"The Prospects for Sustainable Development: The Case of Wind Power in India"

By

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ABSTRACT

The Prospects for Sustainable Development: The Case of Wind Power in India

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The development establishment adopts a "win-win" approach to sustainable development. In this approach, technological innovation promoted by market-oriented policy frameworks enables the mainstream development model of industrial, economic growth to proceed within environmental limits. Less-developed countries enjoy the benefits of increased goods and services whilst the environment is preserved. Energy is a critical input to development. The negative environmental impacts of global energy systems dominated by fossil fuel combustion make such systems unsustainable. To succeed, the "win-win" approach requires a transition to a sustainable energy system. Renewable energy technologies are a key component of such a system and wind power is widely regarded as one of the leading such technologies. This thesis assesses the prospects for the "win-win" approach to sustainable development through an examination of the case of wind power in India.

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"Towards what ultimate point is society tending by its industrial progress? When the progress ceases, in what condition are we to expect that it will leave mankind?" (John Stuart Mill 1857)

ABBREVIATIONS

CASE	Commission for Additional Sources of Energy
C-WET	Centre for Wind Energy Technology
DNES	Department of Non-Conventional Energy Sources
FYP	Government of India, Five-Year Plan
GEDA	Gujarat Electricity Development Agency
GOI	Government of India
IREDA	India Renewable Energy Development Agency
Kwh	Kilowatt Hour
LDC	Less Developed Country
MEDA	Mahashtra Electricity Development Agency
MNES	Ministry of Non-Conventional Energy Sources, Government of India
MW	Megawatt
RETs	Renewable Energy Technology
Rs	Rupees
SED	State Electricity Board
SERC	State Electricity Regulatory Commission
SNAs	State Nodal Agencies
TEDA	Tamil Nadu Electricity Development Agency
TWh	TeraWatt Hour

FOREWORD

During the 1990s the concept of sustainable development became one of the dominant themes of the mainstream development discourse. Adams says that sustainable development became the "dominant leitmotif of the discourse of development planners, commentators and bureaucrats" (Adams 1993, p. 207). Lélé calls sustainable development the "development paradigm" of the 1990s (Lélé 1991, p. 607). The concept encompasses the idea that there are environmental limits to development that need to be observed if positive development outcomes are to be sustained into the future. The development establishment presents sustainable development as a "win-win" scenario (Beckerman 1974, p. 12).[1] In this scenario, less-developed countries ("LDCs") are able to enjoy the increased goods and services provided by the mainstream development model of industrial, economic growth ("industrialization"). Such growth occurs within environmental limits through the use of modern technologies that are promoted by market-orientated policy frameworks. Development is advanced and the environment is preserved through this combination of technology and market-orientated policy.

The establishment or mainstream "win-win" interpretation of sustainable development is contested. The critiques are heterogeneous. A common theme is rejection of the notion that continuous industrialization can be accommodated within environmental limits. The assumptions that market-orientated policy frameworks can effectively promote the development of environmentally benign technologies and that technology can solve the environmental problems associated with the development model of industrialization are disputed. Accordingly, the model of industrialization can only be accommodated within environmental limits if growth is constrained or the model is implemented differently. Other critics regard a development model based on industrialization as intrinsically unsustainable, incapable of being accommodated within environmental limits on any basis. To them the adoption of sustainable development by the development establishment is seen as the "establishment appropriation" of a concept that originated as a challenge to the mainstream development model (Lawn 2001, p. 13).[2] For these critics, to be sustainable, development must be based on an alternative model.

Now is an opportune and appropriate time to re-examine the mainstream "win-win" interpretation of sustainable development. A number of events in 2005 focused the attention of the public, media and policymakers on a key issue within the sustainable development debate, namely energy consumption and its impact on the environment. In February 2005 the Kyoto Protocol, an international attempt to address concerns about the contribution that greenhouse gas emissions make to climate change, came into effect. Energy consumption through the combustion of fossil fuels is the most significant source of such greenhouse gas emissions. At the G8 summit in Britain in July 2005 climate change, energy and sustainable development were key issues.[3] High oil and gas prices throughout 2005 re-ignited debates about the prospect of non-renewable fossil fuels being exhausted as the pace of economic growth in China and India fueled a rapid increase in their consumption. At the same time, the climate change debate has focused attention on the causative role of fossil fuel combustion in global warming.

The broad question that provides the context for this thesis is whether a "win-win" scenario of sustainable development based on the mainstream development model of industrialization is plausible. This debate is examined in Chapter 1. The specific case of energy and sustainable development is taken up in Chapter 2. Energy is a critical input for any form of development, but is particularly fundamental to the development model of industrialization. If, as is argued in Chapter 2, the current, conventional, fossil fuel dominated energy system is not sustainable, the mainstream model of development that this energy system underpins is not sustainable.[4] To render the mainstream development model sustainable, its proponents need to create an energy system that can provide the necessary energy inputs in a sustainable way.

As outlined in Chapter 2, within the mainstream "win-win" sustainable development scenario, a sustainable energy system is to be created through the adoption of new energy-related technologies that are promoted by market-orientated policy frameworks. Renewable energy technologies ("RETs") are regarded by proponents of a sustainable energy system as one of the key categories of new technologies that will form the basis of such a system.[5] Wind power is a leading RET, the promotion of which is being encouraged in several developed countries through market mechanisms and favorable policy frameworks. Resulting growth in the use of RETs is widely touted by their advocates as evidence of the success of this approach. However, given the growing energy demands of LDCs it is appropriate to evaluate the prospects for the mainstream approach to the promotion of wind power in LDCs.

This thesis examines these prospects in India. Chapter 3 sets out the current status of development in India and describes how India has pursued the mainstream development model of rapid industrialization. It outlines the critical role that energy has and continues to play in India's pursuit of this development model and the role of RETs within the Indian energy policy framework. It describes the policy framework that has been adopted in India to promote the development of wind power and examines India's wind power development in the context of its overall national energy policy. Based on the data presented in Chapter 3, Chapter 4 first evaluates the extent to which the adoption of a mainstream approach has succeeded in promoting the development of wind power in India and the contribution that such development has made to the creation of a sustainable energy system in India. Following this evaluation, Chapter 4 discusses the implications that this Indian experience has for the mainstream model of sustainable development.

CHAPTER 1: INTRODUCTION—SUSTAINABLE DEVELOPMENT

Sustainable development is a contested concept, the definition of which remains elusive. It has been called a "fashionable phrase that everyone pays homage to but no one can define" (Lélé 1991, p. 607). In the academic literature there have been numerous attempts to provide a definition whilst practitioners often use the term in a loose and undefined way.[6] Part of this definitional difficulty arises because the concept attempts to marry two other concepts, each of which is the subject of intense debate. These two concepts are "development" and "sustainability".[7]

At its most generic, the concept of development is concerned with improving human welfare in LDCs. Defining such improvements and how to achieve them are perennial subjects of debate. Notwithstanding these debates, within mainstream theories of development, economic growth is regarded as a key component of the development process (Redclift 1987, p. 15).[8] Although various "alternative" development approaches have shifted the focus from economic growth as an end in itself to growth as a means to development, these alternatives still regard economic growth as a necessary condition for the achievement of development goals (Seers 1972, pps. 22-24; UNDP 1990, p. 9; Sen 1988, pps. 11-12).[9]

If, as Lélé puts it, there is within development theory a "deep-rooted normative notion of development as economic growth", the model of such economic growth is industrialization (Lélé 1991, p. 618). Industrialization is a process equated by many LDCs with modernization and the ultimate goal of their national economic policy.[10] Goods and services provided by industry are seen as necessary to furnish people with even basic needs. Accordingly it has been said, "all nations require and rightly aspire to efficient industrial bases to meet changing needs" (WCED 1987, p. 206). The economic growth paradigm is based on a perspective of "energy-intensive industrial development as the natural endpoint of a universal process of social evolution and modernization" (Redclift 1993, p. 444).

Broadly, the concept of sustainability is concerned with the ability to continue or sustain something. Sustainable development thus concerns the sustaining of either a development process or a state of development (Lélé 1991, p. 608). This requires identification of all of the conditions that lead to development and the continuation of those conditions. However, the sustainable development discourse is more focused than this. It concentrates on one condition, being the need to observe environmental limits if development is to be sustained (Adams 1990, p. 58).[11] This concern with environmental limits is based on two premises. The first premise is that natural capital, in the form of natural resources and ecosystem services, is a necessary input to economic growth and human welfare. The second premise is that natural capital is finite and once exhausted cannot be replaced. By contrast, other forms of capital used in development (for example, social, financial, physical) are manmade and thus considered replaceable.

Given these conceptions of "development" and "sustainability", the key questions for the sustainable development debate are whether industrialization can occur in LDCs within environmental limits and, if not, on what basis can development be sustainable? The position taken on the first of these questions is often seen to divide proponents of sustainable development into two camps. Adams refers to these two camps as the reformists and radicals (Adams 1990, pps. 66-67). Constanza et al. divide the two camps into those who adopt a "technological optimist worldview" and those who adopt a "technological skeptic vision" (2000, p. 150). Other commentators describe the two camps as being divided between those who advocate a weak concept of sustainability and those who advocate a strong concept of sustainability (Solow 1992, p. 14; Lawn 2001, pps. 18-19). Whilst this binary view of the sustainable development debate is a simplified presentation that does not capture the full spectrum of positions within the debate, it highlights the critical divide between those who believe that the mainstream development model of industrialization can be implemented within environmental limits and those who believe that it cannot, at least not as currently implemented.

To a large extent, the argument that industrialization cannot be the basis for sustainable development relies on a view of absolute or hard environmental limits. Growth that consumes natural capital inevitably encroaches on and ultimately exceeds those limits. By contrast, the mainstream argument that industrialization can be sustainable relies on a view of relative or soft environmental limits. Present day characteristics of technology and socio-economic organization impose these environmental limits. As these characteristics change, so the environmental limits they impose will shift, enabling further industrial growth to be accommodated. Underlying these contrasting views of environmental limits are differing concepts of sustainability, differing perspectives on the finite nature of natural resources and contrasting assumptions about the contribution that technology and the market can make towards keeping industrial, economic growth within environmental limits.

Proponents of absolute environmental limits tend to adhere to a concept of "strong sustainability". According to this concept, natural and human capitals are not interchangeable inputs in the economic growth process. Rather, they are complementary and interdependent, requiring natural capital to be preserved if economic growth is to be sustained (Lawn 2001, pps. 18-19; Daly 2001, p. 397). This contrasts with the concept of "weak sustainability" adhered to by proponents of relative limits.[12] In this concept, human and natural capitals are seen as perfectly or near-perfectly substitutable (Solow 1992, p. 19). Given this substitutability, there is not the same imperative to preserve natural capital. Rather, advocates of weak sustainability argue for the preservation of an aggregate portfolio of human and natural capital that provides a "generalized capacity to produce economic well-being" (Solow 1992, p. 14; World Bank 1992, p. 8).

The belief in absolute environmental limits is based on a static view of natural resources. In this static view, natural resources are fixed and finite. A development process that uses ever-increasing amounts of non-renewable natural resources and increasingly exploits or over exploits renewable natural resources and environmental sinks will ultimately exhaust all of these resources, destroying the capacity for development. The relative view of environmental limits is based on a dynamic, rather than static, view of natural resources. In this dynamic view, the fact that any given natural resources might ultimately be finite is not relevant. Useable resources are defined by their economic usefulness and the ability of technology to exploit them (Beckerman 1974, pps. 229-230; Degregori 2002, p. 137). The interaction of prices and technological development in the face of the scarcity of any given resource results in new sources of or substitutes for such resource being found.[13] In this way, the exhaustion of any particular resource never operates as a constraint on the growth process.

Both the ability to substitute human capital for natural capital and the dynamic view of natural resources upon which the case for relative environmental limits is predicated depend, in large part, on technological development. It is assumed that technological developments and advances can and will be used to control the negative environmental impact of industrialization allowing it to proceed within environmental limits. New sources of existing resources and new resources will be found and developed and methods will be found for controlling and rendering wastes harmless. This assumption reflects what Constanza et al. (2000, p. 150) call a "technological optimist" worldview.[14] Within the mainstream approach, the market is seen as a critical mechanism that facilitates necessary technological and socio-economic responses to environmental problems. The World Bank states "market-based instruments are best in principle and often in practice" (World Bank 1992, p. 3).

Advocates of absolute environmental limits have, by contrast, a less optimistic view of technology. This view reflects what Constanza et al. call a "technological skeptic" worldview (2000, p. 150). This worldview assumes that technology cannot be relied upon to continuously expand or overcome environmental limits through the development of new or alternative sources of natural resources and ways to control the emission of wastes into the environment. Although technology may be important in mitigating the negative environmental impacts of industrialization, "technical progress is ultimately constrained by the dynamic ecological carrying capacity of the Earth" (Constanza et al. 150).[15] In relation to the market, critics of the mainstream approach to sustainable development take a less sanguine view of the market as an appropriate and effective instrument for determining and guiding necessary responses to environmental problems.

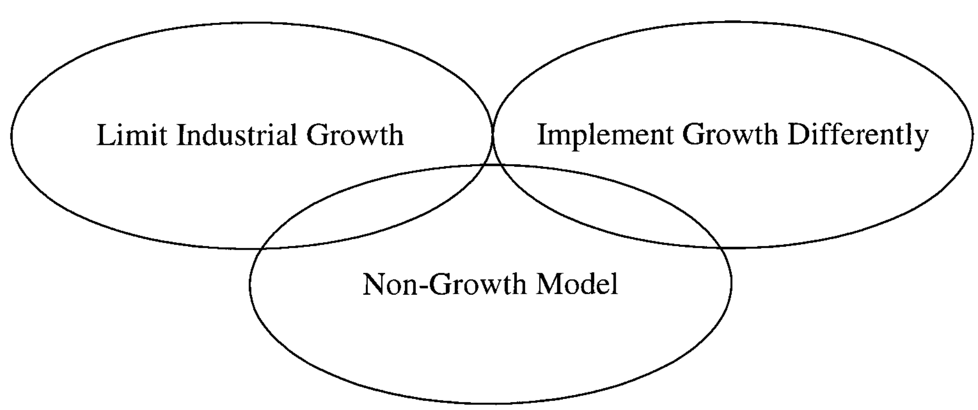
The following table summarizes the contrasting positions taken by the development establishment and its critics to sustainable development:

Mainstream Approach	**Critics**
Relative/soft environmental limits	Absolute/hard environmental limits
Weak sustainability	Strong sustainability
Dynamic view of resources	Static view of resources
Technological optimist	Technological skeptic
Market advocate	Market neutral/skeptic

Meadows et al. are amongst the leading proponents of the view that environmental limits are absolute, rendering the development model of industrialization unsustainable. They have predicted that exponential growth in input consumption and output production arising from rapid industrialization in LDCs will exhaust the finite capacities of environmental sources and sinks within a relatively short time frame (Meadows et al. 1992, pps. 14, 44 and 50-62).[16] Boulding, another proponent of absolute limits, argues that the development model of industrialization is premised on a "cowboy" economy and a romantic belief in the inexhaustible resources of the "illimitable plains" that encourages "reckless, exploitative, romantic and violent behavior" (1973, p. 127).[17]

The pursuit of a development model of industrialization in the face of environmental limits is predicted to lead to environmental and ecological disasters. This will potentially result in a decline in industrial production and populations (Meadows et al. 1992, p. xv). It is argued that any such impacts will hit LDCs hardest given the limited resources they have to deal with them (Meadows et al. 1992, p. xv; Mishan 1993, p. 28). Mishan states that the pursuit of an industrial, economic growth model means "with the growth in global population, concentrated mainly in the Third World, the rising tide of consumption must inevitably quicken the depletion of natural resources and move us closer to the brink of ecological catastrophe" (194).[18]

There is no consensus amongst advocates of absolute environmental limits on how to avoid these negative consequences and achieve development goals in a sustainable away. The alternatives to the mainstream "win-win" model represent what Adams calls a "certain chaotic diversity of thought" (Adams 1990, p. 67). The alternatives can be split into three categories. The first is to limit economic growth, in particular industrial economic growth, to avoid environmental limits being exceeded. The second is to implement the model of industrialization in a different way to render it more sustainable. The third is to implement a different model of development that may be intrinsically more sustainable. These three alternatives are not, in reality, distinct and separate options but rather overlapping with the lines between them blurred. This is represented in the following diagram:



Supporters of the alternative of limiting industrial, economic growth themselves represent a diverse community.[19] They are distinguished by working within the growth paradigm, albeit within limits. A key constituency operating within this alternative comprises the supporters of a "steady-state" or "stationary" economy. They recognize that some degree of economic growth is necessary in LDCs to furnish them with the goods and services they need to meet their development goals. However, they argue that aggregate growth at global, regional and national levels needs to be constrained to remain within environmental limits. Accordingly, once quantitative growth has reached its environmentally imposed limits, an economy has to be based on qualitative economic growth.

