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Sustainable Energy: Balancing the Economic, Environmental and Social Dimensions of Energy

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Abstract *– **Many of the problems the World faces are managed from a mostly technical or economical perspective, even though problems also have social and environmental dimensions and could be better managed with a more integrative, global perspective. A common trait of these global issues is their interdisciplinary nature, which makes them complex problems difficult to address from one particular discipline. Energy is an example of a global, interdisciplinary problem which is usually approached from a narrow technical or economical perspective. This paper will approach the energy dilemma from the broader perspective of sustainability, striving to achieve a balance among the economic, environmental and social dimensions of energy. Such a balance can benefit the energy policy process by providing a framework that account for many of the interests involved in developing future energy directions and policies.***

Index Terms— Sustainable energy, energy policy, externalities of energy.

I. ENERGY POLICY IN THE UNITED STATES

U.S. domestic energy policy from the late 19th century to the early 1990's presents a direct link between the level of energy production and the gross national product (GNP). Since GNP is assumed directly proportional to general society welfare, energy production and consumption is related to the welfare of society and the economy. U.S. energy policy has favored large-scale, high-technology, capital intensive, integrated and centralized energy producers which rely on fossil fuels. This policy, developed over the last 100 years, served the USA well, providing long periods of reliable energy at relatively low prices. Changes to this way of dealing with energy policy will face great obstacles. Policymakers continue to support this model since they feel it can continue generating economies of scale, and greater efficiencies. This belief will persist until evidence of viable alternative models are presented and convince policymakers [1].

The electric industry regulatory framework had its first major legislation in 1935 with the Public Utility Holding Company Act (PUHCA). This law gave the Securities Exchanges Commission (SEC) the authority to break the large monopolies in the electricity and gas industries, and to regulate the finances of the reorganized industry to avoid new monopolies. It also restricted ownership across state borders. Also in 1935, the Federal Power Act (FPA) established a federal mechanism for interstate electricity regulation under the Commerce Act of the US Constitution that eventually evolved into what today is known as the Federal Energy Regulatory Commission (FERC). For the next forty years, the electric power industry evolved into public utility companies that operated as regional monopolies that were regulated at the state and federal levels (if the utility engaged in interstate commerce of electricity). It was the belief that electric power generation was a natural monopoly, thus it was better for the public to have one company that own all segments of the electric power sector in a given territory [2]. During this period the state regulatory framework also evolved through public service or public utility commissions. Their duties were and still are to assign territory to state utilities through certificates of public convenience and necessity, set service standards and enforce the duty to serve, regulate rates and ensure they are just and reasonable, approve spending and control abandonment.

The oil crisis of the seventies brought about landmark legislation in the form of Public Utility Regulatory Policies Act (PURPA) of 1978 to reduce U.S. use of foreign fossil fuels, increase energy efficiency and conservation. PURPA encouraged the use of renewable energy for electricity production, and promoted the diversification of generation technologies. PURPA also fostered the growth in nonutility generators and independent power producers (IPP) by requiring utilities to buy power generated by small power producers, or from co-generating facilities, at the utility's avoided cost (cost of generating utility power). PURPA did not grant direct access to IPP to utilities' transmission lines. However PURPA laid the groundwork for deregulation and competition by opening wholesale power markets to nonutility producers of electricity. It demonstrated electricity generation was not a natural monopoly. Although not without critics, PURPA is still in effect, with supporters arguing that it is irresponsible to think of energy crises as too infrequent to plan for.

The Energy Policy Act (EPAct) of 1992 encouraged states to open access of transmission lines for sales by private generators (known as wheeling). EPAct 92 promoted growth in nonutility generators by exempting them from regulatory constraints of the PUHCA. It also promoted greater

competition in the bulk power market (e.g., interstate commerce of electric power), and clarified and extended FERC's wheeling authority. It also encouraged the use of distributed generation (DG), generators operating at lower voltage levels closer to the points of use of electricity that are smaller than traditional fossil-fuel generators . However, it was left to individual states how DG was to be allowed in each state. This created different electric power grid interconnection rules and standards across the U.S.

