nov. 1991, 21.
75. Press Conference Transcript, NBC Nightly News, July 5, 1991.
76. A comprehensive exposition of the technical attributes of the CEN Juragua are contained in Miguel Serradet Acosta, "Programa Nucleoenergetico Cubano" (paper presented at the Regional Seminar on Public Information, in Havana, Cuba, May 19, 1995). For details see also proceedings of the congressional hearing "International Commercial Reactor Safety," July 25, 1991, before the Subcommittee on Nuclear Regulation of the Committee on the Environment and Public Works, U.S. Senate, 102d Congress (Washington, D.C.: GPO, 1991); and "Nuclear Safety: Concerns with the Nuclear Power Reactors in Cuba," testimony before the House Subcommittee on the Western Hemisphere, Committee on International Relations (GAO/RCED-92-262, Sept. 24, 1992, and GAO/T-RCED-95-236, Aug. 1, 1995).
77. Berta García, Tamara Acosta, Elizabeth Caraballo, and Julio Enrique Milían, "Correspondencia Con los Lectores: Preguntas y Inquietudes Acerca de la Central Nuclear en Juragua," *Nucleus*, no. 19 (1995): 55–56.
78. Interview by author with Miguel Serradet Acosta, Director, Centrales Electronucleares, MINBAS, Havana, Jan. 15, 1996.
79. Interview by author in Havana, Cuba, Jan. 18, 1996.
80. Kenneth O. Fultz, "Nuclear Safety: Concerns with the Nuclear Power Reactors in Cuba," testimony before the Subcommittee on the Western Hemisphere, Committee on International Relations (GAO/T-RCEED-95-236), Aug. 1, 1995, 1,8.
81. Ibid., 7; see also Jerome L. Heffter and Barbara J. B. Stunder, *Transport and Dispersion for a Potential Accidental Release of Radioactive Pollutants from the Nuclear Reactor at Cienfuegos, Cuba,* NOAA, Air Resources Laboratory, Aug. 1992.
82. For a summary of Cuba's nuclear bureaucracies, see Darío Gandarias Cruz and Daniel Codorniú, *El Programa Nuclear Cubano y Su Infraestructura Cientifico-Tecnico* (Havana: Agencia de Energía Nuclear de Cuba, 1995).
83. Comments taken from a presentation at the Washington seminar on Juragua, May 9, 1996; see also Jonathan Benjamin-Alvarado, "The Washington Seminar on the Juragua Power Plant: Threat to U.S. Security?" *The Monitor: Nonproliferation, Demilitarization, and Arms Control* 2, no. 3 (summer 1996): 31.
84. The total investment for the third partner is estimated at $500 million over a three-year period; the Russian investment would total about $300 million. The Cuban contribution to the joint venture would be in the form of labor provided in bulk construction. See author's interview with Serradet Acosta; and Serradet Acosta, *Program Nucleoenergetico Cubano*, 12–13.
85. Igor Ivanov, "The Atlantis of the Castro Brothers: Will Fidel's Bulb Light Up Cuba?" *Literaturnaya Gazeta* in *JPRS Proliferation Issues,* June 25, 1992, 20.
86. There remains some confusion as to whether the name change was permanent as the acronym CIEN is still being used, and recent literature still refers to the Centro de Informacion de la Energia Nuclear.
87. Interview by author with a senior Cuban nuclear official, Havana, Cuba, May 25, 1997.
88. The choice is based on the assumption that a "turnkey" project would take less

time to complete and that Cuba could enjoy the benefits of a lessened dependence on fossil fuels.

89. Ivanov, "Atlantis," 20.
90. B. N. Semevski, *Economicheskaya geographiya Kuby (The Economic Geogra, hy of Cuba)* (Leningrad: Nauka, 1970), 67. This monograph is still considered by some to be the most comprehensive study on the Cuban geography.
91. Ivanov, "Atlantis," 20.
92. The phrase refers to the billboard across the street from the U.S. Interests Section in Havana, Cuba, in which a Cuban revolutionary dressed in full combat gear stares across the water to a wart-nosed caricature of Uncle Sam states, "Señores Imperialistas No Tenemos Ningun Miedo de Uds."
93. Much has been made of the vaunted Ansaldo feasibility study. Since its release in 1995, it has served to verify, more than anything else, that much work remains before the the Juragua reactor can be completed. Moreover, the $800 million price tag for completion places it far outside the reach of either Cuba or Russia. Cuba remains a high-risk economic environment for any potential investor, regardless of political persuasion. Until such time as the Cuban economy demonstrates a measure of economic stability and growth, most prudent investors will steer clear from any projects in Cuba that do not possess the potential for a short-term return. Unfortunately for Cuban nuclear aspirations, the Juragua project does not exhibit such a potential at this time.
94. Smart, "The Consideration of Nuclear Power," 22.