Advocates of a steady-state economy see it being based on a constant stock of people and capital and low throughputs that are ecologically sustainable in the long run with growth in non-physical goods, namely services and leisure (Daly 1973a, pps. 14 and 20; Lawn 2001, p. 5; Boulding 1973, p. 127). Lovins says, "though the potential for growth in the social, cultural and spiritual spheres is unlimited, resource-crunching material growth is inherently limited" (Lovins 1979, p. 13). Although no prescriptions are given for how to achieve a steady-state economy, it is recognized that a move to such an economy will require a revolutionary change in socio-economic "values" (Meadows et al. 1992, p. 190; Daly 1973a, p. 19). In addition to this value re-orientation, population control is regarded as necessary to ensure that environmental limits are not exceeded (Daly 1973b, pps. 158-60).[20]

The alternative of implementing the model of industrialization in a different way also comes in a variety of guises. One of the principal options suggested in the literature is the adoption of a neo-Marxist approach, involving a fundamental restructuring of the global political economy. In this approach it is argued that environmental problems in LDCs are directly related to a global economic system that supplants traditional, sustainable economic activity with imported, industrial practices and subordinates LDCs to the economic needs of developed countries (Redclift 1987, p. 12; Cheru 1992, pps. 500-503; Ganguly 1996, p. 181). Industrialization does not need to be abandoned but the political economy of the world economic system restructured. This enables LDCs to "break with the linear model of growth and accumulation that ultimately serves to undermine the planet's life support systems" and to incorporate in their development models indigenous knowledge and strategies of resource use (Redclift 1987, pps. 4 and 150).

Finally, various development models have been proposed as complete alternatives to the model of industrialization. Although these may not be specifically designed with sustainability in mind, they are often argued to be inherently more sustainable than the mainstream model. One of these alternatives is the "green" alternative to capitalism and socialism advocated by Friberg and Hettne. This alternative involves a process of de-modernization, with self-reliant, endogenous development based on the community and characterized by social justice and ecological balance (Adams 1993, pps. 214-215).[21] As with many of these alternatives, there is no blueprint for such a path since its precise shape must be locally determined, but it does reject the capitalist, world economic system and its associated developmentalist linear model of economic growth.[22]

Implementing any of the three alternative approaches to sustainable development would have profound implications for the socio-economies of LDCs and developed countries alike. At a minimum, the need to operate within absolute environmental limits, which underlines each of the alternatives, implies a ceiling on the expansion in the supply of goods and services and thus the aggregate material standard of living that can be enjoyed (Daly 1973a, pps. 19, 168-170). Since some expansion in the supply of goods and services in LDCs is necessary for them to achieve their development goals, observing limits will require developed countries to be primarily responsible for curbing growth in the first instance. In a global growth economy everyone's absolute share can increase regardless of his or her relative position. However, in a universe of constrained growth "the division of physical wealth will be a zero sum game" in which the "problem of relative shares can no longer be avoided by appeals to growth" (Daly 1973a, p. 19).

Advocates of relative environmental limits deny that such limits have such implications for the mainstream development model. Instead, such advocates see the possibility for a "win-win" situation in which continued industrial, economic growth is possible in both LDCs and developed countries, without environmental limits being exceeded (Beckerman 1974, p. 12). This is possible because of the ability to manage technological change and socio-economic behavior (WCED 1987, p. 8; World Bank 1992, p. 9). The development establishment adopts this "win-win" approach to sustainable development enabling it to promote its development model of industrialization as a sustainable development model.

The World Commission on Environment and Development ("WCED") defines sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987, p. 8).[23] This definition of sustainable development has been adopted by the development establishment and is used as the basis for promoting their "win-win" approach to sustainable development (Lélé 1991 p. 611; Adams 1990, p. 58).[24] It articulates both the necessity of continued economic growth to meet the development needs of present generations and the requirement that such growth observe environmental limits, thus preserving the capacity for future generations to meet their development needs.

In relation to the need for economic growth, the WCED says that such growth is "absolutely essential to relieve the great poverty that is deepening in much of the development world" (WCED 1987, p.1). The World Bank states that economic growth is the "only sustainable mechanism for increasing a society's standard of living" (World Bank 2003, pps. 1 and 6). Furthermore, it is industrial economic growth that remains the key to achieving development goals, with industry "central to the economies of modern societies and an indispensable motor of growth" (WCED 1987, pps. 206 and 213). At the same time environmental limits and their importance are acknowledged. The World Bank notes that neglecting environmental issues, amongst other things, will "endanger the durability and sustainability of the growth process" (World Bank 1992, pps. 1 and 4; World Bank 2003, pps. 1 and 22). The UNDP notes that ignoring environmental sustainability for short-term gains will undermine the long-term goal of poverty reduction (UNDP 2003, p. 123).

In the "win-win" scenario the apparently conflicting objectives of pursuing a development model based on industrialization and observing environmental limits are reconciled through the use of new technologies which are promoted by market-orientated policy frameworks. Within this perspective, the market signals the scarcity of resources or ecosystem services through increased prices. Such increased prices motivate technological development at the micro-economic level to reduce costs and maintain profits. Thus, the market and technology interact to provide a negative feedback mechanism that avoids environmental limits being exceeded. The development and use of new technologies underpins both the dynamic view of natural resources and the "weak" version of sustainability on which the "win-win" scenario is based. It is argued that technological development can expand available resources since "any given level of technology defines a set of useable resources that are fixed, finite and inherently exhaustible" (Degregori 2002, p. 137). Technology enables the substitutability of resources that is another foundation of "weak" sustainability to be continually increased (World Bank 2003, p. 14).

In the "win-win" scenario, technology is not only important in removing the limits imposed on industrial, economic growth by a finite supply of natural resources. It is also seen as important in ensuring that the capacity of the environment to absorb the wastes generated by such growth is not exceeded. Technology plays a vital role in neutralizing or eliminating pollution from existing production processes and developing production processes that emit less or zero pollution (Huesemann 2001, p. 272). It is argued that, owing to technological advances, the link between environmental pollution and economic growth has largely been broken in developed countries and that LDCs can "leap-frog" the polluting phase of industrial growth by using modern, clean technologies (World Bank 1992, pps. 38 and 115; 2003, p. 3).

The WCED say, "with careful management, new and emerging technologies offer enormous opportunities for raising productivity and living standards, for improving health and for conserving the natural resource base" (1987, p. 217). Advances in information technology, material technology, biotechnology, space technology and agricultural technology are regarded as key technology areas for the future. The UNDP notes, "the 20th century's unprecedented gains in advancing human development and eradicating poverty came largely through technological breakthroughs" (UNDP 2001, p. 2). However, the development of the technologies needed to realize the "win-win" scenario of sustainable development will not occur within a vacuum. Rather, such technological development is promoted within an appropriate policy framework. It is only with the right policy-framework that the world's challenges "in water supply and sanitation or energy and industrial output or food production" can be met in a sustainable manner (World Bank 1992, pps. 9 and 42).

The goal of an appropriate policy framework is to "ensure through incentives and disincentives that commercial organizations find it worthwhile to take fuller account of environmental factors in the technologies they develop" (WCED 1987, p. 60). Within the mainstream approach to sustainable development, the means to achieving this goal is the incorporation of the costs of negative environmental externalities in economic decision-making. These costs may be associated with the over exploitation of a particular resource or the emission of harmful wastes into the environment. It is believed that when such costs are reflected in prices, the market will provide the negative feedbacks needed to guide economic activity on to a sustainable path. An increase in costs of production resulting from increased prices of a scarce resource or the imposition of additional costs on the emission of certain waste products will, it is argued, motivate the development of technologies that will mitigate such increased costs. Both market-based and regulatory policy instruments can be used to ensure that negative environmental externalities are reflected in economic decision-making (World Bank 2003, p. 32).

Within the mainstream approach to sustainable development the preference is for market-orientated economic instruments rather than regulation (WCED 1987, p. 220;

Beckerman 1974, p. 157). Policies should "work with the grain of the market rather than against it, using incentives rather than regulations wherever possible" (World Bank 1992, p. 3). The market is seen as the most efficient mechanism for guiding economic behavior, provided all relevant information as to costs can be reflected in the prices in the market. In addition, it has been argued that the market, rather than the state, is better suited to engineering the kind of systemic change required to re-orientate industrial economic processes towards sustainability, a process that is "intrinsically unpredictable" and not susceptible to command and control regimes (Roodman 1998, p. 22). Market-orientated policy instruments include investment or production tax breaks, low-interest loans, depreciation allowances, pollution waste-charges and non-compliance fees, taxes and subsidies (WCED 1987, p. 220; World Bank 1992, pps. 74-75; Roodman 1998, p. 222; Hammons 2001, p. 863).

Although market-orientated policy instruments are preferred, it is recognized that market and policy failures mean that the market alone cannot deliver sustainable development. Accordingly, some degree of regulation is necessary as well (World Bank 2003, pps. 27-28).[25] As Beckerman says, "the free-market system will not achieve an optimum allocation of resources to the environment. Society must intervene in the environmental choice" (Beckerman 1974, p. 246). Market failures include the failure of the market to include the cost of negative environmental externalities in the price mechanism, an inability to effectively address the problems of over-use or under-provision associated with open-access or common-resource properties, lack of information and the lack of any market at all for the goods or services in question (World Bank 1992, pps. 10 and 64; World Bank 2003, pps. 27-28). Policy failures include situations where existing policy interventions operate against the interests of the environment, such as where state subsidies support environmentally damaging industries. The appropriate mix of instruments within the policy framework will depend on the particular situation within any country including institutional capacity (World Bank 1992, p. 13).

A key premise of the development establishment's "win-win" approach to sustainable development is that environmental limits are relative and not absolute. It is this premise that underpins the proposition put forward by advocates of the "win-win" approach, namely that a development model based on industrialization can be accommodated within environmental limits through the use of appropriate technologies, promoted by a market-orientated policy-framework. The "win-win" approach is attractive because it holds out the prospect of welfare gains in LDCs without the need for significant compromises to the lifestyles enjoyed in developed countries. If it is possible, it avoids the need to choose between achieving development goals in LDCs and achieving environmental goals both in LDCs and elsewhere.

This thesis assesses the prospects for the success of the "win-win" approach to sustainable development in LDCs. The validity of the key premise that underlies the "win-win" approach to sustainable development in LDCs relies on three broad assumptions. The first is that LDCs are able to implement appropriate, market-orientated policy frameworks. The second is that such frameworks do, in fact, promote the development and adoption of modern, environmentally benign technologies. The third is that the adoption of such technologies enables industrialization to take place within environmental limits. Each of these assumptions has to be correct if the "win-win" proposition is to succeed. The thesis assesses the validity of these three assumptions through an examination of energy-related technologies and attempts in India to promote wind power as part of a more sustainable energy system as a foundation for its pursuit of a mainstream development model based on rapid industrial growth.

The research design used in this thesis combines qualitative data gathering methodologies with more quantitative knowledge claims (Creswell 2003, p. 11; Thies 2002, p. 357). The thesis is based on the single case study of the development of wind-power in India, seeking to explore this subject in depth, using a historical, narrative approach. The approach is intended to be both descriptive and explanatory, describing the development of the energy policy framework in India and explaining how and why that has or has not facilitated the development of wind-power there. Although a single case study cannot by itself be used to substantiate a hypothesis of more general application, it can provide limited support or a specific counter-example and thus contributes to the debate (Guba and Lincoln 2004, p. 30).

The use of a case study has particular advantages that are useful in the examination of national policy development. A case study allows for the exploration of processes that are part of the world of political economy, such as institutional change (Odell 2001, pps. 169-171). The historical, narrative approach used in the case study is well suited to the study of politics and interest groups, enabling policy changes to be understood contextually (Harris 2002, p. 490; Berg 2004, p. 235). This approach allows an examination of the temporal dynamics of both agency and structure (Griffin 1993, 1098).

Selectivity and researcher bias are controlled for by a degree of reflexivity on the part of the researcher and through the use of multiple sources and/or methodologies to triangulate data and the inclusion of incongruent facts in the research account (Thies 2002, p. 355). Sources of secondary data used include: government records, reports and studies of independent commissions, reports and working papers of development agencies such as the World Bank and the Asian Development Bank and information from private sector and NGO sources. The use of diverse and multiple data sources provides for a degree of triangulation and reduces some of the risks associated with the use of secondary data such as biases in the collection of the data, errors or omissions in its processing and the fact that the purpose for which the data was collected differs to the purpose for which it is employed in this thesis.

Chapter 2 outlines how energy is a critical input to the mainstream development model of industrialization. It is argued that the existing fossil fuel dominated energy system is not sustainable and that, if the "win-win" model is to be sustainable as a whole, the energy system that underpins it must be sustainable. The Chapter describes the energy technologies that are identified as potentially contributing to a sustainable energy system and the policy measures that are advocated to facilitate their introduction. The case of wind power development in India is described in Chapter 3. The contribution of wind power and other alternative energy technologies to total energy production in India, the policies introduced to promote wind power and the impact of such policies on wind power development in India are examined. The analysis and discussion in Chapter 4 assesses the implications of the Indian case for the validity of the "win-win" approach both in India and LDCs generally.

CHAPTER 2: ENERGY, DEVELOPMENT AND SUSTAINABLE DEVELOPMENT

2.1 Introduction

Chapter 1 discussed the definition of sustainable development and examined the debate about whether the mainstream development model of industrialization can be sustainable. This Chapter examines the case of energy within the context of this sustainable development debate. If, as proposed in Chapter 1, sustaining development requires the creation and continuation of the conditions needed for development, access to modern energy services is a crucial one of these conditions. As Lovins says, energy is "pervasive, symbolic, strategically central to our way of life" and where energy policy leads other policy areas may follow (1979, p. 6). Goldemberg et al. note that in LDCs "energy systems command such a large share of development resources that energy policy cannot be considered apart from development policy generally" (1987, p. 98).

Section 2.2 describes how energy is a critical input to development and, in particular, to the mainstream development model of industrialization. Section 2.3 argues that existing energy systems dominated by fossil fuel combustion are unsustainable. Accordingly, the mainstream development model that they underpin is also unsustainable. To be sustainable, the model needs to be based on an alternative, sustainable energy system. Section 2.4 outlines the contours of such an energy system. Within the mainstream approach to sustainable development such a system is based on alternative energy conversion technologies. Market-orientated policy frameworks are seen as the means to promote the development of these technologies. RETs are one of the leading categories of these alternative energy technologies. Section 2.5 discusses the potential of wind power, widely seen as a leading RET.

2.2 Energy and Development

Energy is a critical input for meeting the most basic of human welfare needs and access to modern energy services is a critical condition for the achievement of development goals. Energy is necessary for lighting, heating and cooking. Energy is required for pumping, purifying, storing and distributing water. Energy is necessary for the provision of health and medical services. Modern medical equipment requires electricity, hospitals require heating or cooling and lighting and storage of drugs requires refrigeration. Energy inputs improve agricultural development and productivity through water pumping, crop processing and the provision of improved storage and transportation to market. Industry requires energy for heating, cooling and driving machinery. The movement of goods and people requires effective transportation, a very energy intensive sector. In addition, energy is a critical input for the provision of modern communication systems such as radio, television, telecom and the internet. (WEHAB 2002, p. 7; WCED 1987, p. 168; UNDP et al. 2000, p. 44).

Energy use is linked to a wide range of social issues including poverty alleviation, population growth, urbanization and a lack of opportunities for women (UNDP 2000, p. 7; WEHAB 2002, p. 7). A lack of access to modern energy services and reliance on traditional energy forms such as fuel-wood reinforces poverty and other social and environmental problems. The use of fuel-wood in poorly ventilated stoves is associated with significant health problems. Women and children are prevented from engaging in productive activities or education as a result of time spent searching for fuel-wood. The over-exploitation of fuel-wood sources leads to deforestation and other environmental problems. The poor often pay more to meet their daily energy needs, limiting their capacity to accumulate capital for more productive uses (UNDP et al. 2000, p. 46;

WEHAB 2002, p. 7; IEA 2002, p. 7). Access to affordable, modern energy services is seen as essential to meet the Millennium Goal of halving the proportion of people living on less than a dollar a day by 2015 (WEHAB 2002, p.10).[26]

Energy is particularly important as an input for a development model based on industrialization. This is illustrated by comparing the electricity consumption of industrialized, developed countries with that of less industrialized LDCs.[27] Table 1 compares the levels of electricity consumption in the USA, Germany and Japan, as examples of developed countries, and of China, India, Brazil and Nigeria, as examples of LDCs.[28] In 2001 the aggregate electricity consumption of the United States, with a population of 288 million, was 3687 TeraWatt hours ("TWh")[29]. China's aggregate consumption in the same year was 1397 TWh , less than half that of the United States, with a population of 1.28 billion, more than four times that of the United States. On a per capita basis, the United States' consumption was more than 10 times that of China. India's aggregate electricity consumption was just 421 TWh and its per capita consumption 30 times less than that of the United States.

These figures illustrate that the industrial economies of developed countries have much higher energy demands than those of the less industrialized LDCs. If LDCs successfully pursue the development model of industrial economic growth based on existing energy conversion technologies, their energy consumption will increase significantly. All forecasts of world energy growth point to the largest increases in energy consumption coming from LDCs (EIA 2005, pps. 1 and 67; Anderson 1997, p. 190; IEA 2001, p. 27). These increases are seen as a function of rapid economic growth and industrial expansion in LDCs combined with population increases and urbanization.[30]

World GDP is predicted to more than double from US$33 trillion to US$67.3 trillion between 1997 and 2020 (IEA 2000, p. 36). The share of all of the OECD countries is predicted to fall whilst that of LDCs is expected to increase. Much of this growth is forecast to occur in Asia, specifically India and China the economies of which are predicted to grow at annual rates of 5.5 percent and 6.2 percent respectively in the period 2002 to 2025 (EIA 2005, pps. 13-14).