In line with the EPAct 92 discussion, the Federal Energy Regulatory Commission (FERC) established Orders 888 & 889 to comply with EPAct. FERC regulates and oversees energy industries in the economic and environmental interest of the American public. It is an independent agency that regulates the interstate transmission of natural gas, oil, and electricity. FERC also regulates natural gas and hydropower projects [1].

Orders 888 and 889 provide clear rules for how the EPAct 92 mandates are to be implemented. For example, in order to have Open Access to transmission lines (Wheeling), utilities are required to divest their generation and transmission assets from other services to avoid unfair operation of power markets. The orders encourage the use of non-profit Independent System Operators (ISOs) with the only objective to operate the system to ensure reliability. Regional Transmission Organizations (RTO) the for-profit version of ISOs are also allowed. The orders also mandated the creation of Open Access Same-Time Information Systems (OASIS) to make information available to all customers avoiding unfair denial of access to the utility owned transmission lines [2].

In 2005 Congress passed a new Energy Policy Act (EPAct). The EPAct of 2005 reinforced federal programs on energy efficiency and renewable energy. For example, at the federal level EPAct 2005 mandates a 20% energy reduction in federal buildings, and that 7.5% of energy used be from renewable sources by 2013. It also states that utilities and public service commission (or their equivalent public utility commissions) had to consider important operating modes different from the dominant energy model: Interconnection of DG, and net metering (the sale of power by private producers at the same rate that utilities sale power to clients).

The evolution on electric energy policy in the U.S. seems to indicate that U.S. policymakers are being convinced of viable alternatives to the dominant energy model. The introduction of EPAct 2005 defines the law as a "comprehensive energy policy that will promote conservation, reduce our growing dependence on unstable Middle Eastern oil, improve our economy and create new jobs." The dominant energy model needs to be complemented with an alternative scenario in which renewable energy sources, conservation and energy efficiency strategies and technologies are used to the maximum extent possible. The challenge for policymakers is to develop market based regulations that incorporate environmental and social costs in energy prices [1]. In our view, not internalizing the so-called externalities results in short-term economic gain at the expense of environmental degradation and long term economic loss. Sustainability presents a framework, not only of considering environmental and social "externalities" but to include them as integral parts in the energy decision making process.

II. SUSTAINABILITY

It is important to emphasize that the transition from the dominant energy model to a more decentralized model should not be viewed as a mostly technological matter. Focusing only on technological fixes for our energy problems has historically proved to be a wrong strategy. The authors firmly believe that the world's complex problems require a more holistic approach that integrates the expertise and will of many diverse fields and individuals. In fact, history provides numerous examples in which the technological approach has yielded grave unintended consequences. Sustainability presents a holistic approach to integrate not only the technological dimension, usually tied up with economic considerations, but also the environmental as well as the social dimensions of development, energy in our present discussion. The sustainability concept evolved from ideas on human impact on the environment and the welfare of people, one of the first international forums on the subject was the Stockholm Conference on Human Environment in 1972 [3]. There are many definitions of sustainability or sustainable development. In fact, there is literature comparing the various stances on sustainability, classifying definitions in terms of weak, strong or normative sustainability (for an example comparing Solow, Holling, Leopold, Pearce and Barbier see Chapter 8 of Norton's *Sustainability* [4]). There are also various indicators of sustainability such as the ones from the World Bank, the European Union, and UN [5]. Perhaps one the best -known definitions of sustainable development is from Our Common Future and deals with how we use resources today in a way that does not compromise the ability of future generations to meet their needs [6]. Wider exposure was given to sustainable development in the 1992 UN Earth Summit in Rio de Janeiro. Besides conflicting definitions, there are opposing views to sustainability, for example how can we determine the most important interests that future generations will have [7].

Regardless of particular positions on what is sustainability, a sustainable future will require sustainable energy sources and practices. A reference point that will be used in this chapter is that sustainable energy integrates the economic, social and environmental dimensions of energy issues in decision making. Furthermore, an energy ethics, a moral obligation to deal with the energy problems, should be at the center of that decision making process. Figure 1 illustrates this idea that has also been proposed by others [3].