Chapter 4: The External Factors of Influence on Cuba's Nuclear Ambitions

1. Among the most audacious of these tomes is Andres Oppenheimer, *Castro's Final Hour: The Secret Story behind the Coming Downfall of Communist Cuba* (New York: Simon and Schuster, 1992).
2. See Andrei V. Kortunov, "The Role of External Factors in the Cuban Transition," in *The Military and Transition in Cuba: A Reference Guide for Policy and Crisis Management*, ed. Nestor Sanchez (Leesburg, Va.: International Research 2000, Mar. 17, 1995), III-13–2.
3. Vladimir A. Borodaev, "Economic and Political Relations: Issues and Trends in the 1990's," in Sanchez, ed. *The Military and Transition in Cuba*, III-10–4.
4. Kortunov, "The Role of External Factors," III-13–2.
5. Ibid.
6. For details of this development, see the section entitled "Assessing the State of Nuclear Energy in Cuba: Structure and Function" in chapter 3.
7. In 1998, this includes nine major agencies under the Agencia de Energia Nuclear (AEN) within the Ministerio de Ciencia, Tecnología y Medioambiente (CITMA). For details of the bureaucratic structure and functions, see Darío Gandarias Cruz and Daniel Codorníu Pujals, "El Programa Nuclear Cubano y Su Infraestructura Cientifico-Tecnica" (paper prepared for the Regional Seminar on Public Information, Havana, Cuba, May 19, 1995).
8. Quoted in José De Cordoba, "Survival Tactics: Its Economy Dying, Cuba Seeks Salvation in Dollars," *Wall Street Journal*, July 19, 1993, A1.
9. Wilson Dizard III, "Christopher Says Moscow to Pay Juragua's $30-million Mothball Tab," *Nucleonics Week*, Sept. 30, 1993, 7.
10. This includes the concluding of these types of agreements in July 1993, October 1995, June 1997, and most recently February 1998. See Sergei Batchikov, "The Cuba That We Are Losing Everyone Else Is Finding: Russian Departments Are Hampering Trade with That Country," *Current Digest of the Post-Soviet Press*, Dec.

17, 1997, 21; see also "Cuba, Russia promise to reach deal soon on US-feared nuclear plant," Agence France-Presse, Feb. 21, 1998, via Clari.Net.