It has been found that household energy consumption is strongly correlated to income (IEA 2002, pps. 368-371). If the forecast economic growth in LDCs translates into rising incomes, energy demand and consumption will increase accordingly (EIA 2003, figure 13). It is predicted that this increase will result in levels of energy demand and consumption converging on those to be found in developed countries (EIA 2003, figure 13). Even in a scenario of low economic growth in China and India, it is predicted that electricity consumption will increase from 1312 TWh and 497 TWh respectively in 2001 to 2418 TWh and 989 TWh respectively by 2025 (EIA, 2003, p. 226).

2.3 Energy and Sustainable Development

Existing global energy systems are dominated by energy conversion technologies based on fossil fuel combustion. Estimates put fossil fuels at between 80 and 90 percent of the world's primary fuel mix. This dominance is predicted to continue until at least 2020 (Goldemberg 2004, p. 3; IEA 2001, pps. 16-19). Oil is predicted to be the single largest source with 40 percent of the total mix. Natural gas is predicted to increase its share from 22 percent to 26 percent. Coal's share is predicted to decline slightly from 26 percent to 24 percent. As illustrated in Table 2, fossil fuels account for by far the largest proportion of energy consumption in each of the representative developed countries and

LDCs referred to previously (the United States, Germany, Japan, China, India, Nigeria and Brazil). Primary solid biomass is the second biggest source in each of the four LDCs (principally fuel-wood and agricultural residues).

The fossil fuel dependence of the current energy system coupled with the huge predicted growth in energy consumption in LDCs brings the sustainability of this system into question. This, in turn, brings into question the sustainability of the mainstream development model of industrialization that is based on this energy system. The un-sustainability of a fossil fuel dominated energy system derives from two facts. The first is that fossil fuels are a non-renewable resource. Their ultimate exhaustion is inevitable and will be accelerated by rapidly growing consumption. Between 1860 and 1985 the human economy's throughput of energy grew by a factor of 60. In 1989 this was predicted to grow by another 75 percent by 2020 (Meadows et al. 1992, p. 66).[31] The second fact is that the combustion of fossil fuels is associated with wide-ranging negative environmental impacts. These negative impacts will be significantly aggravated by the realization of the forecast increased energy consumption in LDCs. One of most significant and prominent of these impacts is the emission of greenhouse gases that are widely considered to be a major contributing factor to global climate change (Meadows et al 1992, p. 96; Weubbles and Jain 2001, p. 99; IPCC 2001; EIA 2005, p. 4).

Despite concerns about the exhaustion of non-renewable fossil fuel resources, industry related predictions indicate that the actual physical exhaustion of fossil fuel reserves is not likely to prove an immediate threat to the model of industrialization. Proven global reserves of oil are estimated at one trillion barrels with predicted demand between 2000 and 2020 being 730 billion barrels. Proven natural gas reserves of 164 trillion cubic meters are considered sufficient to meet predicted demand for 170 to 200 years. Estimated coal reserves in the order of one trillion tonnes are believed to be sufficient to meet demand for approximately 200 years (IEA 2001, pps. 32, 132 and 244). The UNDP concludes that the fossil fuel resource base, including both conventional and unconventional sources, is large enough to last comfortably for at least 50 to 100 years, at prices not much higher than they are today (UNDP et al. 2000, p. 148).[32]

Whilst these estimates of fossil fuel reserves suggest that this primary energy supply will not operate as a constraint on the mainstream development model in the short term, the timeframes for which predictions of the continued availability of fossil fuel resources can be made with any reliability are, in the scheme of human history, short. Reserve estimates are customarily only made for a 20- to 25-year period making larger term predictions somewhat speculative. Amongst much uncertainty in the sustainability debate, one certainty is that the continued rapid growth in consumption of fossil fuels will hasten their eventual physical exhaustion. Before such exhaustion occurs, the relative scarcity of fossil fuels will undermine their ability to continue as the basis for the energy system that underpins the model of industrialization. Such scarcity can arise from social, economic, political and unrelated environmental factors as well as physical shortages.[33] In 2005 fossil fuel supply-side constraints created concern for global economic growth prospects and therefore development prospects. The IEA's chief economist noted that as a result of higher oil prices "global economic growth will suffer" (Nickles, 2005).

In addition to the finite nature of fossil fuel supplies, the limited capacity of the environment and ecosystems to absorb emissions from fossil fuel combustion is a significant constraint on the sustainability of the existing dominant energy system and the mainstream development model. Negative environmental impacts associated with fossil fuel combustion include global climate change, acidification and other atmospheric pollution (Dincer and Rosen 1999, pps. 429-433). Currently the most prominent of these negative environmental impacts is the contribution made to climate change by greenhouse gases produced by fossil fuel combustion.[34] Together, the limited supply of fossil fuels and the negative environmental impacts from their combustion means "the ultimate limits to global development are perhaps determined by the availability of energy resources and by the biosphere's capacity to absorb the by-products of energy use" (WCED 1987, p. 58).

There is a wide degree of scientific consensus that global warming is occurring and that human activities, including fossil fuel combustion, contribute to such warming and its consequences.[35] The Inter-governmental Panel on Climate Change ("IPCC") has concluded, "the balance of evidence suggests a human influence on climate change" (Weubbles and Jain 2001, p. 99). The increase in mean global temperature between 1990 and 2000 was outside the normal variability of temperature change in the past 1000 years. 1998 was the hottest year on record, the ten hottest years having occurred since 1980 and eight of those having occurred in the last eleven years (Weubbles and Jain 2001, pps. 99 and 101). The IPCC's prediction of future changes in global temperatures is for an increase of between 1.4 and 5.8 degrees Celsius depending on whether a low or high energy increase scenario is adopted. This is two to ten times the increase between 1900 and 1990 and it concludes very likely unprecedented in the last 10,000 years (IPCC 2001, p. 8). One of the four main findings of the UN sponsored Millennium Ecosystem Assessment is that over the past 50 years "humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history" (UN 2005, pps. 16 and 18).[36]

Increased levels of anthropogenic greenhouse gases are primarily due to the combustion of fossil fuels, agriculture and land use changes. Carbon dioxide emissions are considered especially significant in the context of climate change because of their radiative forcing effect and their volume (IPCC 2001, p. 4; Weubbles and Jain 2001, p. 101). Carbon dioxide contributes 50 percent to the anthropogenic greenhouse gas effect. Fossil fuel combustion is estimated to contribute 80 percent of total emissions of anthropogenic carbon dioxide (Weubbles and Jain 2001, p. 101; EIA 2003, p. 157). As a result, emissions from fossil fuel combustion are estimated to account for half of the radiative balance changes caused by greenhouse gases (Dincer and Rosen 1999, pps. 431-432). Table 3 sets out the 1998 carbon dioxide emissions of each of the United States, Germany, Japan, China, India, Nigeria and Brazil. The combustion of fossil fuels accounts for the majority of the carbon dioxide emissions in these countries. Electricity generation is the principal culprit, except in Nigeria and Brazil where it is transportation.

The differences in per capita emissions of carbon dioxide between the developed countries and the LDCs shown in Table 3 are significant for future carbon dioxide emissions and thus global warming and climate change. Based on existing fossil fuel based energy conversion technologies, the pursuit by LDCs of a development model of industrialization will result in increased fossil fuel combustion and associated carbon dioxide emissions (EIA 2003, p. 158). This is notwithstanding expected improvements in carbon intensity as a result of increased energy efficiency. Such improvements are forecast to have a minimal impact on energy consumption growth (WCED 1987, pps. 31

and 170; IEA 2002, p. 39).[37] By 2025 LDCs are expected to contribute 46 percent of carbon dioxide emissions, up from 38 percent in 2002 whilst developed countries' share is expected to fall from 49 percent to 42 percent. The IPCC's predictions of future atmospheric concentrations of CO_2 is in the range of between 490 and 1250 parts per million (ppm) by 2100, compared to 368 ppm in 2000 and approximately 280 ppm in the pre-industrial era (IPCC 2001, p. 8).

Studies have shown that human health, ecological systems and socio-economic sectors such as water resources, food production and coastal systems are sensitive to change in the climate as well as changes in climatic variability (Weubbles and Jain 2001, p. 113). Predicted outcomes of global climate change include: a geographical and compositional shift in ecosystems leading to a reduction in biodiversity; a major impact on regional water resources as a result of changes in patterns of precipitation and evaporation; a fall in agricultural yields and productivity owing to increased temperatures and water availability; irregular and large-scale losses of living trees in boreal forests; declining productivity in marine fisheries; and a rise in sea levels of between 25 and 100 centimeters by 2100 owing to the thermal expansion of water and the melting of the ice-caps and glaciers. Any sea-level rise in the upper part of this range would have a serious impact on coastal areas causing flooding, property loss and damage, coastal erosion, salt-water infiltration and the pollution of water for irrigation and drinking. Human health would be adversely affected as disease vectors change their geographic distribution as a result of temperature changes (Weubbles and Jain 2001, pps. 113-115). Table 4 summarizes some of the more significant of these negative impacts.[38]

Although climate change may have beneficial as well as adverse consequences on environmental and socio-economic systems, the greater the change the more likely it is that the adverse consequences will prevail (IPCC 2001, p. 9). Impacts will vary by region with the tropics and sub-tropics being hit the hardest by many of the anticipated changes. Significantly, it is believed that "the impacts of climate change will fall disproportionately upon developing countries and the poor persons within all countries, and thereby exacerbate inequities in health, status and access to adequate food, clean water and other resources" (IPCC 2001, p. 32).[39] Beg et al. also argue that the most severe impacts of climate change will be in LDCs where populations are most vulnerable and least able to adapt to the consequences of climate change (132). LDCs that are more reliant on agriculture are more vulnerable to changes in temperature and water supply and quality, have less tolerance to coastal and water resource changes and have lower financial, technical and institutional capacity to adapt. It has also been noted that the degradation of ecosystem services, to which global warming and climate change contributes, is a "significant barrier to achieving the Millennium Development Goals" (UN 2005, p. 17).

Scarcity and the ultimate exhaustion of fossil fuels, the negative environmental consequences of their combustion and the disproportionate impact of such consequences on LDCs render the existing, conventional fossil fuel-based energy system incapable of delivering development that is sustainable (UNDP et al. 2000, p. 166). WEHAB says that "current energy systems are not consistent with the goals of sustainable development" and a "fundamental reorientation is required to make the transition to more sustainable energy systems" (2002, p.11). The UNDP says, "today's energy system is unsustainable because of equity issues as well as environmental, economic and geopolitical concerns" (UNDP et al. 2000, p. 3). Chapter 9.9 of Agenda 21 notes that much of the world's energy is "produced and consumed in ways that could not be sustained if technology were to remain constant and overall quantities were to increase substantially" (UN 1992b).

2.4 Sustainable Energy System

The sustainability of the mainstream development model of industrialization requires a transition to a sustainable energy system in which the production and use of energy is at least compatible with long-term human well-being and environmental limits (Spalding-Fecher et al. 2005, 99; UNDPet al. 2000, p. 3). A sustainable energy system comprises two core components. The first is increased efficiency in the production, distribution and end-use of energy. The second is the introduction of energy conversion technologies that reduce or eliminate environmentally harmful impacts (Dincer and Rosen, pps. 433-434; UNDP et al. 2004, p. 12; World Bank 1992, p. 117). Lovins says that a sustainable energy system "combines a prompt and serious commitment to efficient use of energy, rapid deployment of renewable energy sources matched in scale and in energy quality to end use needs and special transition fossil fuel technologies" (Lovins 1979, p.25). Within the mainstream "win-win" approach to sustainable development an appropriate policy framework will facilitate the development of the requisite alternate sustainable energy conversion technologies (WCED 1987, pps. 15 and 200-201; Watson, 2004, 29).

In relation to energy efficiency, globally the conversion of primary energy into useful energy services is estimated to be about 37 percent efficient. UNDP et al. state that, "more efficient energy use is one of the main options for achieving global sustainable development in the twenty-first century" (UNDP et al. 2000, p. 175). Improvements in energy efficiency can be made on the supply side, the end-use side and in transmission and distribution. On the supply-side, efficiency improvements include, for example, reducing the primary energy used to generate each unit of electricity (Hammons 2001, p. 853). End-use efficiency measures increase the level of energy services that can be provided by each unit of electricity (UNDP et al. 2000, p. 175; Reddy and Goldemberg 1990, p.112). Efficiency gains can also be made in the transmission and distribution of electricity (World Bank 1992, p. 17). The World Bank noted in 1992 that cutting transmission losses by one-tenth would reduce the power generating investment needed in the South-East Asia region by $8 billion.

However, despite the potential for improvements in energy efficiency through operational improvements and technological changes, there is less scope for reducing energy consumption in LDCs than in developed countries based on efficiency gains because of their low relative consumption compared to developed countries (Goldemberg et al. 1987, pps. 8-9). Accordingly, meeting the energy needs of LDCs as they pursue their development goals will require significant additional energy supplies (Reddy and Goldemberg 1990, p. 113). A number of alternative energy conversion technologies are potential candidates for providing these additional energy supplies in a sustainable way. These include new generation clean fossil fuel technologies, nuclear technologies and RETs.

New generation clean fossil fuel technologies include "end-of-pipe" technologies that abate emissions of sulfur dioxide and nitrous oxide and advanced combustion technologies that are more efficient, requiring less fuel and thus reducing some emissions (Rubin et al. 2004, p. 1552). Despite these improvements, these new fossil fuel technologies do not yet provide an adequate solution to the issue of carbon dioxide emissions. To be sustainable the global energy system must reduce both its energy intensity and its carbon intensity (Hammons 2001, p. 861). To stabilize greenhouse gas emission in accordance with the recommendations of the IPCC and in line with the commitments made in the Kyoto Protocol, it is necessary to switch to energy conversion technologies that emit near zero levels of carbon dioxide (World Bank 2003, p. 176).[40]

A category of technologies that supplies energy on a near zero carbon dioxide emission basis is nuclear energy technologies (UNDP et al. 2000, pps. 307-318).[41] The ability of such technologies to provide energy with virtually no greenhouse gas emissions has led to them receiving support from some environmentalists as a sustainable energy option (for example, Lovelock 2005). However, a variety of factors militate against the promotion of nuclear technologies as a viable sustainable energy option for LDCs (UNDP et al. 2000, p. 274). From a sustainability perspective, finite supplies of uranium, a non-renewable resource, raise the same issues as finite supplies of fossil fuels. Similarly, whilst the nuclear option mitigates greenhouse gases, nuclear wastes pose their own environmental challenges. In addition to these environmental issues, concerns about the safety of nuclear power plants, their costs and the danger of the proliferation of nuclear technologies for military purposes have meant that nuclear technologies have historically had few advocates.

A third category of alternative energy conversion technologies is RETs. These have the zero carbon dioxide emission advantage of nuclear technologies without any of the same disadvantages. In addition to being emission free and thus mitigating environmental and health problems, RETs are seen to have other important potential benefits. Such benefits include an increase in energy security from a diversified supply, increasing national energy self-sufficiency and improving balance of payments, the promotion of technological innovation and employment and increased flexibility given their potential for use in distributed, off-grid applications (Goldemberg 2004, pps. 3-8; RETF 2001, 17; Hoogwijk et al. 2004, p. 890; UNDP et al. 2000, p.221).[42] Reddy and Painuly state that, "Shifting from non-renewable to renewable energy technologies (RETs) should be the top priority in moving to a sustainable energy system" (2004, p.1431).

The WCED says RETs "offer the world potentially huge primary energy sources, sustainable in perpetuity and available in one form or another in every nation on earth" (1987, p. 192). This potential contribution of renewable energy sources is demonstrated by Table 5. Whilst the global RET technical potential is currently considerably smaller than the theoretical potential, it far exceeds current global electricity use by a factor of more than 100 (Johansson et al. 2004, p. 3). A review of key future energy scenarios that have investigated the potential contribution of RETs to the global energy supply indicate a contribution in the range of between 20 and 50 percent by the year 2050 (UNDP et al. 2000, p. 265; Johansson et al. 2004, p. 24).[43] Based on RETs that are currently proven and at a commercial or near-commercial stage of development it has been said that, "the physical resources and adequate technologies are available to meet the challenges of sustainable development" (UNDP et al. 2004, p. 12).

Notwithstanding their advantages and current potential, RETS only provide about 2 percent of the existing global energy supply (Johansson et al. 2004, p. 1). The realization of the potential contribution of renewable energy sources to a sustainable energy system is hampered by, among other things, inertia within the existing energy system. This is a result of existing conventional physical and institutional infrastructure and the fact that RETs cannot, in many cases, compete economically with conventional fossil fuel energy conversion technologies (Johansson et al., p. 24). The World Bank noted that between 1997 and 2020 LDCs are expected to spend some US$1.7 trillion on new electricity generating capacity, with more to be spent on transmission and distribution systems (World Bank 2003, p. 179). Given the life span of such infrastructure, policy choices made now will determine whether such investment follows a sustainable energy path or continues to lock investment into an unsustainable energy regime by reinforcing existing infrastructure, policies and lifestyles (World Bank 2003, p. 179; UNDP et al. 2000, p. 365).

In order to overcome the barriers to increasing RETs' role in the global energy system a favorable policy framework is required at the local, national and international levels. The UNDP et al. state that the decisive issues in respect of RETs are the "institutions, rules, financing mechanisms and regulations needed to make markets work in support of energy for sustainable development" (UNDP et al. 2004, p. 12). This philosophy and approach to RETs is consistent with the mainstream, "win-win" approach to sustainable development in which favorable, market-based policy frameworks will promote the development of the technologies needed to establish industrial, economic growth on a sustainable basis. Three priority areas of policy are generally identified as being necessary for the successful promotion of RETs. These are: establishing renewable energy markets, expanding the financing options available to those seeking to develop RETs and developing institutional and technological capacity (Renewables 2004, p. 34; UNDP et al., 2000, pps. 264-265).