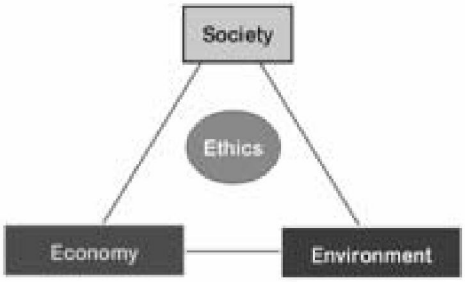

Figure 1: Sustainability Triangle and Ethics

Two common approaches used to integrate economic, environmental and social aspects in decision making are Life Cycle Analysis (LCA) and the Internalization of Externalities. LCA is a process to evaluate the environmental burdens associated with an activity by identifying and quantifying energy and material usage and environmental releases, to assess the impact of those energy and material uses and releases on the environment, and to evaluate and implement opportunities to effect environmental improvements [8]. On the other hand external costs are defined as those actually incurred in relation to health and the environment and quantifiable but not built into the cost of a product or service to the consumer, but borne by society at large [9-11]. Example results of these methodologies are provided in the tables 1-2. Notice that both LCA and external costs provide a better estimate of the impact of these technologies to society. These methods strive to correct market failures that ignore these environmental and social costs in traditional economic analysis. This is not a trivial process, but it is necessary to get a more leveled playing field when comparing alternatives on current energy practices and technologies.

Table 1: LCA Emission Estimates for Electricity Generation [12]

Generation type	SO_2 (g/MWH)	NOx (g/MWH)	Particulates (g/MWH)	CO2 (g/MWH)
Nuclear	32	70	7	**19,700**
Coal	326	560	182	815,000
Gas	3	277	18	362,000
Oil	1,611	985	67	935,000
Wind	15	20	4.6	6,460
PV (Residential)	104	99	6.1	**53,300**

III. STRUGGLING FOR SUSTAINABILITY IN A FOSSIL-FUEL DEPENDENT SOCIETY

Puerto Rico is an island with an area of about 3,500 square miles. It has been a territory of the U.S. since 1898. Its population is 3.8 million, it has 3,015,227 vehicles (among the largest in the world per capita), and Puerto Rican's Emissions per capita are 230% that of the average per capita of the Rest of the World, and 333% that of Latin America [13]. The Island is 99% dependent on fossil fuels for transportation and electricity, but there are no fossil fuels in PR. Figure 2 shows the fuel distribution for the electric power sector. The Puerto Rico Electric Power Authority (PREPA) is a self-regulated, public corporation that is the only utility in the Island. Puerto Rico has two co-generators under PURPA, EcoElectrica (uses Natural Gas), and AES (uses coal). The Island's has an inefficient and irresponsible energy use, and the demand increased dramatically in the 90s. The social, environmental and economic costs of current energy sources and practices are too high. The Environmental Protection Agency has fined heavily our local electric utility for emissions. Industrial and commercial representatives have long voiced their concerns about high operating costs in the Island. Health problems related to pollution are commonplace, especially in vulnerable communities. Construction and urban development are pillars of the local economy, fostering urban planning disorder.

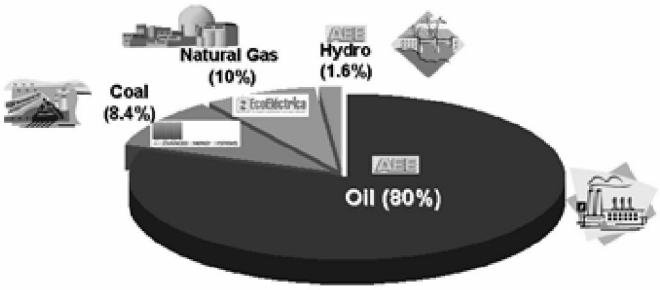

Figure 2: Fuel Distribution in the Power Generation Industry

Laws that encourage the conservation of natural resources are ineffective insofar the legal framework is disconnected from the reality with regard to energy and economic development strategies. For example: "The sustainable development strategy of Puerto Rico must recognize the need for a new vision that considers the environment and natural resources, in particular with regards to land and water use, transportation, energy production, waste management and coastal zone management. We must support our economic development but in a sustainable way, so that its cost does not involve an excessive degradation and destruction of the environment and natural resources or social injustice" this is part of Puerto Rico's Sustainable Development Law #267, September 10, 2004.