11. There is also a mothballed reactor in Slovenia. It is uncertain given the hostilities in the region if the project will ever be resurrected. See Alexei Zayko, "Cabinet Gives the Green Light to Nuclear Power Engineering Development Program," *Russkiy Telegraf* no. 65 (Dec. 19, 1997), 4.
12. Ibid., 4.
13. Vladimir Teslenko, "Russia's Nuclear Power Reactors for Sale," *Moscow News*, Dec. 25, 1997, 52.
14. Sergey Rybak, "Russians to Resume Juragua Construction Alone, Minatom Says," *Nucleonics Week* 38, no. 7 (1997): 2.
15. Sergei Batchikov, "The Cuba That We Are Losing," 21.
16. Ibid.
17. Ibid.
18. Interview by author with Russian Ministry of Atomic Energy officials, Athens, Ga., Oct. 6, 1997, and Nov. 15, 1997.
19. This is the acronym of the Soviet trading consortium, the Council of Mutual Economic Assistance. Prior to 1991, more than 80 percent of Cuba's export and import trade was with this group of states.
20. Richard Kessler, "Argentina and Cuba Signed a Nuclear Cooperation Agreement," *Nucleonics Week*, Nov. 13, 1986, 12–13.
21. Richard Kessler, "Argentina Confirms It Plans Deeper Nuclear Ties with Cuba," *Nucleonics Week*, Feb. 11, 1988, 3–4.
22. Mark Hibbs, "Siemens Looking for Contracts to Upgrade I&C for Cuban PWR's," *Nucleonics Week*, May 16, 1991, 1, 10–11.
23. See "Cuban N-Plant: Completion Study Ready Soon," *NucNet News*, Aug. 9, 1995; Mark Hibbs, "Havana Says Juragua Feasibility Study Will Be Ready by Aug.," *Nucleonics Week*, Jun. 29, 1995, 3–4; "Minister Enlists Russia's Help to Complete Nuclear Power Plant," Radio Rebelde (Havana), May 6, 1995, in *Latin American Developments*, FBIS-LAT-95-090, May 6, 1995.
24. Interview by author with Miguel Serradet Acosta, Director of Nuclear Energy Facilities, Ministry of Basic Industry, Havana, Cuba, Jan. 26, 1996.
25. The author was a part of a delegation from the Center for Defense Information investigating the Cuban nuclear program. The delegation visited the construction site of the nuclear reactor at Juragua from Oct. 25–31, 1997.
26. "Foreign Capital to Fund Expansion of Cuban Capacity," *Latin American Power Watch* 4, no. 4. (Feb. 1, 1998).
27. Ibid.
28. "Cuba: Construction Plans for Proposed $150,000,000 Build-Operate (BO) Power Plant Project, Sherritt Power Corp., Canada—Order #: 0331198," *Export Sales Prospector: ESP—Business Opportunities in Latin America & the Caribbean* 7, no. 3 (Mar. 1, 1998).
29. "Project Planned to Increase Power Generation in Matanzas," Radio Rebelde (Havana) in Spanish, Jan. 27, 1998; British Broadcasting Corporation, Feb. 3, 1998.
30. See Fidel Castro Díaz-Balart, *¿Energía Nuclear: Peligro Ambiental o Solución para El Siglo XXI?* (Torino, Italy: Ediciones Mec Grafic S.A., 1998), 368.
31. The three INFCIRC.66 model agreements are: INFCIRC 281 (signed May 5, 1980); INFCIRC.298 (signed Sept. 25, 1980); and INFCIRC.311 (signed Oct. 7, 1983). INFCIRC/66 model agreements relate to "item-only" safeguards, particular technologies or materials. Any new projects that Cuba might consider in the future will have to be based on the INFCIRC/153 model. These agreements cover "full-scope"

safeguards, all nuclear material in the peaceful activities of a nation. As Cuba has signed but not yet ratified the Treaty of Tlatelolco, it will have to renegotiate full-scope safeguard agreements for all of its existing facilities and technologies.

32. See United States General Accounting Office, *Nuclear Safety: International Atomic Energy Agency's Nuclear Technical Assistance for Cuba*, GAO/RCED-97-72) Mar. 1997, 2
33. These projects include the contracting of translation services of official IAEA documents and technical reports into Spanish by Cuban nuclear agencies. Interview by author with senior Cuban nuclear official, Havana, Cuba, May 25, 1997.
34. This training consisted of courses in radiation protection and nuclear safety, probabilistic safety assessment, safety analysis and assessment techniques for operational safety of nuclea power plants, and quality assurance for nuclear plants. In addition, from 1989 through 1996, the IAEA spent $433,000 on research contracts for Cuba. Under the IAEA's research program, the agency places contracts and cost-free agreements with research centers, laboratories, universities, and other institutions in member states to conduct research projects supporting its scientific programs. See U.S. General Accounting Office, *Nuclear Safety: International Atomic Energy Agency's Nuclear Technical Assistance for Cuba*, 3, 5.
35. Ibid., 8.
36. This is consistent with Cuban legislative measures to bolster the legal basis of nuclear activities in Cuba. See Jonathan Benjamin-Alvarado, "The New Cuban Nuclear Law Project: commentary on Cuba's Decreto No. 208," *The Monitor: Arms Control, Nonproliferation and Demilitarization* 3, no. 3 (summer 1997): 40–45.
37. *Nuclear Safety: International Atomic Energy Agency's Nuclear Technical Assistance for Cuba*, 9.
38. The author attended these joint meetings in Havana. The "International Symposium in Nuclear and Related Techniques in Agriculture, Industry, Health and Environment (NURT-97)" focused on the wide spectrum of nuclear techniques being applied in the region. They included those related to pest control; crop production; plant breeding; water resources; nondestructive testing in industry; radiation-processing techniques; nuclear medicine; radiotherapy and radiopharmaceuticals; and nuclear analytical techniques in environmental studies. The "Workshop on Nuclear Physics (WONP-97)" covered topics on fast neutron physics and activation analysis; software on nuclear applications; development and design of nuclear instrumentation for spectroscopy and experimental physics; and advanced semiconductor detectors and related electronic research and developments. These meetings were attended by more than four hundred scientists and technicians from thirty countries.
39. Speech by Daniel Codorníu Pujals, President, Agencia de Energia Nuclear, before the 38th Session of the General Conference of the International Atomic Energy Agency, Vienna, Austria, Sept. 22, 1995. Translated by author.
40. Six months after the Cuban Missile Crisis of October 1962, the presidents of Bolivia, Chile, Ecuador, and Mexico, all deeply affected by the crisis, announced their intention to develop a multilateral accord with the objective of prohibiting the production, importation, storage, and testing of nuclear weapons in their territories. After two years of intensive efforts, on February 14, 1967, the Treaty for the Prohibition of Nuclear Arms in Latin America was signed at the Mexican Ministry of Foreign Relations in the Tlatelolco district of Mexico City. The treaty was entered into force on April 22, 1968. For a detailed history of the treaty, see Monica Serrano, *Common Security in Latin America: The 1967 Treaty of Tlatelolco* (London: Institute of Latin American Studies, 1992).
41. The total figure of UNDP assistance to the Cuban nuclear program from 1963