Of these three policy areas, advocates of RETs regard the priority as ensuring that energy markets work effectively or to create such markets where they do not exist (UNDP et al. 2000, p. 416; Sawin and Flavin 2004, pps. 1 and 2). Such advocates suggest that achieving an effective market for RETs will require government intervention since the market alone will not ensure that the energy needs of the most vulnerable groups are met, that negative environmental externalities associated with fossil fuels are reflected in pricing mechanisms, or that public goods such as basic technological and scientific research are provided (UNDP et al. 2000, p. 423; RETF 2001, p. 33). The RETF says "where markets fail to secure energy services, protect the environment and secure wider access and other important public benefits, it is appropriate for governments to guide and complement energy sector reform with cost effective incentives and guarantees to encourage inclusion of renewables in the energy portfolio" (RETF 2001, p. 33).

A number of different policy mechanisms are generally regarded as necessary to create an effective market. Sawin and Flavin identify five categories of policy mechanisms (2004).[44] These are: the use of financial or fiscal incentives to stimulate development; regulations to ensure RETs have access to the electricity grid; regulations to provide for payment of a minimum price for RET generated electricity or to ensure utilities are required to purchase a minimum amount of electricity from RET sources; the creation of industry standards; and education and dissemination. In addition, indirect policy measures are regarded as necessary to support the development of a market for RETs. Such measures would create a level playing field, enabling RETs to compete on an even footing with other energy conversion technologies. Two policy initiatives are identified as necessary. The first is the ending or re-orientation of state subsidies provided to existing fossil fuel energy conversion technologies.[45] The second is the internalizing of the health and environmental costs of such technologies in their pricing. This can be done, for example, through carbon emission levies or energy taxes.

The expansion of financing options is regarded by advocates of RETs as another policy area that is important for RET development. RETs suffer from high capital start-up costs and their developers have limited access to conventional sources of finance. Bankers often do not understand the technologies involved properly and are unprepared to take the additional credit risks that such projects appear to entail over well-understood conventional energy supply projects (RETF 2001, p. 39). In order to assist with this problem, governments could provide low-interest loans or credit-guarantees to developers (Sawin and Flavin 2004, p. 20). In addition, increasing understanding of RETs and their potential would facilitate access to funding.

The third part of the proposed policy framework for promoting RETs relates to the development of institutional and technological capacity. Institutional capacity within the state bureaucracy is required in order to create, implement and enforce the other policies needed to promote RETs. Institutional capacity also includes the capacity to co-ordinate a sustainable energy policy across different economic sectors and government departments or ministries. In addition to developing state institutional capacity, it is important to disseminate information and raise the awareness of different stakeholders, develop private sector skills in relation to the successful development of RET projects and to educate financiers, all of which can be considered institutional capacity (Christensen 2004, pps. 9-13).

Increasing technological capacity involves the promotion and financing of research and development of RETs. Existing RETs have to become more cost effective and new technologies must be developed if RETs are to fulfill their potential. Luther notes that government sponsored research and development peaked in the 1980s and that the vast majority of energy-related research spending since then has been on nuclear energy technologies (Luther 2004, p. 5). The UNDP et al. state that the "technology innovation pipeline" requires "research, development, demonstration, bringing down the cost of innovative energy technologies along their learning curves" (UNDP et al. 2000, p. 265). The World Bank notes that public funding of basic research is needed if RET technologies are to succeed in large-scale commercial realization (World Bank 2003, p. 180).

2.5 Wind Power

One RET that is technically proven and at a commercial or near commercial stage of development is wind power. As with other RETs, the potential of wind-power can be divided into the categories of theoretical, geographical, technical and economic potential (Johansson et al. 2004, p. 1; Hoogwijk et al. 2004, p. 891; UNDP et al. 2000, p. 164). The theoretical potential of wind power is the total energy content of wind. Its geographical potential is the energy that can be generated from turbines situated on the land available for turbines and the quality and distribution of wind-resources in such areas.[46] The technical potential depends on the energy conversion efficiency of available technology. The economic potential is the amount of wind-power that can be economically generated given the cost of alternative sources of power.[47] Table 6 shows an estimation of the theoretical and geographical potential of regional wind power resources. Hoogwijk estimates global onshore wind-power's theoretical potential as 290 times current world energy consumption, its global technical potential as six to seven times such consumption and, at costs of below US$0.07/kWh it has the economic potential to generate the equivalent of 2001 world electricity consumption (Hoogwijk et al. 2004, pps. 893-995).

Wind power is technically proven and its estimated energy potential is huge. In addition wind power has significant environmental and other advantages over the energy conversion technologies. Wind power shares the generic environmental advantages of all RETs. The construction of wind turbines involves no potentially harmful substances so decommissioning is unlikely to be environmentally damaging. The energy payback of the turbines, which is the time it takes them to generate the energy used in their construction, is estimated at only three to four months (UNDEP et al. 2000, p. 233). Wind power is an extremely flexible energy source and can be used in a number of different applications. It has the potential to meet a significant proportion of the on-grid demand necessary for fuelling industrial and manufacturing processes and meeting the demands of large urban centers. Wind power can also be used effectively on a stand-alone basis, providing mechanical power for agricultural purposes such as irrigation. In distributed applications it has the potential to expand access to electricity in remote, rural areas that are not connected to the grid (UNDP et al. 2000, p. 230).

The positive features associated with wind power as an RET have led to the implementation in several countries of policies similar to those described in Section 2.4 above. These countries include Denmark, Germany, the USA, the United Kingdom and Spain. These policies have resulted in an increase in the installed generating capacity of global wind power projects from 2MW in 1991 to some 30,000MW in 2003 (Johansson et al. 2004, 11; Hoogwijk et al. 2004, p. 890).[48] In the past five years grid-connected generating capacity has grown at 30 percent per annum. Martinot et al. note "wind power is now the fastest growing energy technology in the world" (2002, p. 322). If the growth rate of the past decade continues until 2020 it is estimated that wind-power could meet between 45 and 50 percent of global electricity demand (Johanssen et al. 2004, p. 24, Sawin 2003, p. 91). Although this is not considered likely, meeting up to 20 percent of on-grid demand is feasible without requiring any significant engineering or operational changes to electricity grids and a contribution of between 10 and 30 percent of total on-grid electricity demand is considered possible with the right institutional framework (Sawin 2003, pps. 92-94; Johansson et al. 2004, pps. 10-11 and 15).

Supporters of wind-power and RETs argue that the implementation of appropriate policy frameworks has supported the creation of viable markets for wind-power which have stimulated further technological development contributing to cost reductions which have, in turn, further stimulated the market (Hammons 2001, pps. 856-859; Martinot et al. 2002, p. 322; Sawin 2003, p. 97). Technological developments have brought the cost of wind-power down to a level where it can be argued that, at installations in windy sites, the cost is competitive with most conventional forms of energy generation.[49] The per unit generating cost fell from US$0.44/kWh in the early 1980s to between US$0.04 and

US$0.06/kWh in 2003. Wind turbine manufacturing costs fell 43 percent between 1990 and 2000 (Sawin 2003, pps. 91 and 97; Anderson 1997, p. 195). The generating potential of a single wind turbine has increased from the 200kWh of earlier models to onshore turbines with capacities of more than 1MW onshore and offshore turbines with capacities of up to 3.5MW (Sawin 2003, p. 91; Johansson et al. 2004, p. 11). Improvements in power control mechanisms have led to better control over output and increases in power quality, making wind-generated power more suitable for integration into existing electricity infrastructure (Johansson et al. 2004, p. 10).

The advances in the promotion of technological development in the wind power sector and the growth in wind power generating capacity in certain developed countries through the implementation of a favorable policy framework that are cited by advocates of RETs may be seen to support the mainstream, "win-win" approach to sustainable development. If wind resources can be harnessed as an integral part of a sustainable energy system through market-orientated policy-frameworks, there may be reason to be optimistic that other RETs can enjoy similar success and that a sustainable energy system can be developed as the basis for environmentally sustainable industrial economic growth. However, the success that wind power has enjoyed in certain developed countries has to be replicated in LDCs before it can be heralded as a cornerstone of a new era of sustainable development based on the development model of industrialization. Those operating within the mainstream development paradigm face key challenges in the energy sector in LDCs needing:

> "first to dramatically increase access to affordable, modern energy services in countries that lack them, especially for poor countries; and secondly, to find the

mix of energy sources, technologies, policies and behavioural changes that will reduce the adverse environmental impacts of providing necessary energy services" (Spalding-Fecher et al. 2005, p. 99).

Chapter 3 examines the attempt to meet these challenges in India through the use of market-orientated policies to promote wind power as a component of their energy system. In viewing this case of wind power in India, regard needs to be had to the three assumptions that underlie the "win-win" approach to sustainable development referred to at the end of Chapter 1: that LDCs can successfully implement market-orientated policy frameworks, that such frameworks lead to the introduction of environmentally benign technologies and that such technologies enable industrialization to occur within environmental limits. These assumptions underlie the specific proposition that a sustainable energy system is achievable just as they underlie the general case for the mainstream, "win-win" approach to sustainable development and are not generally acknowledged or addressed in the literature that discusses sustainable energy systems and the potential of RETs.

The promotion and use of a market-orientated policy framework presupposes that the infrastructure for a market-based system exists in LDCs or that the institutional capacity exists to create one. It also presupposes that either populations in LDCs can afford to pay market rates or close to them for modern energy services or that governments can afford to subsidize such services. Whether such policies lead to the adoption of modern, environmentally benign technologies depends on the ability of LDCs to develop such technologies or their availability at an affordable price on the open-market. Finally, the ability to provide modern energy services on a sustainable basis is twice the challenge for LDCs as developed countries given the requirement to do so at the same time as massively expanding access to modern energy services. The very fact that LDCs do not have the institutional and technological resources of developed countries and, by definition, have considerably less financial resources raises doubts over whether the "win-win" sustainable development model can be successfully implanted in LDCs.

CHAPTER 3: WIND POWER IN INDIA

3.1 Introduction

Chapter 2 argued that achieving the mainstream "win-win" sustainable development scenario of industrialization within environmental limits requires that such industrialization be based on a sustainable energy system. As outlined in Chapter 2, wind power technology is regarded by many proponents of a sustainable energy system as a key component of such a system and a favorable market-orientated policy framework as necessary for the successful promotion of wind power. Since the early 1990s, India has attempted to introduce such a market-orientated policy framework to promote the development of wind power to help meet rapidly rising energy demands resulting from its pursuit of the mainstream development model of industrialization. This Chapter describes the steps taken to implement such a policy framework for the purpose of assessing whether the introduction of such a framework has contributed to India's ability to pursue the mainstream development model within environmental limits, that is to achieve sustainable development on a "win-win" basis.

India continues to face enormous development challenges, with an estimated one-third of its population still living in poverty (World Bank 2000, 3). It is following a mainstream development model based on rapid, industrial and agricultural growth. This growth together with population growth and urbanization, has contributed to a huge increase in demand for modern energy services. To help meet this rising demand, India has promoted RETs, in particular wind power, as part of its national energy policy framework. As a result of this promotion, India is the leading LDC in terms of installed wind power generating capacity with 2980MW of installed wind energy generating capacity by early 2004, the fifth largest in the world (Shikha, Bhatti and Kothari 2004, p. 68).[50]. Given all these factors, India's efforts to introduce a market-orientated policy framework to promote wind power provides an interesting case for evaluating the validity of the mainstream, "win-win" model of sustainable development and the assumptions on which it is based in an LDC context.

Section 3.2 outlines India's development challenges of poverty, population growth and increasing urbanization and its pursuit of a development model of rapid economic growth to try to meet these challenges. Section 3.3 describes how India's pursuit of a development model of economic growth has driven a huge and continuing increase in the demand for modern energy services and the key elements of India's national energy policy which attempts to address this demand. The role of RETs, including wind-power, within this national energy policy are outlined. Section 3.4 examines the evolution and implementation of the policy framework intended to promote wind power as a leading RET. Section 3.5 examines the growth in installed wind power generating capacity within the context of India's overall energy policy.

3.2 India's Development Challenges and Policy

Poverty

Poverty reduction has been a central focus of Indian national policy and a prime goal of its national Five Year Plans ("FYPs") since Independence. The pursuit of welfare and development goals is enshrined in the Constitution.[51] Significant progress in reducing poverty was made from the early 1970s to the mid-1980s, with the percentage of the population living in poverty falling from 54 percent in 1973-4 to 38 percent by 1985.[52] However, in the late 1980s and early 1990s the incidence of poverty increased. Although the incidence of poverty began to decline again from the mid-1990s, it was estimated in 2001 that more than 300 million people, over a third of the population, were still living on less than US$1 per day, approximately the same level as in 1997 (World Bank 2000, pps. 11 and12; World Bank 2001; IGIDR 1999, pps. 50-52). Table 7 illustrates India's performance on certain human development indicators in 2000. Whilst India's indicators compare favorably against those of the Least Developed Countries and the average for South Asia, they are significantly behind those of China, the OECD countries and the world average.

Population Growth

Rapid population growth in India has made the achievement of its human development goals more challenging. The Government of India ("GOI") has stated that "the fairly high rate of population growth neutralizes to a significant extent the fruits of economic growth" (GOI, 7th FYP, vol. 1 para. 2.7). According to the Indian census, between 1991 and 2001 the population increased from 846 million to 1028.7 million, a 21.3 percent increase (GOI, Census of India 2001). Median estimates of population growth indicate that the population will grow to 1592 million by 2050, a more than 50 percent increase on the 2001 level (UN 2004). Whilst the GOI recognizes that reducing population growth is important for the achievement of development goals, reductions in growth rates have persistently fallen short of targets set in successive five year plans (GOI, 8th FYP, vol. 1, para. 2.3.5).

Urbanization

Population growth has been accompanied by increasing urbanization in India. In 2000 the urban population was approximately 282 million, 27.7 percent of the population. The UN has predicted that this percentage will rise to approximately 37 percent by 2025 (UN 2004). The GOI's own forecast is that a 37 percent urban population will be achieved by 2011, approximately 426 million people (GOI, 8th FYP, vol. 1, Table 2.2). India also has several of the world's largest urban centers by population including Mumbai with a population of over 18 million, Calcutta with a population of nearly 13 million and Delhi with a population of approximately 11.5 million.

National Development Policy

India's national development policy has been to promote rapid agricultural and industrial growth as the means of achieving its primary development goal of poverty reduction. GDP growth has consistently been the prime macro-policy target, underlying other FYP objectives. Average per annum growth rate targets rose from 5 percent in the 7th FYP to 8 percent in the current 10th FYP. Although it is recognized that economic growth alone will not achieve India's development goals, economic growth remains the over-riding policy focus and the foundation for the achievement of other goals.[53] In the 10th FYP it is stated that it is "absolutely essential to build up the economy's productive potential through high rates of growth, without which we cannot hope to provide expanding levels of consumption for the population" (GOI, 10th FYP, vol. 1, para 1.4). Whilst the development-related goal of the 10th FYP is to reduce the poverty ratio by 5 percent by 2007 and by 15 percent by 2012, the achievement of such goals is dependant on the generation of sufficient resources through economic growth (GOI, 10th FYP, vol. 1, para 1.22).

3.3 Growth in Energy Demand and National Energy Policy

Growth in Energy Demand

India's pursuit of a development model of rapid economic growth, its rapid population increase and associated urbanization has driven a massive increase in energy consumption. In the period from the early 1950s to the year 2000, India's energy consumption has been estimated to have increased by between 800 and 1000 percent. (EIA 2004; GOI, 9th FYP, vol. 1 para. 111). To try and meet this demand, public energy expenditure under the FYPs has risen from Rs1,960 crores (US$428 million)[54] under the 1st FYP to a predicted Rs318,183 crores (US$70 billion) under the 10th FYP (GOI, 10th FYP, vol.2, annexure 3-A). At the start of the 10th FYP India was ranked 6th in the world for energy demand and this demand was predicted to continue to grow by 5.2 percent during the course of the plan (GOI, 10th FYP, vol. 2, para 7.3.1).

Transition from Non-commercial to Commercial Energy Sources

A defining characteristic of India's growth in energy consumption has been a transition from consumption of non-commercial primary energy sources to commercial energy sources.[55] Table 8 illustrates the trends in the changing patterns of primary energy consumption from 1953 to 1997. By 2002 commercial primary energy use had increased to 75 percent of total primary energy use, reversing the ratio of commercial to non-commercial energy use that existed in 1953-1954 (GOI, 9th FYP, vol. 1, para. 6.25). At the same time the mixture of the sources of commercial energy has changed (see Table 8). Coal has decreased from approximately 80 percent of the commercial energy mix to 29 percent and petroleum products and electricity have increased from 17 and 3 percent respectively to 48 and 17 percent. These changes reflect the growth of the transport sector and the expansion of access to modern energy-services in households, industry, agriculture and business.

Growth in Electricity Consumption and Generating Capacity

Electricity's increase from 3 percent to 17 percent of the commercial energy mix represents a growth in electricity consumption of approximately 274 percent since 1985 and almost 100 percent since 1990 as illustrated in Table 9. Electricity demand is predicted to rise by a further 200 percent or more by 2025 from 497 TWh to between 989 TWh based on a scenario of low economic growth and 1248 TWh based on a scenario of high economic growth (EIA 2004, p. 226). Installed electricity-generating capacity increased by 271 percent between 1987 and 2005 from 42,585MW to 115,544MW (GOI, MOP, Installed Capacities of Power Utilities). Table 10 illustrates existing installed generating capacity, divided by primary fuel feedstock.