Under the scenario described above, there is an urgent need for a social and technological transition to a new culture of social and environmental justice, based on sustainable practices and technologies. Solutions being sought and implemented are mostly economic, and in many times short term in nature. For years the cost of electric energy has been identified as a major obstacle for doing business in the Island. Yet, long-term changes in the electricity cost have not occurred in Puerto Rico. The recent government effort towards supporting biosciences, and the investments of major biotechnology companies in Puerto Rico, stress the need to provide a business environment where the fixed operating costs are diminished as much as possible. Furthermore, other economies are also investing in attracting these same biosciences companies to their countries. Businesses will go wherever the investment environment is more opportune.

However, the electricity needed by Puerto Rico's businesses, citizens, and visitors comes at a premium cost [14]. Puerto Rico's average electricity cost per kWh is the highest in the United States. The average cost per kWh in the United States was $0.0814 during the year 2005. In Puerto Rico the average cost per kWh was $0.1691 more than twice the U.S. average (see Table 2). In 2008, electricity reached $0.30/kWh for residential consumers during the summer.

Table 2: Average retail sales price by sector in 2005 of electricity in the United States vs. Puerto Rico (in ¢/kWh)

Sector	Puerto Rico	United States
Residential	16.57	9.45
Commercial	17.94	8.67
Industrial	14.64	5.75
Average	16.91	8.14

The increase in electricity price is directly related to our dependence in foreign oil to produce electricity. Contrary to the United States where only 3% of the electricity is generated from oil in Puerto Rico we depend on oil for around 80% of our electricity production. In the near future, especially in an island-environment like Puerto Rico's, the traditional view of equating energy use to economic development is not sustainable. A new perspective on energy use at all levels, and its relationship to economic development must be established. On the other hand, the fuel diversification strategy for the electric industry of equal division among coal, gas and oil perpetuates this dependence on external sources of energy. Alternatives that create local jobs and keep the money in Puerto Rico need to be sought. The electric utility recently announced plans to reach up to 20% of renewable energy production. However, which are the realistic goals for those energy alternatives and how to begin a transition to some of those alternatives represent a complex problem.

There are substantial benefits from increased use of renewable energy resources. Among the benefits those cited most frequently in the literature are:

- Reduced cost of fuel for electricity;
- Reduced reliance on imported oil supplies and exposure to the volatile prices of the world oil market;
- Risk management by diversifying the portfolio of electricity generation options;
- Job creation and economic benefits; and
- Environmental benefits.

However, this call for reducing fossil-fuel dependence is not new. "A general broad consensus is needed in Puerto Rico so that plans and actions for oil substitution alternatives on a large scale may be implemented as soon as possible. Plans to implement alternative energy sources should be translated into action promptly. If not, in a few years our people will suffer from our present inaction. Oil is vanishing steadily and continues to be a very politically unstable energy source. Puerto Rico cannot afford to wait or relax until tomorrow. Prudence and economics dictate that we move toward energy self-sufficiency as rapidly as possible". These words seem to be taken from this week's newspaper but they are in fact from a 1983 talk by Dr. Juan A. Bonnet-Diez [15]. Dr. Bonnet was the Director of the Center for Energy and Environmental Studies (CEES) at the University of Puerto Rico. Dr. Bonnet was a strong advocate for action that would liberate Puerto Rico from its fossil fuel energy dependency. In 1980 the CEES commissioned a study from the National Academy of Sciences that concluded: "Puerto Rico, in dealing with its own energy problems, should grasp its opportunity to become an international energy laboratory, seeking and testing solutions especially appropriate to the oil-dependent tropical and sub-tropical regions of the world. The Island's geographical position and its established energy research and development facilities enhance this potential" [16].