through 1997 is $2.26 million; see Table 4.3. Almost all of these funds have been channeled to Cuba in the form of grants to the IAEA.

42. Fidel Castro Díaz-Balart, *Energía Nuclear y Desarrollo: Realidades y Desafíos en los Umbrales del Siglo XXI* (Havana: Editorial de Ciencias Sociales, 1990), 368.
43. Cuba currently has a safeguard agreement in force concluded on a voluntary basis with the IAEA as required by the Tlatelolco Accord and the Nuclear Nonproliferation Treaty. Cuba has signed item-only safeguard agreements (INFCIRC/66) with the IAEA for facilities on the island. By adopting the Tlatelolco Accord, Cuba will be required to negotiate full-scope safeguard agreements (INFCIRC/153). These agreements not only cover the facility but also monitor the transfer or diversion of any nuclear materials.
44. Interview by author with Antonio Bolufe Gutíerrez, Director, Consultoria Delfos, Havana, Cuba, Jan. 9, 1996.
45. *Washington Post*, June 27, 1996, A20.
46. See U.S. General Accounting Office, *International Atomic Energy Agency's Nuclear Technical Assistance for Cuba*, GAO/RCED-97-72, Mar. 1997.
47. See "Text of a Circular Letter of June 16, 1997 from the Permanent Mission of the Republic of Cuba to the International Atomic Energy Agency," Attachment, INFCIRC/537, July 30, 1997.
48. Jonathan Benjamin-Alvarado, "The Cuban New Nuclear Law Project," *The Monitor: Nonproliferation, Demilitarization, and Arms Control* 3, no. 3 (summer 1997): 41.
49. Frank Gaffney Jr. and Roger W. Robinson Jr., "Stop the 'Cuban Chernobyl,'" *Wall Street Journal*, (Jan. 21, 1997), A24.

Chapter 5: On Cuba's Decision to Pursue a Nuclear Energy Capability

1. Stephen Van Evera, *Guide to Methodology for Students of Political Science* (Cambridge, Mass.: DAC/MIT, 1997), 42.
2. Robert Yin, *Casa Study Research: Design and Methods* (Newbury Park, Calif.: Sage, 1989), 4–5.
3. See James Everett Katz and Onkar S. Marwah, eds., *Nuclear Power in Developing Countries: An Analysis of Decision Making* (Lexington, Mass.: Lexington Books, 1982).
4. Raju G. C. Thomas, in *Energy and Security in the Industrializing World*, Raju Thomas and Bennett Ramburg, eds. (Lexington: University of Kentucky Press, 1990), 1–12.
5. Smart, "The Consideration of Nuclear Power," in *Nuclear Power in Developing Countries*, James Everett Katz and Onkar S. Marwah, eds. (Lexington, Mass.: Lexington Books, 1982), 21.
6. Raju G. C. Thomas, in *Energy and Security in the Industrializing World*, Raju G. C. Thomas and Bennett Ramburg, eds. (Lexington: University of Kentucky Press, 1990), 2–3.
7. This statement is supported with the understanding that Cuba most likely would not have engaged in any of these activities unless the Soviet Union had not pledged its support (both technically and financially) to the Cuban effort.

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