Shortfall in Generating Capacity as Constraint on Growth

Notwithstanding large increases, generating capacity in India has not kept up with the growth in demand for electricity (Banerjee and Taplin, 1999). Ambitious targets for additions to generating capacity under successive FYPs have not been met. Under the 8th and 9th FYPs the actual installation of capacity fell respectively 46 percent and 47 percent short of the targeted additions (Thakur et al., 2005; GOI, 9th FYP, vol.2, para. 6.54; GOI, 10th FYP, vol. 2, para. 8.2.2). In the 9th FYP the GOI recognized that meeting forecast demand would require the addition of more capacity by 2012 than had been added between 1953 and 1995 (GOI, 9th FYP, vol. 1, para. 111). As a result of a lack of generating capacity, India continues to experience power shortages in almost all states

(World Bank 2000; United States, DOE; GOI 10th FYP). These power shortages have a negative impact on India's ability to pursue and implement its development policy of rapid industrial and agricultural growth. In the 2002-2003 Economic Survey it was reported that, "Scheduled power cuts, unscheduled outages and incorrect voltages are common in most states, leading to enormous disruptions in all aspects of economic life." (GOI, MOF, ES 02/03, para. 9.7).

Key National Energy Policy Objectives

The absence of reliable, quality power is recognized as a key barrier to the success of India's high-growth-oriented policy (IGIDR 1999, p. 123). The GOI notes that "the energy-transport infrastructure will be a major constraint on any effort to achieve a significant acceleration in the growth of GDP during the Tenth plan period" (GOI 10th FYP, vol. 1, para. 1.82). A primary objective of India's national energy policy is to overcome the constraint on economic growth imposed by the lack of an adequate and reliable power supply through demand-side management and increases in generating capacity. The 10th FYP has targeted the addition of 46,939 MW of generating capacity during the Plan period. However, a further 100,000 MW, or a near doubling of current generating capacity, is needed if supply is to keep pace with forecast demand (GOI, 10th FYP, vol. 2, para 8.2.3; GOI, MOF, ES 02/03 para. 9.8).

A second major focus of Indian energy policy is the reduction of reliance on petroleum imports, seen as a matter of national security (GOI, 10th FYP, vol. 1, para. 1.17). India relies on imports for 60 to 70 percent of its requirements, rendering its balance of payments vulnerable to changes in global oil prices (Asian Development Bank, "Key Indicators"). In the context of increasing power generation demands, reducing reliance on petroleum means promoting alternatives to oil as primary energy supplies for power generation. A third important component of India's energy policy is expansion of access to clean, modern energy services in rural and remote areas for uses such as pumping water for drinking and irrigation, heating, cooking and lighting, thereby improving the welfare of rural populations (see, for example GOI, 7th FYP, vol. 1, para 2.62; GOI, MOP "About Rural Electrification").[56] Interest in RETs, including wind power, has been stimulated by the potential contribution that they can make to each of India's three national energy policy objectives

Wind Power Potential

As illustrated in Table 11, the Ministry of Non-Conventional Energy Sources ("MNES") currently estimates that wind-power in India has a gross generating potential of approximately 45,000 MW and a technical generating potential of nearly 13,400 MW. This compares with pre-1999 estimates of gross generating potential of 20,000MW and technical generating potential of 9,000MW. The upward revisions are a result of improvements in the data available for prospective wind power sites and improvements in technological design. The design improvements have increased the range of sites considered to have commercial potential and improved the operating efficiencies of the wind turbines, including increasing their size and improvements in the capacity of the grid to take power from such intermittent sources.[57]

India's wind-power potential is a result of strong winds during the summer and winter monsoons, with winds being strongest in the period from May to September. The wind-power potential is not evenly distributed throughout the country. The greatest potential is located in the south and west. The states identified with the highest potential are Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka, Kerala, Madhya Pradesh and Maharashtra. Table 11 shows the estimated wind resource potential and installed capacities in the States with the greatest potential. Maharashtra is estimated to have the highest technical potential at 3040MW with Tamil Nadu, Gujarat and Andhra Pradesh having roughly equivalent potentials of approximately 1800-1900MW.

3.4 Wind Power Policy Framework[58]

The development of India's wind power policy framework can be divided into the three priority areas of policy development for the promotion of RETs identified in Section 2.4. These three areas are the creation and expansion of markets, the provision of financing alternatives and the development of institutional and technical capacity. Sections 3.4.1 to 3.4.3 describe policy developments in each of these areas. Although examined separately, the three areas of policy are inter-linked. The development of institutional and technical capacity provides the capability to implement policies for market development. At the same time, the availability of reliable, economically competitive technology attracts investors to wind power development and makes financing wind power projects a sounder proposition. The provision of financing options assists interested parties to enter the wind power market.

India's wind power policy development falls into two broad phases separated by the fiscal crisis in India in 1990-1991. Prior to 1990, during the 6^{th} and 7^{th} FYPs, the focus of policy was to promote technological development through the use of government sponsored demonstration projects. RETs, in particular wind power, were seen as useful for mechanical and other direct end-use applications, such as pumping and heating, as well as for electricity generation either in stand-alone applications or on a decentralized, local grid (GOI, 7th FYP, vol. 1, para 2.62).[59] There was little direct effort in these early years to stimulate market development.

After the fiscal crisis, during the 8th FYP, policy focus switched to the rapid commercialization of wind power technology. Such technology was now seen to be able to make a broader contribution to India's national energy objectives (GOI, 9th FYP, vol. 2, paras 6.46-6.47; GOI, 10th FYP, vol. 2, para. 8.2.101). Given the parlous condition of government finances, one of the main goals of the revised policy framework has been to attract private sector investment by developing a profitable market for wind power. The switch to a market-led approach for RET development is consistent with broader macro-economic attempts to liberalize and reform key economic sectors following the fiscal crisis in order to attract increased private investment.[60] One such sector was the power sector.[61]

In addition to introducing its own policy measures through MNES, the central government has sought to encourage State governments to follow-suit and adopt policies that are attractive for market-based development of RETs generally and wind power in particular. In 1993 MNES issued a set of guidelines to the States (the "MNES Guidelines") setting out the policies and incentives that they ought to adopt for the promotion of grid-quality electricity generation from renewable sources (Hasan and Vipradas, 2004; GOI, MNES, Guidelines). Implementation of policies based on the MNES Guidelines has been inconsistent across states and through time. Tables 13 and 14 provide summaries of the current status of existing central and state government policies relating to wind power.

3.4.1 Development of the Market

This Section 3.4.1 examines the policies introduced by the central and state governments to create a market for wind power. It examines the introduction of financial and fiscal incentives for wind power developments, the provision of access to electricity grid for wind generated power and the mandating of minimum prices or purchase requirements in respect of wind power. It also discusses the extent to which Indian policy makers have sought to create a "level playing field" that would allow wind power to compete in the market place on an equal footing with conventional electricity generating technologies.

Fiscal and Financial Incentives

The main focus of central government policy has been to provide financial and fiscal incentives for the development of wind power. During the early phases of wind power development the principal thrust was direct financial support for demonstration projects. The central government continues to provide direct financial support for demonstration projects in States that have seen little or no wind power development to date. However, the principal focus of central government support for the development of wind power switched to indirect fiscal incentives during the 8^{th} Five Year Plan. The fiscal incentives currently provided by the central government include:

- 100 percent accelerated depreciation of the project cost in the first year of operation, now reduced to 80 percent depreciation;
- a 10 year income tax holiday;
- relief from excise duty for wind operated electricity generators and their components and parts;

- favorable customs duty rates on specified wind turbine parts including electricity generators and parts for their manufacturer and turbine blades and parts and materials for their manufacture.

(GOI, MNES, 2004; GOI, MNES, Wind Power Programme, Fiscal and Financial Incentives; Kumar 2002).

In addition to these incentives, the MNES Guidelines suggest that the wind power policy framework adopted by the States include:

- exemptions from electricity duty for renewable power projects ;
- exemptions from sales tax for renewable power projects; and
- the granting of industry status to renewable power projects so that they can benefit from the exemptions from taxes and duties and capital subsidies enjoyed by industrial projects from time to time.

Tamil Nadu was one of the first states to introduce policies based on the MNES Guidelines. In addition to introducing an exemption from sales tax for wind power projects Tamil Nadu offered a 10 percent capital subsidy to wind power projects of up to Rs15 lakhs (US$35,000). The central and state government fiscal incentives were particularly attractive to large, profitable industrial concerns in the cement and textile sectors in Tamil Nadu during the mid-1990s. Tax credits and accelerated depreciation helped them shelter profits from tax through the establishment of wind power projects and such projects provided captive generating capacity that reduced reliance on an unreliable state power supply (Jagadeesh, 2000; Shikha, Bhatti and Kothari, 2004). Central and state government fiscal and financial incentives helped to fuel a boom in the installation of wind power capacity in India during the mid-1990s as illustrated by Figure

1. Installed capacity rose from 54MW in 1993 to 900MW in 1997, of which 630 MW was added in Tamil Nadu, approximately 75 percent of the total (Jagadeesh, 2000).

The fiscal environment provided by central and state governments has not been uniformly and consistently favorable to wind power project development. In July 1996 the GOI introduced the Minimum Alternate Tax ("MAT"). Under this regime profitable companies that had hitherto managed to shelter taxable profits using wind power tax incentives were taxed at a flat rate of 12 percent on their profits, removing a significant driver of wind power investment (Mishra, 2000; TERI 1999; Jagadeesh 2000). The introduction of MAT coincided with a reduction in general corporate tax rates and a slow-down in the economy as a whole. Both of these reduced the overall tax burden on companies and their motivation to utilize wind power fiscal incentives to reduce their tax bills.

In the late 1990s the Tamil Nadu government withdrew the 10 percent capital subsidy it had previously offered. In addition, it increased the financial burden on wind power developers by imposing a new levy of Rs0.10/kWh for the withdrawal of power from the grid by wind farms when the turbines start-up (known as "reactive power"). Overall, from 1997 through the remainder of the 1990s the fiscal and financial environment for wind power investment worsened significantly, notwithstanding that the specific central government incentives remained in place. Only 267MW of additional wind power capacity was installed in India between 1997 and 2000, less than a third of that between 1993 and 1997. Only 43 MW of capacity was installed in Tamil Nadu between 1997 and 1999.

Since the year 2000, the fiscal and financial environment for wind power project development has improved once more. In particular, a number of states other than Tamil Nadu have started to offer attractive policies for wind power investment. Since 1999 MNES has been actively negotiating with states to have them implement policy frameworks in line with the MNES Guidelines, including the fiscal and financial incentives. By 2002 MNES reported seven states as having implemented polices to encourage private sector participation in wind energy electricity generation, increasing to nine states by 2004 (GOI, MNES, AR 2001-2002, para. 5.2; AR 2003-2004, para. 5.6.9). There are now 14 states with such policies in place. Table 12 summarizes the key policies implemented in Andhra Pradesh, Gujarat, Maharashtra and Tamil Nadu, the leading four states in terms of wind power resource and potential.

Both Gujarat and Maharashtra now have policies that are more attractive overall than Tamil Nadu. From a fiscal and financial policy perspective, Gujarat exempts 30 percent of installed capacity from electricity duty whilst Maharashtra provides a 30 percent capital subsidy up to a maximum Rs20 lakhs (US$46,000). In addition, Maharashtra announced a revised wind power policy framework in February 2004 that includes the state providing financial contributions to the cost of establishing infrastructure for a wind power project, such as sub-stations, power lines needed to evacuate power to the grid, and the building of access roads (MEDA, 2004). In June 2002 Gujarat announced its new wind power generation policy, the previous policy having lapsed in 1998 (GEDA, 2002). Under this policy 766 hectares of land had been set aside for the project developers under a new land policy that allows the state government to lease wasteland to wind developers for a period of 20 years (Baad, 2005).

Policies implemented in Maharashtra have contributed to installed wind power growing faster there than in Tamil Nadu since 2000 with 111MW installed between 2001 and 2002 compared to only 42MW in Tamil Nadu.

Access to Grid

Ensuring that the power from wind power projects has access to and can be transmitted over the electricity transmission grid and distribution networks is critical to the development of a market for wind power. The sites of wind projects are often not proximate to existing electricity transmission infrastructure requiring interconnections to be constructed. The intermittent nature of wind resource and the power generated by it imposes operational strains on electricity transmission grids that require stable power inputs to function effectively. In addition, transmission networks are often owned by a state-owned monopoly, as is the case with the SEBs in the Indian states. For all these reasons, providing the necessary grid access for wind power can be problematic. Accordingly, a critical piece of the MNES Guidelines is the guideline that wind power producers should be able to transmit their power over the state-owned electricity grids to third party customers (known as "wheeling") or for their own (captive) use at a uniform charge of 2 percent of the energy fed into the grid, irrespective of the distance transmitted.

The provision of grid access, albeit limited, was another part of the wind power policy framework introduced in Tamil Nadu in the early 1990s, contributing to the successful promotion of wind power there in the 1993 to 1997 period. However, like the favorable fiscal and financial incentives this access was withdrawn in the 1996 to 1997 period. As detailed in Table 12, Tamil Nadu now does allow transmission of wind power on the grid but only for captive consumption and not for sales to third parties. Even for captive generation access is only permitted for certain categories of high-tension customers (GOTN, Consultative Paper).[62] The charge for this is 5 percent of the energy transmitted, the highest charge of the four states listed in Table 13 and well above the MNES Guidelines suggestion of 2 percent.

A recent report of the Confederation of Indian Industry in Tamil Nadu called on the state to allow third party sales, improve the tariff offered and allow wheeling to all high-tension customers to make investments in its wind power sector more attractive and competitive with other states (Business Line, 2005). However, as Table 12 shows, Tamil Nadu is not alone in being slow in introducing policies relating to grid access based on the MNES Guidelines. Of the four leading states listed, only Maharashtra allows wheeling for sales to third parties and has a tariff at the MNES suggested rate of 2 percent of the energy transmitted.

The central government has recently tried to stimulate greater access to the grid for renewable power projects. The Electricity Act 2003 contains provisions that mandate non-discriminatory access to a state's transmission networks and for phased access to its distribution networks. The GOI hopes that these provisions will provide the open access regime necessary to stimulate the expansion of the wind power market.

Minimum Prices

Ensuring the developers of wind power projects can get a minimum price for the power they generate is the third piece of a policy framework critical to the development of a wind power market. Some form of long-term price guarantee is necessary to ensure that private investment can be attracted by the economic returns available in the wind power sector. In addition, such price guarantees provide a pre-determined revenue stream over the life of a project, which assists in the securing of financing for wind power projects. The MNES Guidelines recommend that the state electricity boards purchase the electricity generated by renewable power projects at a minimum rate of Rs 2.25/kWh, with an escalation in this minimum price of 5 percent per annum from 1994-1995 for 10 years and to enter into power purchase agreements with a term of 20 years, extendable by 10 years.[63]

The introduction of policies based on this MNES Guideline has been slow. As before, Tamil Nadu initially introduced an attractive tariff but withdrew it in the late 1990s when it set the tariff for new wind power projects below that for existing projects with no escalation for inflation. As shown in Table 12, Andhra Pradesh, Gujarat and Maharashtra all currently offer a higher price per kWh than Tamil Nadu and all offer some form of indexing to account for inflation. The Electricity Act 2003 provides that one of the responsibilities of the State Electricity Regulatory Commissions ("SERCs") is to mandate that a certain percentage of electricity must be purchased from RETs and that this percentage should rise progressively.

A Level Playing Field

The creation of a level playing field for energy conversion technologies has been held to require an end to subsidies to conventional fossil fuel technologies, the internalization of the costs of the environmental and health costs associated with the combustion of fossil fuels in their prices and price support for RETs whilst they gain market acceptance. Subsidies can be provided both to generators of power and to consumers of power.[64] Polices relating to price support for RETs have been discussed above. These include fiscal and direct financial incentives as well as polices mandating minimum prices for power generated or minimum percentages of power to be bought from RET sources. The remainder of this section discusses the subsidization of power generated from conventional fossil fuels technologies and the internalization of environmental and health costs.

No firm data was found to support the existence of direct subsidies to the central government owned public sector electricity generating undertakings, such as the National Thermal Power Corporation. Some data indicated that these central public sector undertakings operate on an independent financial basis, covering their operational and capital costs from their revenues. As of April 2002 the Administered Price Mechanism, which regulated the prices of coal and petroleum products, has been dismantled removing a mechanism through which the central government was able to indirectly subsidize the central and state public sector electricity generating undertakings by keeping the price of the primary fuel feedstock low as against world market prices (GOI, 10th FYP, vol. 2, para. 7.3.86).

However, other data indicates that the central government continues to provide both direct and indirect financial support for the public sector thermal, hydro and nuclear generating entities. One example, is that under the 2005-2006 budget the central government will provide direct equity support to these undertakings of Rs14,040 crores (US$321.5 million) (GOI, MOF, Plan Investment in Public Enterprises). Indirect financial support is provided through a number of programs aimed at developing these sectors. The Accelerated Power Development Programme was launched in 2000-2001. This provides financial assistance to the states to renovate and modernize their existing thermal and hydro generating plant (GOI, MOF, ES 2001-2002). In 1998-1999 the Indian government launched a mega-project policy that is designed to promote the maximum generation at the lowest possible tariff by exploiting economies of scale. Projects for over 1000MW enjoy a number of advantages including expedited regulatory clearances and favorable customs duty regimes. Only large-scale thermal or hydro generating plants are able to take advantage of these favorable regimes. As shown in Table 14 public expenditures in each of the thermal, hydro and atomic generating sectors remain very high. These expenditures are at least implicitly underwritten by the state, a form of indirect financial support.