Puerto Rico did not become the international energy laboratory it could have been. We still depend heavily on oil for electricity production to the point that every time the price of the barrel of oil increases $10, hundreds of millions of dollar leave Puerto Rico's economy. And after the initial uproar and short-term strategies vanished, we fall again in the complacency of "acceptable" oil prices, even though hundreds of millions of dollars are still leaving the Puerto Rican economy. We remain waiting, as if the answer to our oil dependency problem could be imported. To put in perspective our unfinished business with regard to the road towards energy sustainability, Hawaii has committed to 70% use of renewable energy by year 2030 [17]. Hawaii is a good benchmark for Puerto Rico because of the islanded nature of its electrical system, its high energy prices and its dependence on outside energy sources. In words of the Assistant Secretary of Energy Alexander Karsner: "Hawaii will be a living laboratory for integrated, renewable energy development". Meanwhile Puerto Rico remains stagnant, with an unfulfilled potential to become a showcase of renewable energy in the Caribbean. This must change.

IV. CHALLENGES FOR RENEWABLE ENERGY IN PUERTO RICO

This section briefly lists some of the issues that need to be addressed so that renewable energy can be a viable and important alternative in the energy source scenario of Puerto Rico (PR). First, the dominant energy model of central generation has existed for over 100 years. In Puerto Rico the dominant model has worked well, and the scale economies generated by the use of fossil fuels cannot be denied. Thus, any new energy alternative will face opposition from the industry establishment, and the burden is on proposers of the new practices to prove that their alternative is better, in some cases, much better, than current, well-known energy practices and sources.

Second, the regulatory structure in Puerto Rico presents a huge challenge. On one hand, the 1941 law that established the Puerto Rico Electric Power Authority (PREPA) gives it ample powers over all things related to electric power, including being mostly self-regulated. There are historic reasons for that decision, and the strategy definitely was vital in the economic development of Puerto Rico during the second part of the 20th century. However, such powers and structures should be evaluated in light of the new global and local conditions in the energy industry. Regulation of power however is not all in the realm of PREPA. There have been federal regulations that apply to Puerto Rico, regardless of the fact that our regulatory environment is different from the regulatory entities that exist in the 50 states. In PR, there would not be fuel diversification without PURPA (Ecoelectrica – natural gas, and AES-coal, both entered the PR market through PURPA).

The Energy Policy Acts (EPAct) of 1992 and 2005 also apply to PR. EPAct 92 encouraged states to open access of transmission lines for sales by private generators (known as wheeling). It also encouraged the use of distributed generation (DG), generators operating at lower voltage levels closer to the points of use of electricity. EPAct 2005 reinforced federal programs on energy efficiency and renewable energy. It also stated that utilities and public service commission (or their equivalent public utility commissions, none of which exist in PR with regard to electricity) MUST consider important operating modes different from the dominant energy model: Interconnection of DG, and net metering (the sale of power by private producers at the same rate that utilities sale power to clients). It has been through EPAct 2005 that PREPA acted and approved interconnection of DG, and will also act on net metering by August 2008. The challenge is to obtain just and reasonable regulations and rules for both interconnection of DG and net metering that effectively encourage the use of renewable energy in PR. Another challenge is how Puerto Rico can be proactive in future energy alternatives instead of reactive to external energy measures. We must evaluate how to best comply with federal mandates in a way that is not a one-sided application of the federal laws or the development of state regulations with seemingly patronizing attitudes towards consumers in PR.