Whilst the position relating to subsidies is not entirely clear at the central public sector electricity undertaking level, at the state level the public sector undertakings of the SEBs that own the state-owned thermal and hydroelectric generating infrastructure, continue to receive considerable direct and indirect financial support from both the central and state governments. The financial losses of the SEBs, have contributed to state governments running substantial budget deficits. Transfers from the central government to the states which help to finance their budgets and these deficits are, in effect, an indirect central government subsidy to the SEBs and their conventional fossil fuel and large scale hydroelectric power generating plant.

The state governments also provide direct subsidies to the SEBs to cover their operating losses. In the financial year 2004-2005 direct transfers from the state governments to the SEBs totaled Rs9, 825 crores (US$2.1 billion). In that year there was an additional uncovered subsidy to the SEBs of Rs17,530 crores (US$3.84 billion), up from Rs3231 crores (US$700 million) in 1991 to 1992 (GOI, MOF, ES, 2004-2005, para.

91.4). The central government has also provided financial support to the SEBs through its program of arranging the securitization of their outstanding dues to central public sector undertakings. Pursuant to this scheme the states have had access to capital markets that would not have otherwise been open to them. 27 states have issued bonds totaling Rs29,883 crores (US$65.4 billion).

Very little progress has been made in India towards including the negative externalities of conventional energy technologies, such as environmental and health costs, in their pricing. Any additional cost of wind energy generated electricity as compared to the cost of thermally generated electricity does not reflect the positive externalities of wind power. Although there are practical and political problems to internalizing the costs of such externalities, the practical difficulties, such as how to estimate the costs, are not insurmountable (UNDP et al., 2004). Suggestions for internalizing such costs have included carbon or energy taxes or the implementation of emissions trading systems. In India, the move by the state of Maharashtra to introduce a carbon tax to fund a Green Fund to be used to help develop the RET sector may be seen as a first step in the right direction on this front (MEDA, 2004).

3.4.2 Development of Financing Capability

The availability of financing for wind power projects is an important part of the successful development of a viable wind power sector. Three factors contribute to the difficulty of financing such projects. The first is their relatively high start up costs, estimated in India to be between Rs 4.5 and 5.5 crores (US$1 million and US$1.2 million) (GOI, MNES, Economics). The second is the unfamiliarity of mainstream banks with wind power electricity generation technology and its financing risks as compared to conventional power generation technologies, particularly at early stages of development. The third is the difficulty of securing the revenue streams to repay financing and/or finding security as collateral for the projects. In relation to this third factor, the parlous financial condition of the SEBs throughout the 1990s meant that they were likely to default on their payment obligations under private power purchase agreements with wind power developers. Any financing of wind power projects was vulnerable to such default since these payments constituted their revenue stream (Mishra, 2000).

It is in this context that the establishment by the GOI of the Indian Renewable Energy Development Agency ("IREDA") has been seen to play an important role in the successful development of the wind power sector in India. Jagadeesh describes it as playing a "crucial role" whilst Martinot et al. note that "the availability of commercial financing for wind power in India in the 1990s, through the Indian Renewable Development Agency, was one of the key factors facilitating the market expansion that took place" (Jagadeesh, 2000, p. 162; Martinot et al. 2002, p. 336). IREDA was established in 1987 as an autonomous public sector undertaking under MNES to provide concessional financing and support to RETs, including wind power. It has provided financing to the wind power industry in three categories: project financing, equipment financing and manufacturing financing.[65] Under its current lending terms, the rates of interest range between 9 to 11 percent, as against market rates of at least 11 percent.[66] Loans are repayable over between 7 and 10 years with a moratorium on the repayment of principal for the first year. Loans of between 70 and 100 percent of the project cost are available (IREDA, Wind Energy).

In the mid-1990s IREDA disbursed some Rs119.5 crores (US$26 million) in loans to wind power projects at the then interest rate of 13.5 to 14 percent. At that time the prevailing market interest rate was 16 to 18 percent. This concessional financing contributed to the addition of 49.9MW of installed capacity (Mishra, 2000). An increase in its lending rate to 18 percent in 1996 is considered to be another contributing factor to the slow down in capacity addition in the late 1990s (Jagadeesh 161 and 166; Shikha, Bhatti and Kothari, 2004, 247). As at 2004, IREDA had sanctioned some Rs 2082.41 crores (US$455 million) of loans to wind power projects of which Rs1265.01 crores (US$276 million) had been disbursed. These amounts represented approximately 33 percent and 37 percent of its total loan sanctions and disbursements respectively (GOI, MNES, AR 2003-2004, para. 10.5). In 2003-2004 it introduced a new, shorter-term loan of between 7 to 8 years for wind power projects with lower interest rates. The GOI makes an annual contribution to IREDA's lending operations and allows it to raise finance through issuing tax-free bonds in the Indian capital markets (GOI, MNES, AR 2002-2003, para. 9.2). In addition to these sources it relies on funding from multilateral agencies. The World Bank, the Danish International Development Agency (DANIDA), the Asian Development Bank, the Global Environmental Facility and the Government of The Netherlands have all provided financing.

The significance of IREDA's role is not just the funding that it has provided directly. Its early funding helped the commercial wind power sector to grow. This growth and the successful performance of IREDA's loans led to other financial institutions extending finance to wind power projects. These have included the Industrial Development Bank of India, the Industrial Credit Investment Corporation Limited, the

Industrial Finance Corporation of India and the Power Finance Corporation (Mishra 2000). Although these other financial institutions have typically not offered as favorable lending terms as IREDA, with shorter loan periods and no grace periods, they nonetheless attracted about 70 percent of the business in the sector because of "their established loan approval procedures, easy accessibility, single-window facility and their countrywide presence" (Mishra, 2000, 7).

3.4.3 The Development of Capacity

(a) Institutional Capacity

Central Government Institutional Development

The earliest step in the establishment of Indian institutional capacity for the development of RETs, including wind power, was the establishment of the Commission for Additional Sources of Energy ("CASE") in 1981. CASE's mandate was to promote research and development in the area of new and renewable sources of energy. In 1982 alternative energy was promoted to departmental status with the establishment of the Department of Non-Conventional Energy Sources ("DNES") within the Ministry of Energy and CASE was moved to DNES. The establishment of CASE and DNES were part of a broader drive under the 6th FYP to push sustainable and environmental issues in government policy-making.[67] In 1992 DNES was upgraded to full ministry status as the Ministry of Non-Conventional Energy Sources. India is unique in being the only country in the world to have a government ministry dedicated to non-conventional and renewable sources of energy (GOI, MNES, AR, 1999-2000, para. 1.3).

State Government Institutional Development

At the state-level, state-nodal agencies ("SNAs") have been established to foster the development of RETs. This took place primarily under the 6th and 7th FYPs (GOI, 8th FYP, vol. 2, para 8.72.2). The SNAs provide a focal point for the development and dissemination of RETs in the states and are responsible for the development of RET policies within the states. Thirty states and union territories currently have SNAs. An example is the Tamil Nadu Electricity Development Agency ("TEDA") formed in 1986 to pursue and promote non-conventional energy programs in Tamil Nadu (GOTN, Energy Dept. Policy Notes, 2002-2003). MNES cannot impose its policy frameworks directly on SNAs and state governments. However, it does issue guidelines and has used the states' reliance on the GOI for a substantial part of their funding as leverage in negotiations with the states to secure the implementation of policies at the state level based on its guidelines.

MNES's Mandate

MNES's mandate extends to all RETs and new energy technologies.[68] Its objectives in relation to wind energy, are to supplement power generation from conventional fossil fuels, promote rural electrification and provide energy for water pumping (GOI, MNES, AR 1999-2000, para 1.4). MNES's functions include policy-making and planning, program formulation and implementation, technology research, development and commercialization, the promotion of demonstration projects and the provision of fiscal and financial incentives. MNES aims to oversee the orderly development of the wind-power sector through its Wind Power Programme (GOI, MNES, AR, 1999-2000, 6). CASE continues to exist within MNES as the principal policy-making body and it meets several times each year. It co-ordinates research and development programs and ensures the implementation of government policy.

Policy Development

Prior to 1993, MNES was organized along technology lines. Each RET, including wind power, was promoted through technology design and development support and the establishment of demonstration projects by or with the support of MNES. The objectives of the policy and programs were to create an indigenous technology and manufacturing base, to create a demand for RETs through the use of government financial incentives and to raise public awareness of the potential of RETs through education and training programs (GOI, 7th FYP, vol. 2, para. 6.187 and 6.202). The focus was on technology development and demonstration, with an emphasis on rural energy program applications (TERI 2000). Under the 6th FYP, MNES spent a total of Rs3.32 crores (US$726,000) installing 1000 windmills for pumping drinking water and irrigation (GOI, 7th FYP, vol. 2, para. 196). In the 7th FYP the budget for wind power was Rs20 crores (US$4.4 million). Fifty percent of this budget was for research and technology, aimed at bringing down costs, improving wind data and developing medium to large wind-powered generators (GOI, 7th FYP, vol. 2, para 6.220).

Under the 8th FYP the focus of MNES's RET policy, including wind power, shifted away from subsidy-driven dissemination and demonstration programs to technology promotion through large-scale commercialization with an emphasis on the cost effective generation of grid quality power (GOI, 8th FYP, vol. 1, paras. 1.4.27-1.4.28; TERI 2000). In 1993 MNES issued a "New Strategy and Action Plan" which added the generation of grid-quality power from wind energy, small-scale hydro power, bio-energy and solar power as a policy priority alongside meeting rural energy needs. The new strategy and plan had three limbs: to continue to provide government support for demonstration programs; to provide concessional financing through the Indian Renewable Energy Development Agency ("IREDA"); and to provide fiscal, financial and other incentives for the private sector (TERI 2000). As part of this shift in direction, MNES was internally reorganized in 1993 along end-use lines. It was divided into three main divisions: the rural energy division; the urban and industrial energy division; and the power division. This reorganization aimed to create more emphasis on developing the market linkages needed to commercialize RETs and attract greater private sector involvement.

In 1999-2000 MNES formulated a National Renewable Energy Policy that is intended to form the basis for a smooth transition from a fossil fuel economy to a sustainable economy on the basis of RETs (GOI, MNES, AR 1999-2000, 7). This policy development reflected a growing awareness within the Indian energy policy-making establishment of the potential of RETs within the overall energy supply mix. The three main objectives of this policy are to meet minimum rural energy needs, to provide decentralized energy systems and to provide a supply of grid-quality power generation. At the time of writing, this new policy has not been published although some elements have been incorporated in the new Electricity Act 2003.

Policy Co-ordination

Ensuring that different aspects of RET policy development and implementation are coordinated and that RET policy is coordinated with other aspects of the overall national energy policy is challenging. As part of its institutional infrastructure, MNES has a division that handles coordination of renewable energy and wind power policy matters (GOI, MNES, AR 1999-2000, para. 2.5). It prepares, monitors and implements the non-conventional energy aspects of the FYPs, provides reports to the Prime Minister and Cabinet, interfaces with other ministries and co-ordinates all matters relating to financial and fiscal incentives for RETs in India. In the 10th FYP, the GOI recognized the need for greater coordination between the different ministries responsible for conventional, nuclear and non-conventional energy (GOI, 10th FYP, vol. 2, para. 8.6). As a result the Apex Committee of Experts has been created to provide such coordination and drive greater integration in energy policy making. MNES is represented at the ministerial level on this body along with the Ministers of Power, Coal, Petroleum and Natural Gas, Finance, External Affairs, Railways, Department of Atomic Energy, Planning Commission and others (GOI, 10th FYP, vol. 2 para. 7.3.32).

Development of Human Capital

To develop the human capital needed to implement renewable energy programs, MNES organizes training programs for its own officers and those of the SNAs. Officers attend training programs both within India and abroad, where they gain experience in international best practice in management, policy and technical aspects of RETs (GOI, MNES, AR 1999-2000, para. 2.10). Between 1999 and 2004 some 37 national training programs were run and approximately 40 MNES officers participated in international training programs (GOI, MNES ARs, 1999-2004). To raise public awareness of the potential of and developments relating to RETs, MNES runs an Information and Public Awareness Program to inform the public and stakeholders about developments in RETs. Together with the SNAs, MNES also runs a Special Area Demonstration Program. This involves the setting up of energy parks in which various RETs are demonstrated. MNES and the SNAs share the costs of these programs (GOI, MNES, AR 1999-2004).

Financing and Technological Institutional Capacity

Two other institutional developments have been important to India's wind-power program. The first is the establishment of the Indian Renewable Energy Development Agency ("IREDA") under the 7th FYP in 1987 as an autonomous public sector undertaking under the MNES (GOI, 8th FYP, vol. 2, para 8.72.2). It is discussed in more detail in sub-section 3.4.2 below. The second institutional development is the establishment of the Center for Wind Energy Technology (C-WET) in 1999 as the focal point for fostering the development of indigenous wind technology in India. C-WET is discussed in more detail in below.

(b) Technical Capacity

Demonstration Projects

Demonstration projects have been an important component of India's wind power policy framework because they raise public awareness of wind power potential, illustrate the viability of wind power technology, allow valuable operating data to be obtained and stimulate the development of necessary project capacity and experience within SNAs and other agencies (GOI, MNES, AR 1999-2000, 57; Hammons, 2001). Demonstration projects are examples of "learning investments" which result in a reduction of costs owing to improvements made as a result of "learning by doing" (RETF, 2001, 44).[69] Hammons says of the demonstration projects that, "Their role in catalyzing and accelerating the [wind power] program can hardly be over-emphasized" (Hammons, 2001, p 857). Demonstration projects have been implemented through the SNAs, state governments and state electricity boards ("SEBs) with financial support from MNES.

The 6th FYP period saw the development of small scale demonstration projects for wind-power technology. They were designed to demonstrate the viability of and to improve existing technology. They were largely related to the mechanical uses of wind power in the agricultural sector.[70] Under the 7th FYP the focus of demonstration projects shifted to developing wind power technology for electricity generation. 32MW of generating capacity were installed in demonstration projects in Gujarat, Tamil Nadu, Orissa and Maharshtra, utilizing turbines of up to 55kW (GOI, 8th FYP, vol. 2, para. 8.72.10). By 2002-2003 demonstration programs with an aggregate capacity of 63MW were installed, with the majority of the capacity in Gujarat and Tamil Nadu (GOI, MNES, AR 2002-2003, para. 5.16; Table 12). In 2002-2003 two demonstration projects had achieved wind turbine availability of 95 percent and capacity utilization factors of 23 and 32 percent (compared to an average 17 percent), indicating dramatic improvements in operational performance.

Despite the shift in overall wind policy objectives from technology demonstration to large-scale commercialization, demonstration projects continue to be an important part of the development of the wind power sector in states that have seen little wind power development to date (Hammons, 2001). Under MNES's current policies, 60 percent of the costs of the equipment, installation and commission of a wind-power generating demonstration project are met by central financial assistance, with a ceiling of Rs3.5 crores (US$765,000) per MW (GOI, MNES, "Wind Power Programs"). The remaining costs are met by the state entity that is involved. Projects are eligible in states that have announced a policy framework for the promotion of wind power generation by the private sector. Financial support is no longer available in Tamil Nadu, Maharashtra or Gujarat since they are considered to have sufficient commercial development already. Under the policies, a demonstration project can be no more than 2MW in capacity and a state can have no more than an aggregate of 6MW of demonstration capacity.

Research and Development

Alongside demonstration projects, indigenous research and development into RETs has been a priority of the wind power program since the 6th FYP period (GOI, 7th FYP, vol. 1, para. 1.16). As with the demonstration projects, the early focus of technology development was on rural applications and the use of windmills for pumping. During the 7th FYP the focus of research and development shifted to reducing costs and improving the operational performance of wind energy technologies for power generation in order to facilitate this commercialization (GOI, 7th FYP, vol. 2, paras. 6.202 and 6.220). By the 8th FYP period the primary focus of MNES's wind power development program had shifted away from research and development and demonstration to outright commercialization (GOI, 8th FYP, vol. 2, para. 8.73.1). However, as with demonstration projects, research and development remains an important component of MNES's wind power program. Power generation from wind is a MNES "thrust area" for RET research and development (GOI, MNES, R&D/Technology Development).

In its 2003-2004 Annual Report MNES states that the goals of its research and development program are to indigenize all wind power related design and engineering by 2012, to support Indian technology so that it will become a net foreign exchange earner by 2012, to raise the capacity utilization factor of wind turbines from an average 17 percent to an average 25 percent by 2012 and to continue with its training and resource assessment and siting programs (GOI, MNES, AR 2003-2004, para. 5.6.5). The current emphasis of MNES's approach to research and development is to encourage the private sector to lead research and development initiatives. Under its Industrial Research and Development Policy MNES will support 50 percent of the costs of approved research and development projects carried out by the private sector, either in-house or through an academic institution (GOI, MNES, R&D/Technology Development).