In line with the EPAct discussion, the Federal Energy Regulatory Commission (FERC) established Orders 888 & 889 to comply with EPAct. FERC regulates the inter-state sale of electric power in the USA. Thus, FERC does not have jurisdiction in PR (we have no inter-state sales of power), FERC has some jurisdiction through the use of natural gas. Nevertheless, the importance of orders 888 and 889 is the fact that they provide clear rules for how the EPAct mandates are to be implemented. What does this mean to Puerto Rico? Nothing, if one does not pay attention to alternative ways of operating PR's power system. However, how could a structure like this exist in Puerto Rico? Would it be beneficial to PR? Would this encourage broader use of renewable, decentralized energy sources? How can PREPA be a facilitator in this process? These are the challenges that need to be addressed if renewable alternatives are to have greater participation in Puerto Rico. However, another challenge is: where and how will these questions be discussed, evaluated and debated? Energy stakeholders have no formal forum to engage in this participatory exercise [18].

There is an urgent need to re-think our electric system and energy consumption. Our electric infrastructure must be maintained and defended, and we need to deal with the stranded costs that exist due to the dominant energy model. PR needs to look beyond the limited cost-benefit, and think of alternatives that are good to all energy stakeholders. A challenge in this process is how to deal with the technical limitations imposed by the island nature of our electric system. In that line, there is a challenge in considering energy alternatives that include metrics and methods adjusted to PR's reality. For example, it is necessary to consider energy efficiency instead of "energy use" as an economic indicator. We must also examine current reliability standards in light of cost increase of fossil fuels and consider interruptible loads & rates to balance incentives given to DG.

Conservation, efficiency & renewables could halt new construction of fossil fuel plants, and must be included in the planning of our electric system [19]. Incentives for residential and small commercial customers must be aggressively pursued, and PREPA could become an enabler of DG so that it complements central generation, and considered in the planning and operation of our power system. However, there are no magic tricks or magic wands, including renewables. If there is no wind or sun, there is no energy. Renewables have environmental impact, e.g., the manufacturing of PV panels is energy intensive and has impact since they involve semiconductors. Also, manufacturing PV panels involves waste water, the use of batteries in renewable systems requires an effective battery-recycling program, there are sitting issues, and ethical issues related to renewable systems, especially the impact on vulnerable communities. Finally, what will happen to any program that strives to reduce fossil fuel dependence if such fuels remain in "acceptable" prices? Will society make a commitment to look beyond economics,

and integrate social and environmental matters in decision- and policymaking processes? These are challenges not meant to discourage renewables, but to understand pros and cons of each alternative.

We must stipulate that a sustainable energy future and the decisions related to it are complex matters. We need to make long-term decisions under uncertainty. However, we need not predict the future, we should be enablers of our energy future, and at the very least, not become obstacles to new ideas and practices.

V. A SUSTAINABLE ENERGY FUTURE

It should be emphasized that the challenges in the previous section cannot be an excuse to do nothing. Although those challenges are specific to Puerto Rico, they illustrate the kind of policy challenges that any alternative energy strategy will face. Again there is an urgent need for studies to understand what can be done, and how diversification of energy sources and systems can be achieved. When considering energy alternatives, we must include metrics and methods adjusted to reality of the location being studied. For example, we must begin to consider energy efficiency instead of "energy use" as an economic indicator. The internalization of externalities must be a priority. Conservation, efficiency & renewables should be an integral part of any effort, at all levels to use these alternatives to the maximum extent possible (technical, economical, social, environmental and ethical). There must be effective incentives for residential and small commercial customers to this end. Government needs to pay closer attention to one-sided application of federal laws or state regulations (that is, application should benefit all energy stakeholders, not some). We need to examine current reliability standards, and consider seriously interruptible loads & rates. Utilities should become enablers of DG, in a way that DG can effectively complement central generation, and be considered in the planning and operation of our power system.

It is vital to begin collaborations among government, industry, commerce and citizens. We need to go from an adversarial to a collaborative relationship, from mutual distrust, to a serious and lasting commitment for the public good, for the social, environmental and economic welfare of all stakeholders. National Dialogues that are inclusive and constructive are needed, so that we can have planning that go beyond any political cycle. And that process should yield actions: that are measurable and decisive so that we can hope to achieve a more sustainable future. Besides economical considerations, we need to integrate social and environmental justice. To re-think electric power systems and energy consumption we must talk about utility's stranded costs, and the minimum costs to keep our electric infrastructure in optimum shape. We need to go beyond the utilitarian view of cost-benefit analysis. Also, renewable is not the same as sustainable. We can have a great renewable project that fails in the environmental or social dimension, and thus the project is not sustainable. Finally, renewable sources do have environmental impact as discussed previously.

Nevertheless, in spite of obstacles, it is unacceptable that renewable energy sources are not being used to the maximum extent possible in the U.S. Participatory structures must be created that enables a national dialogue to reach the decisions needed to move forward with sustainable policies. All alternatives need to include social and environmental issues as equally important as the economic issues. The present consumption patterns are simply unsustainable; the Earth does have enough resources to sustain those patters for all human beings. The burden is too high, not only to the present generation, but to coming generations. It is time to quantify the benefit to future generations of sustainable practices, understanding that this strategy could imply sacrifices today. However, we already are passing future generations a huge economic debt, why not passing them a positive legacy with sustainability.

VI. A SUSTAINABILITY EXAMPLE: INTEGRATION OF ENERGY, ENVIRONMENT AND SOCIETY

The Institute for Tropical Energy, Environment and Society (ITEAS in Spanish) was created at UPRM to lead the intellectual and cultural leap necessary to develop public policy, and sustainable energy practices for Puerto Rico. One of the problems in the public policy cycle is that scientists and technical personnel usually participate in a limited way, usually in the form of reports to policymakers. The flaws of this approach are many, requiring a more active participation of energy experts in the decision-making process. ITEAS is committed to retake the unfinished business in terms of research and application in sustainable energy, but with a strong understanding that energy researchers should not just only inform the process, but rather, have to be active participants in all stages of the public policy cycle such as the agenda setting and issue identification stages. One of the main activities in this line is the establishment of participatory structures that allow all stakeholders to be involved in the development of the energy policy needed for the transition to a more sustainable future.

ITEAS has a holistic perspective of energy issues through the development of sustainability-based public policy. Energy is approached as a societal, complex issue that cannot be addressed from a single discipline, but rather from multiple perspectives. The broader perspective of sustainability is assumed, striving to merge energy policy and ethics with special attention to Puerto Rico. ITEAS believes that to have a long-lasting commitment and involvement, the search for sustainable energy must be framed as a moral obligation with an integrative and global perspective. This new energy ethics creates the kind of personal or institutional commitment necessary to withstand the hardships of consensus-building needed in participatory processes [20].

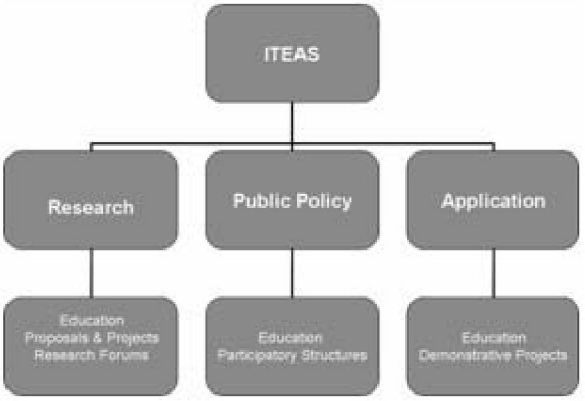

Figure 3: ITEAS Organization

In order to move to a sustainable future, all energy stakeholders need to participate in the generation, evaluation and implementation of long-term strategies: Every sector must assume its responsibilities in enabling a sustainable energy future. Collaborations among government, industry, commerce and citizens need to be established, that enables a transition from the current adversarial positions to collaborative relationships, from mutual distrust, to a serious and lasting commitment for the public good, and the establishment of policies that integrate the social, environmental and economic dimensions of energy.

VII. CONCLUSION

This paper presented the energy dilemma from the broader perspective of sustainability, striving to achieve a balance among the economic, environmental and social dimensions of energy. The dominant energy model needs to be complemented with an alternative scenario in which renewable energy sources, conservation and energy efficiency strategies and technologies are used to the maximum extent possible. Not internalizing the so-called externalities results in short-term economic gain at the expense of environmental degradation and long term economic loss. In spite of the difficulties in achieving sustainability, it presents a framework, not only of considering environmental and social "externalities" but to include them as integral parts in the energy decision making process. Such a framework can account for many of the interests involved in developing future energy directions and policies.