Manufacturing Capacity

The implementation of demonstration projects and promotion of research and development has stimulated the creation of an indigenous Indian wind turbine manufacturing capacity. Early wind turbine technology was almost exclusively imported. By the 8th FYP Bharat Heavy Electricals Limited ("BHEL") had developed a 55kW wind turbine and was working on a 200kW turbine (GOI, 8th FYP, vol. 2, para. 8.72.10).[71] Three other manufacturers of wind turbines were present in India by that time and the path for indigenization of wind power technology was set. There are currently 10 to 12 domestic Indian manufacturers of wind turbines, most of which partner with a developed country company either through licensing technology or in a fully-fledged joint venture.[72] The annual wind turbine manufacturing capacity in India is 500MW and wind power electricity systems of up to 1.25MW are being indigenously manufactured (GOI, MNES, Wind Power Program, Manufacturing Base). MNES estimates that the technology used by Indian manufacturers is 80 percent indigenous (GOI, MNES, AR 2001-2002). Imported technology is needed only for wind power generating systems with the highest capacities.

As well as encouraging an indigenous manufacturing capacity, MNES has supported efforts within the industry to ensure that the technology is adapted to Indian wind regimes. These regimes tend to have lower wind speeds, and different climatic and other environmental conditions to those experienced in Europe and North America where the leading global wind turbine manufacturers are based. Advances in technology have included a transition from fixed speed, asynchronous induction generators to variable speed synchronous machines (TERI 2000, 38). MNES has sponsored a program to develop an intelligent power controller at the Electronic Research and Development Centre which maximizes power generation and reduces the reactive power drawn from the grid when the wind turbines start-up.[73] These developments facilitate the integration of larger capacity machines and wind power developments into the Indian grid systems, which are relatively weak.[74] Five of the manufacturers are ISO certified and some of them are increasingly catering to export markets (Kumar, 2002).[75]

C-WET: Institutionalizing Technological Development

The establishment of C-WET as an autonomous institution operating under MNES, in 1999 at Chennai in Tamil Nadu represented an important step forward for India's indigenous wind power technical capacity (Shikha, Bhatti and Kothari, 2004). C-WET is intended to serve as a focal point for technical development and a center of technology excellence (C-WET, Organization). C-WET carries out in-house research and provides a coordinating role for other wind power research and development programs within industry, academic institutions or other bodies. It aims to disseminate research and development information for the overall benefit of the industry, promoting cost-effective, high quality wind power. Current projects being conducted by C-WET include investigations into factors impacting the effective integration of wind power projects into the Indian grid and studies into reasons for the failure of gearboxes, critical components in wind turbines. A Research and Development Council has been constituted to develop policies and to guide the direction of research and development (C-WET, Research).

Technology Certification

An important part of C-WET's role is the certification of wind power electricity generating systems and the enforcement of technology standards in the Indian manufacturing industry. Early imported wind power generating system technology was certified by internationally accredited standards organizations.[76] The standards set by these organizations proved to be inappropriate for the performance of the imported technology under Indian environmental and climactic conditions. One of the problems experienced by the wind power sector in India following the boom in installed capacity between 1993 and 1996 was the poor operational performance of some wind turbines. This reduced the returns from them and discouraged further investment (TERI 1999). MNES issued its first guidelines regarding technology certification in 1995 with revisions following in 1996, 1997 and 1999 (GOI, MNES, AR 1999-2000, 71). The 1999 revision provided for self-certification by manufacturers in accordance with the guidelines. As a result, State electricity boards, concerned about quality issues arising in a self-certification system, started to demand indemnity bonds from developers and suppliers, creating an additional hurdle to the implementation of projects (TERI, 1999, 16).

In 2000 MNES re-introduced the need for third-party certification, now through the Type Approval-Provisional Scheme of C-WET, referred to as TAPS-2000 (GOI, MNES, AR 2000-2001, para. 5.2.4). This scheme aims to promote the establishment of uniform codes, standards and technical criteria for the design, manufacturing and operation of wind turbines (C-WET, TAPS). TAPS-2000 is a provisional certification scheme pending the issuance by MNES of the final scheme. The scheme is issued by MNES and implemented by C-WET. The purpose of the certification scheme is to help build confidence in the industry in the quality of the wind turbines and to promote high quality technology in the sector. The certification procedure applies to all grid-connected, horizontal axis wind turbines with a rotor sweep area of more than $40m^2$. Eight Indian designed and manufactured turbines have been issued TAPS 2000 certificates ranging from 230kW to 1.25MW capacity (GOI, MNES, AR 2003-2004, para. 5.6.5). A wind turbine testing facility has also been established under the auspices of C-WET in order to enable it to carry out its certification procedures.

Wind-Power Resource Assessment

India's wind resources assessment program ("WRAP") also now falls under C-WET. Detailed mapping of wind resources is critical to the successful development of wind power programs. In India, the Institute of Tropical Meteorology began one of the world's largest efforts at wind resource assessment in 1985. This comprised wind monitoring, wind mapping and complex terrain projects (Shikha, Bhatti and Kothari, 2004; Jagadeesh, 2000). The mapping was carried out by the Institute's Field Units with the assistance of SNAs. In 1985 the Wind Energy Data Handbook was published. This was followed by the publication of data in the Wind Resource Survey of India of which there are now 6 volumes. By 2004 the program had set-up some 1050 wind monitoring stations in 25 states and union territories. 211 sites had been identified as having commercial wind power electricity generating potential based on a wind density of 200watts/m^2 (GOI, MNES, AR 2003-2004, para. 6.6.4). This data is supplied by C-WET to SNAs and other state bodies and to wind project developers at a nominal cost. In addition, MNES and the SNAs have prepared "Master Plans" for 87 of the sites identified as having commercial potential. These plans provide micro-survey wind data, topographical information and other information pertinent to wind power project development such as grid availability, the quality of the grid and ease of access to the site (Shikha, Bhatti and Kothari, 2004).

3.5 Wind Power in Context

India's wind power policy framework as outlined in Section 3.4 cannot be seen in isolation from its overall energy policy. The three principal objectives of this policy are to increase the generation of grid quality power to ensure that its development strategy of rapid economic growth is not constrained, to expand modern energy services in rural areas and to reduce reliance on petroleum imports thereby increasing the country's energy security. RETs, including wind power are regarded as able to make a contribution to meeting these objectives. The National Energy Policy published in February 2005 stated that it is important that non-conventional energy sources are exploited to the full and that "with a view to increase the overall share of non-conventional energy sources in the electricity mix, efforts will be made to encourage private sector participation through suitable promotion efforts" (GOI, MOP, National Electricity Policy, para. 5.2.20).

Although there is recognition of the contribution that RETs can make, India's energy policy statements have continuously asserted that RETs, including wind power, will only be a supplement to and not a substitution for conventional energy conversion technologies (GOI, 10th FYP, vol.2, para. 8.2.101). Accordingly, the principal focus of India's energy program has been to increase power generation from its thermal, hydro and nuclear resources. In the 9th FYP it was stated that:

> "The major problem of the power sector is the optimum generation mix. In the short run, dependence on gas based and oil based plants seems to be inevitable for meeting the power demand on account of the relatively shorter gestation periods of these sources. However, in the long run, the optimum mix has to be planned in such a manner that bulk of the base load requirements will have to be met from coal based thermal electricity, supplemented by nuclear electricity to the extent possible, while the peak requirement has to be met from hydroelectric stations and oil/gas based power" (GOI, 9th FYP, vol. 1, para 1.116).

This focus is reflected in the profile of India's currently installed and planned electricity generating plant and public sector expenditures on electricity generating plant.

Table 10 shows the profile of India's installed generating capacity. As at 31 January 2005 the total capacity was 115,544MW. The thermal power generating capacity of 80,201MW represents 69 percent of the total and coal-based thermal generation capacity of 67,165MW approximately 58 percent of the total. Hydropower capacity of 30,135MW represents approximately 26 percent of the total. Installed wind power generating capacity of 2,488MW represents 2.1 percent of the total. In 2002 the total net generation of electricity was 547.2 billion kWh (US, DOE, Table 13). Total wind power electricity generation was 2.4 billion kWh, 0.4 percent of the total (GOI, MNES, 2004). Over the period from 2000-2012 the Indian government has targeted the addition of 10,000MW of generating capacity from all RETs. This is intended to be 10 percent of the proposed total capacity addition of 100,000MW during this period (GOI, MOP, "Integrated Action Plan", para. 3). The Tenth Five Year Plan has a target of an additional 3,075 MW to be generated from RETs, 1,500 MW of from wind-power (GOI, 10th FYP, vol. 2 para. 927).

Table 14 sets out the public spending on thermal and hydro generation taken together, nuclear generation and non-conventional energy source ("NCES") generation over the 7th to 10th FYPs. Over the period, aggregate spending on thermal and hydro power generation was Rs302,851 crores (US$66.3 billion). Aggregate spending on non-conventional energy source generation was Rs12,952 crores (US$4.4 billion). Under the 7th FYP spending on NCES generation was equivalent to 1.5 percent of spending on thermal and hydro generation. By the 10th FYP this percentage increased to 4 percent. Spending on nuclear generation was almost 4 times higher than spending on NCES generation under the 10th FYP. Spending under the 10th FYP was projected to increase by 221 percent for thermal and hydro generation, 280 percent for nuclear generation and 85.6 percent for NCES generation.

India has ample resource reserves to support its reliance on thermal coal, hydroelectric and nuclear power generation. It has the world's 7th largest reserves of coal, an estimated 214 billion tonnes. These are estimated to be sufficient for 300 years based on current production and usage (US, DOE). The country's hydroelectric generating potential has been assessed at 148,700 MW with an additional pumped storage potential of 94,000MW (GOI, 10th FYP, vol. 2, para. 7.3.16). Only 30,135 MW of hydro generating capacity had been installed as at January 2005 (Table 11). India has relatively limited reserves of uranium at 30,000 tonnes but extensive thorium reserves of 500,000 tonnes (Banerjee and Taplin, 1997). Nuclear energy is regarded as having the potential to generate 350,000MW of electricity and to meet all of India's energy needs (GOI, 9th FYP, vol. 1, para. 1.115). The installation of an additional 10,000MW of nuclear generating capacity has been targeted for 2011-2012 (GOI, 10th FYP, vol. 2, paras. 7.3.3 and 7.3.16).[77]

CHAPTER 4: DISCUSSION

4.1 Introduction

It is a key premise of the "win-win" approach to sustainable development that environmental limits are not absolute. This premise is the basis for the view or belief that a development model based on industrialization can be accommodated within environmental limits. This is to be achieved by the use of appropriate technologies, promoted by market-orientated policy frameworks. If this approach to sustainable development is to succeed in an LDC context the three underlying assumptions referred to at the end of Chapters 1 and 2 must be borne out.

The first assumption is that LDCs are able to design and adopt the market-orientated policy frameworks considered necessary to stimulate the development and adoption of environmentally benign technologies. The second assumption is that, if adopted, such policy frameworks do, in fact, lead to the development and implementation of such technologies. The third assumption is that the development and implementation of such technologies will result in industrial economic growth proceeding within environmental limits.

Section 4.2 examines the extent to which each of the three assumptions underlying the premise of relative environmental limits are supported by the case of wind power in India as described in Chapter 3. It concludes that this case provides, at best, only limited support for the three assumptions in the case of wind power. In the context of that conclusion Section 4.3 discusses the alternative technologies that may be suggested as having the potential to be the basis of a sustainable energy system in India. It concludes that the prospects for a sustainable energy system in India based on the currently available alternative technologies are limited. Accordingly, there appears to be little support in the energy context for taking a policy approach to sustainable development based on the concept of weak sustainability. Section 4.4 examines the implications that the Indian case may have more generally for the prospects of sustainable development in other LDCs based on the "win-win" approach.

4.2 Evaluating the case of wind power in India

Since the 1980s India has developed institutional capacity for the promotion of RETs, including wind power. This capacity resides principally with the central government and, to a lesser degree, at the state level. Such capacity as exists has enabled the formulation and adoption at both the central and state government levels of some policies in each of the areas considered key to promoting the adoption of wind power. These include policies for financial and fiscal incentives for wind power investments, for the provision of debt financing for wind power development and for promoting the technical capacity needed for wind power development. In 2004 India was ranked as having the fifth largest installed wind power capacity in the world. Its installed capacity increased 2000 per cent, in the ten years from 1994 to 2004. These advances in installed wind power capacity are attributed by most commentators to the favorable policies introduced in those years.

Notwithstanding the positive developments in each of the three key policy areas described in Chapter 3 and the growth in installed capacity, significant shortcomings remain in the adoption and implementation of an appropriate market-orientated policy framework for the promotion of wind power in India. These shortcomings bring into question the first of the assumptions that underlies the "win-win" approach to sustainable development being, in this case, that India has the capacity to implement the elements of a market-orientated policy framework that are necessary to promote wind power.

One such shortcoming is that the states have been slow to introduce the policies suggested by the MNES Guidelines. Although more states have introduced some of the suggested policies in recent years, key aspects of the Guidelines continue to be largely ignored. One of the most important examples is a widespread failure to allow access to the electricity grids for the sale of wind power to third parties. This severely restricts developers' ability to sell wind power and limits the "market" to a single monopoly buyer, the state electricity board. The policies introduced by the states have also been inconsistent over time. Tamil Nadu provides one of the most striking examples of this. Here adverse policy changes in the late 1990s virtually halted wind power development in the state and it has yet to recover. As Puri says, "The highest priority for those in the renewable sector is a uniform RE [renewable energy] policy" (2004, pps. 23-24).

A second significant shortcoming is that virtually no progress has been made to create a level-playing field on which RETs can compete on even terms with conventional electricity generating technologies. The direct and indirect subsidization of conventional generation technologies and the subsidization of electricity consumption by agricultural and domestic consumers both continue. No meaningful steps have been taken to ensure that the pricing of fossil fuel based electricity generation reflects the costs of the negative health and environmental externalities associated with such generation. Each of these factors works to keep the cost of conventionally generated electricity artificially low. This ensures that higher priced power from wind developments is discriminated against in the market place.[78] As Jagadeesh says "If the tariff for conventional power is corrected and a level playing field is provided wind energy systems will be commercially viable and become competitive" (1998, 162).

The central government's Electricity Act of 2003 contains provisions that are intended to address several of the existing policy shortcomings, including those described above. Measures contained in the Act include the mandating of open access to electricity grids allowing third party sales, rationalization of tariffs, an end to consumer subsidization and mandating the purchase by state electricity boards of specified quotas of power from RETs. Although, as with the MNES Guidelines, these provisions look good on the statute book, there remains considerable uncertainty as to whether they will lead to the implementation of the intended policies. Puri notes that the impact of the Electricity Act on the development of RETs "can only be marginal, without encouragement from the state governments" but that state regulators "have rarely shown a sympathetic attitude towards renewables" (2004, pps. 23 and 24).

Pessimism regarding the likelihood that the Electricity Act will provide any significant impetus to a fuller implementation of a market-orientated policy development for wind is justified on several fronts. In Tamil Nadu the response to the Electricity Act requirement to rationalize tariffs and end the cross-subsidization of agricultural and domestic consumers for power has been to increase subsidies to consumers, effectively negating the tariff rise (GOTN, Energy Policy Notes 2004-2005).[79] The requirement that a certain percentage of power bought by the SEBs be generated by wind power depends on the SEBs having the financial resources to pay the tariff set for such power. This remains problematic owing to the poor financial condition of the SEBs. This is a structural issue and is discussed below. Provisions in the Act mandating open access for wind power to the states' electricity grids is dependant on both the technical and operational ability of the grid networks to accommodate such an intermittent source of power. This ability is uncertain owing to weaknesses of the grids.[80] Thakur et al. conclude that "the Electricity Act 2003 is largely, and almost completely silent on matters concerning the environment" other than stating that the promotion of efficient and environmentally benign policies is one of its objectives (2005, p. 1996).

A number of reasons for the shortcomings in the existing policy regime can be identified. The first reason is political. In India, the central and state governments have concurrent jurisdiction over power. It is the central government that has taken the lead on formulating market-orientated policies relating to RETs and wind power through MNES. However, the central government has limited ability to ensure the adoption of such policies at the state level. At the state level, support for RETs and for the policies proposed by MNES has been limited. Since the late 1990s, the central government has used the poor financial condition of the state governments and the state electricity boards as leverage to persuade the states to adopt wind-power policies based on the MNES Guidelines in return for central government financial support. It is not clear that the central government will continue to have the financial resources to exercise this leverage, that it will continue to use such leverage for renewable energy policy purposes or that the state governments will remain vulnerable to such leverage.

India is the world's largest democracy. In a democratic system the dominant political party within the central government has to keep its coalition partners happy. Puri noted in relation to the then impending 2004 elections that "the ruling National Democratic Alliance government is likely to concentrate on more populist policies. In the process, critical issues, such as renewables, the environment and national policy may take a back seat" (2004, p.24). Similarly the policies of state governments are dictated to some degree by the need for the governing parties to keep their electorates happy. With over a third of India's population still living in poverty, it is no surprise that power policies that increase the price of power are unpopular with large parts of the electorate and therefore politicians. Sapru notes "the public in India has not provided a necessary clientele to the environmental protection bureaucracy" (1998 p. 175). In a democracy, the state has few tools for driving through change that people do not regard as being in their interests.

A second explanation for the shortcoming of the market-orientated policy framework for wind power development is the continued financial weakness of the SEBs. This is a structural constraint that infects the whole electricity sector in India. It is a major barrier to the implementation of policies by the states that are favorable to wind power. Tongia says, "the principal problem for the Indian power system is its financial insolvency" (2003, p. 23). This is caused by the low tariffs that the SEBs charge their agricultural and domestic consumers. Attempts to cross-subsidize these tariffs by charging industrial users higher tariffs merely results in industrial users establishing their own captive generation. This, in turn, further reduces the revenues available to the SEBs.