A case study from Puerto Rico was presented, to illustrate the challenges of achieving sustainability in fossil-fuel dependent, energy-intensive, unsustainable societies. Participatory structures must be created that enable national dialogues to reach the decisions needed to move forward with sustainable policies. All alternatives need to include social and environmental issues as equally important as the economic issues. It is time to quantify the benefit to future generations of sustainable practices, understanding that this strategy could imply sacrifices today. However, we already are passing future generations a huge economic debt, why not passing them a positive legacy with energy sustainability.

REFERENCES

[1] Tomain, J. and Cudahy, R. 2004. *Energy Law*, Thomson Press.
[2] Bosselman, F., Eisen, J., Rossi, D. Spence, J. Weaver. 2006. *Energy, Economics and the Environment*, 2nd Ed., Foundation Press.
[3] Moffat, J.; Hanlery, R.; Wilson, M. *Measuring and Modelling Sustainable Development*, Parthenon, New York, 2001.
[4] Norton, B. *Sustainability*, University of Chicago Press, 2005.
[5] Hake, J.; Eich,R. "Energy and Sustainable Development," in *Energy and Culture*, Ashgate, UK, 2006.
[6] United Nations. 1987. *Our Common Future*, The World Commission Report on Environment and Development, Oxford Press.
[7] Beckerman, W. *A Poverty of Reason*, Independent Institute, Oakland, 2003.
[8] Graedel H. and Allenby, J. 2003. *Industrial Ecology*, 2nd Ed., Prentice Hall.
[9] Hohmeyer O. and Ottinger R. (eds.). 1991. *External Environmental Costs of Electric Power*, Springer-Verlag.
[10] Hohmeyer O. and Ottinger R. (eds.). 1994. *Social Costs of Energy*, Springer-Verlag.
[11] Krewitt, W. 2002. "External Costs of energy – do answers match the questions? Looking back at 10 years of ExternE," *Energy Policy*, 30:839-848.
[12] UIC, 2004. "Energy Analysis of Power Systems," *UIC Nuclear Issues*, Briefing Paper # 57.
[13] Environmental Protection Agency, PR and Caribbean Office Statistics, 2008.
[14] J. Colucci -Ríos, E. O'Neill-Carrillo, A. Irizarry Rivera, "Renewable Energy in the Caribbean: A Case Study from Puerto Rico," Chapter in *Environmental Management, Sustainable Development and Human Health*, CRC Press, 2009.
[15] Bonnet, J. A. 1983. "The quest for energy self-sufficiency in Puerto Rico," Conference on Energy Planning for the U.S. Insular Areas, CEER-X-161.
[16] U.S. National Academy of Sciences, 1980. "Energy in Puerto Rico's Future," Report to the Center for Energy and Environmental Research.
[17] DOE, 2008. "Hawaii aims for energy independence," DOE/EERE Program News (electronic).
[18] O'Neill-Carrillo,E. Pérez-Lugo, M. Irizarry-Rivera, A. Ortiz-García, C. "Sustainability, Energy Policy and Ethics in Puerto Rico," *Proceedings of Energy and Responsibility: A Conference on Ethics and the Environment*, April 10-12, 2008, Knoxville, Tennessee.
[19] Colucci, J. Irizarry, A. O'Neill-Carrillo, E. "Sustainable Energy in Puerto Rico," *ASME Sustainability '07 Conference*, June 2007, Long Beach, CA.
[20] O'Neill-Carrillo,E. Frey , W. Pérez-Lugo, M. Ortiz-García, C. Irizarry-Rivera, A. Colucci-Rios, J.A. "Advancing a Sustainable Energy Ethic Through Stakeholder Engagement," *Proceedings of the IEEE Energy 2030 Conference*, November 2008, Atlanta, GA., November 2008, Atlanta, GA.