Despite attempts to address this issue through reforms of the electricity sector in the 1990s, the average cost recovery of the SEBs in 2001-2002 was only 68.6 per cent, down from an average 82.2 per cent in 1992-1993 (GOI, MOF, ES, 2002-2003, Table 9.5). The financial weakness of the SEBs means they do not have the financial resources to pay wind developers the premium necessary to make the generation of wind power profitable.[81] This undermines any efforts to introduce policies that mandate minimum tariffs for wind power or establish minimum purchase requirements for power generated from RETs. Since raising prices of power to end consumers is politically very difficult, subsidies endure and the financial condition of the SEB's remains poor.

A third explanation for the shortcomings in the Indian market-orientated wind power policy framework is that wind power and other RETs are not a priority within India's overall national energy policy. As noted in Chapter 3, notwithstanding a commitment by the central government to increase the power generated by RETs, the principal thrust of national energy policy is focused on conventional fossil fuel power generation, large-scale hydro generation and nuclear generation. It is indicative of this focus that the National Renewable Energy Policy formulated by MNES in 1999-2000 has not been adopted as official government policy. After disappearing from sight for a period it was effectively reissued by MNES in late 2005 as the New and Renewable Energy Policy Statement (GOI, MNES 2005). Puri notes, in relation to the progress of RETs in India, that "the absence of a National Policy is proving to be the vital missing link" (2004, p.23). Thakur et al. state that "it is likely that environmental concerns take a back seat, more so because the government is preoccupied with the challenge of providing reliable and affordable supply to all as a matter of priority" (2005, p. 1196).

Deployment of grid-interactive renewable energy is the fourth and last of the priorities listed in the New and Renewable Energy Policy Statement. As discussed in Chapter 3 and illustrated by Table 14, this low priority is reflected in the public spending dedicated to non-conventional energy sources. This amounted to a mere 4 per cent of the total spent on thermal and large-scale hydro generation in the 10th FYP. Such spending also represents a declining percentage of the public expenditure dedicated to nuclear power generation. In the 7th FYP expenditure on non-conventional energy sources was 81 per cent of spending on nuclear power, in the 10th FYP only 22 per cent.

A 2002 Report of the Planning Commission states that, even under a best-case scenario, RETs will likely only meet 5 per cent of India's total energy needs by 2020 unless a massive and aggressive commitment is made to developing RETs (GOI, Planning Commission, 2002, pps. 70-73). This level of commitment is not evidenced either in word or deed by the Indian energy policy-making establishment, whether at the central government or state levels. Given the shelf-life of power related infrastructure, the dominance of thermal, hydro and nuclear power within the Indian energy policy matrix makes it likely that the contribution of RETs to Indian power needs will be dwarfed by these technologies for the next 30 to 40 years at least.

The dominance of the energy policy matrix by conventional energy technologies may also be attributable to the interests of powerful political, bureaucratic and commercial groups that support the status quo. Stewart notes that political economy can prevent the adoption of the "best" technology in developing countries, with structures that support a sub-optimal technology solution combining scientists, politicians, bureaucrats and capitalists (1982, p7). In the context of a sustainable energy system, wind power technology is viewed within the "win-win" scenario as a "best" available technology. Any change in a particular technology choice and promotion will only be effective where incumbent interests, or some of them, see themselves as winners as a result (Stewart, 1982). Since a major reorientation of the India's energy policy away from conventional generating technologies threatens significant interest groups aligned with such technologies, the prospects for such a reorientation are slim.

In India, notwithstanding that a unique institutional infrastructure dedicated to non-conventional energy sources exists, there is a massive, countervailing conventional energy institutional infrastructure. At the central government level, arrayed against MNES are the Ministry of Coal, the Ministry of Petroleum and Natural Gas, the Ministry of Power and the Department of Atomic Energy. In addition, to this bureaucratic infrastructure are the central government state-owned enterprises which include, for example, the National Hydroelectric Power Corporation, the National Thermal Power Corporation (coal) and various other state-owned entities relating to the exploration, development and production of oil and natural gas. Each of these parts of the Indian policy-making institutional framework has a vested interest in the continuation of the status quo. Sapru notes how the majority of resources are concentrated in the hands of the central government that tends to support large-scale development (1998, p.159). This is exemplified by the existence of the Accelerated Power Development Program and Indian government's "mega-project" policy referred to in Chapter 3.

The continued dominance of conventional energy institutional arrangements and the primacy of the interest groups that support them explain the inadequacies of India's environmental policy framework generally. The Ministry of Environment and Forests has no mandate to interfere in the work of other Ministries other than where environmental impact assessments are required. Notwithstanding the requirements for such assessments on many major thermal or hydroelectric power projects, the Ministry lacks the resources to make such assessments an effective tool of environmental policy or sustainable development (Bara 1997, p.197). Bara notes that present-day policies for dealing with the environment are fragmented, sector-orientated and "woefully inadequate", including a lack of institutional capacity and appropriate human capital (1997, p. 197).

In a similar vein, Sapru notes that in India, state-owned entities own most of the polluting industries and control the important natural resources (1998, pps. 162-163). Indian industrialists are well connected at the central and state government levels and the environmental policy-making process is highly politicized and therefore dominated by the industrialists' interests. There is big gap between environmental rhetoric and policy-making and the effective enforcement of even existing environmental policies (Parikh 1999, 95).

As noted above, India has made virtually no progress in introducing regulations to reflect the negative environmental externalities associated with fossil fuel combustion in the prices of fossil fuel generated power. Ways to do this are, for example, to restrict or tax emissions. Experience with existing environmental regulations in India suggests that, even if such policies are introduced, they are unlikely to be effective. A strong political commitment at both the central and state government levels is needed to create the institutional and administrative capacity to properly address environmental issues in the context of the development model of industrialization. There is no evidence of such a political commitment in India and little reason to suppose it will be forthcoming in the absence of an obvious mandate from a sufficiently broad or influential section of the electorate. This poses a conundrum for LDCs given that significant improvements in standards of living are generally required before the environment is preferred by people over development.

The second assumption underlying the premise of the "win-win" scenario of sustainable development is that the adoption of environmentally benign technologies will follow from the introduction of the requisite market-orientated policy frameworks. This assumption needs to be tested against the success or otherwise of the policies described in Chapter 3 in promoting the development of wind power. Growth in installed wind power capacity in India since a market-oriented approach was adopted after the fiscal crisis in 1991 can be broadly divided into four phases. These four phases match the fluctuations and changes in the policy framework as described in Chapter 3. The four phases are reflected in Figure 1. In the period from 1990 to 1994 115MW of installed capacity were added. From 1995 to 1997 capacity addition increased substantially, with 846MW of installed capacity added. From 1998 to 2001 investments fell off and only 440MW of capacity were added. In the period 2002 to 2004 investment increased again with the addition of 1143MW of installed capacity.

The overall growth in installed wind power capacity has been 2000 per cent between 1994 and 2004 and the World Watch Institute described India in 1998 as the "new wind super power" (Shikha, Bhatti and Kothari 2004, p.68). However, although the level of investments in installed wind power capacity appears responsive to the wind power policy environment, this apparent success of the Indian wind power policy framework is not as clear-cut as it may first appear. One factor that tempers such apparent success is the discrepancy between the nameplate capacity (being the stated MW capacity) of installed turbines and their operational performance. Technical problems have adversely affected the performance of the turbines and the ability for the power they generate to be integrated into the grid. As a result the turbines often do not operate to their nameplate capacity, reducing the contribution that they have made to overall power supply in India (Amin 1999, 997).

The discrepancy has partly been a result of the use of investment based fiscal incentives rather than incentives tied to production. Investment incentives provide little incentive for developers to install the best technology. The use of inferior technology has resulted in low capacity utilization (often less than 20 per cent (Amin 1999, 997). In some circumstances developers have failed to maintain or even operate their wind power developments. Given the lack of production-based incentives and a genuine market for the sale of the power to third parties this has little adverse economic impact on the developers, whose upside has been the utilization of up-front tax incentives. Indeed, much of the wind power development in the 1990s was driven more by tax planning of industrial concerns than a genuine interest in wind power as an RET with real commercial potential. Notwithstanding the considerable policy attention in India on the development of technical capacity described in Chapter 3, operational performance within the wind power sector remains sub-optimal and a barrier to widespread adoption.

A second factor that tempers the apparent success of the wind power policy framework is that wind power development in India has been relatively localized. Although more states have been introducing favorable policy regimes, Tamil Nadu continues to represent more than 50 per cent of the total installed wind power capacity in India. Tamil Nadu's installed capacity represents 72 per cent of its assessed technical wind power potential. Accordingly, even if more favorable policies are to be re-introduced in that state, there is little scope for significant wind power growth there. By comparison, the installed capacities in Andhra Pradesh, Gujarat and Maharashtra represent only 5 per cent, 11 per cent and 7 per cent of their respective technical potentials. Each of these states thus appears to have considerable headroom for significant further wind power development.

There are, however, significant hurdles to the realization of the potential in these other states. The maintenance and enhancement of existing favorable market-oriented wind power policies in such states will not be enough. Jagadeesh's study of Tamil Nadu found that the success of wind power development there was a result of several non-wind policy related factors that may not be present in other states (2000). These include the existence of good road infrastructure, the happenstance of indigenous wind turbine manufacturers being located in Tamil Nadu, the boom in the textile and cement industries there which made the fiscal incentives offered for wind power particularly attractive in the mid-1990s and the Chennai Port having excellent facilities for the importation of machinery. Replicating the success of wind power development in Tamil Nadu clearly requires more than a favorable wind power policy framework. Such a policy framework is merely a necessary but not a sufficient condition for the promotion of wind power technologies.

Whether other states in India that have a significant wind resource have the necessary infrastructure to support wind power development is a question for future research. However, it has been suggested that there is a correlation between the lack of wind power development in certain areas that have greater wind resource than Tamil Nadu and the less developed ancillary and supporting infrastructure in those areas

(Shikha, Bhatti and Kothari, 2004). Without a proximate market for the power that has been generated (as with the textile and cement industries in Tamil Nadu) there is little incentive for wind power development. The only alternative is the building of extensive and expensive transmission networks. Given the dire condition of India's transmission network it is unlikely that resources can or will be dedicated to building out the transmission network to the remote areas where the best wind resources are often located.

The third assumption that underlies the premise of the "win-win" approach to sustainable development is that the adoption of environmentally benign technologies will enable industrialization to take place within environmental limits. The case of India, as described in Chapter 3, does not support this assumption. There are no grounds to believe that wind power can be other than a marginal part of the overall power supply for India as it continues to pursue its ambitions for rapid industrial and agricultural economic growth. Despite the headline figures on India's growth in installed wind power capacity mentioned above, MNES's report that wind power has made a "significant" contribution to India's grid-quality power installed capacity rings hollow.

As at the end of 2004 MNES reported that total installed wind power capacity was 2,980MW (MNES, Newsletter, 40). India's total installed power generating capacity as at the start of 2005 was 115,544MW. Wind power capacity, notwithstanding the heralded 2000 per cent growth from 1994 to 2004, was a mere 2.57 per cent of total installed capacity. In terms of actually generated power, as noted in Chapter 3, wind power represented a mere 0.4 per cent of the total in 2002. This is a considerably lower percentage than the 2.57 per cent of installed capacity. The difference between wind power as a percentage of installed capacity and as percentage of power generated is an indicator of the poor capacity utilization and other operational failings of wind power developments. The remaining 97.43 per cent of installed capacity and 99.6 per cent of power generated is based on conventional power generating technologies, principally coal-based thermal generation and large-scale hydroelectric generation.

The 10th FYP has targeted the addition of 3,075MW from RETs, with 1,500 from wind power (GOI, 10th FYP, vol. 2, para 927). If this growth in wind power is achieved it will represent more than a 50 per cent increase in installed capacity over the course of the 10th FYP. The Indian government's overall stated objective regarding RETs is to increase power generated from them by 10,000MW by 2012, a target that presumably includes the targeted increase in wind power over the 10th FYP. If this 10,000MW were achieved based entirely on wind power India would have close to its currently stated technical potential for wind power of 13,400MW. This would be 11.6 per cent of India's existing installed capacity, an improvement on the current 2.57 per cent. However, as noted in Chapter 3, the total targeted increase in generating capacity over the same period to 2012 is 100,000MW, bringing total installed generating capacity to 215,544MW by 2012. The current maximum technical potential of wind power of 13,400MW would only be 6.2 per cent of this total. It is reasonable to assume that wind power's contribution to actual power generated will continue to be a lower percentage than this installed capacity percentage.

Even assuming that all the shortcomings relating to wind power development in India and the structural causes of such shortcomings can be ignored or overcome, the total contribution that wind power can make to India's power generation will remain marginal based on current forecasts of India's total power demand and its estimated wind power resources. The current assessed gross, or theoretical potential for wind power in India is 45,000MW. This potential is insignificant set against a total hydroelectric generating potential of approximately 242,000MW and an estimated potential for nuclear generation of 350,000MW. Given the shortcomings in India's policy framework, technical issues relating to the operational performance of wind power developments and the importance of factors other than wind polices to the growth of more than 50 per cent of India's installed capacity in Tamil Nadu there is little likelihood that wind power will achieve even its limited potential in India in the next twenty years. Accordingly, it cannot be concluded that wind power can provide a significant contribution to a sustainable energy system in India.

4.3 Alternatives for a Sustainable Energy System

If wind power, the leading RET in terms of its technological development and economic competitiveness, cannot provide more than a marginal contribution to a sustainable energy system in India are there alternatives that can provide the basis for such a system? Chapter 2 outlined some of the other potential technological contributors to a sustainable energy system. These include other RETs, such as solar and small-scale hydro developments, technologies aimed at achieving greater efficiency in power generation and consumption, so-called clean varieties of conventional coal-based power generating technologies and nuclear generating technologies. Although a detailed review of the potential of these alternatives from a sustainable energy perspective is a subject for further research, some general observations can be made.

As described in Chapter 2, all RETs face similar barriers to adoption. In the Indian context all RETs fall under the remit of MNES. There is no reason to assume that the structural constraints that have limited the growth in wind power will not place similar limitations on the development of other RETs. Other RETs are not yet as economically competitive as wind. The IEA has said that "the average costs of renewable electricity are not widely competitive with wholesale electricity prices" and that "grid-connected solar PV is not yet competitive, except in locations with extremely high retail power rates" (REN21 2005, p. 11). This provides reason to assume that the pace of their adoption will be even slower, particularly in a market-orientated policy environment in which consumers will look to the lowest cost options for their power.

In addition to being uncompetitive, other RETs have not yet developed a capacity to generate quantities of power needed to input into the grid for supplying the rapidly growing urban and industrial centers in India. Grid-connected solar photovoltaic power is starting to grow in the United States, Japan and Germany but is still only installed on a meager total of 400,000 households in those three countries (REN21 2005, p.7). Certain RETs that have distributed applications have the ability to meet the power requirements of remote or rural centers. This includes biomass power generation and small-scale hydropower generation. However, these technologies generally do not replace demand for grid-quality power as the demand centers they serve are not connected to the grid at present.

The potential for efficiency gains to make significant contributions to a sustainable energy system are limited by the fact that the per capita consumption of modern energy services is so low relative to that of developed countries. Table 1 illustrates this. In India, per capita electricity consumption was a mere 408kWh in 2001, compared to 12,896 in the United States, 7,907kWh in Japan and 6,806kWh in Germany.

Although efficiency improvements are part of the Indian' government's overall energy policy there are a number of obstacles to achieving the state efficiency goals. One obstacle is that achieving efficiency gains is challenging, requiring as it does, multiple initiatives in relation to, for example, building codes and standards for appliances. The UNDP et al. note that "Because it is a decentralized, dispersed activity, energy efficiency is a difficult issue around which to organize support. It has little visibility and is not generally a popular cause for politicians, the media or individuals" (2004, p. 47).

A second obstacle to achieving efficiency gains is that achieving energy efficiency at the household level invariably makes energy services more expensive in the short-term. Such additional expense puts household efficiency gains beyond huge segments of the population in India and other LDCs unless accompanied by significant financial support from the state. In any event, there is no hard correlation between increased efficiency and reduced consumption. Sayigh's quoting of Stanely Jevons from 1865 is on point: "It is wholly a confusion of ideas to suppose that the economical use of fuel is equivalent to diminished consumption. The very contrary is the truth. It is the very economy of its use which leads to its extensive consumption" (1999, p. 29). In India, in the short to medium term, it can be expected that increasing household affluence will result in higher energy consumption, regardless of efficiency gains (IEA 2002; Goldemberg et al. 1987).

Given the predominance of coal-based thermal power generation in India and the extensive coal reserves that it enjoys, clean coal power generation technologies offer the prospect of a path to a sustainable energy system for India. The promise of these technologies is that they will produce power with virtually no emissions of greenhouse gases or other pollutants. However, this promise is, at this point, just that. Although advances are being made in the development of these technologies, their use in power generating applications is at least a decade away, even in developed countries. It has been noted, for example, that "many components of clean coal technology are at present either uneconomic or technologically unproven in Alberta" (Carlson 2003, p. ii). The current goal of an industry body that advocates the potential of these technologies in Canada, the Canadian Clean Power Coalition, is to have a full-scale demonstration project able to remove greenhouse gas and all other emissions by 2012, at the earliest (Stobbs 2005).

Clean coal technologies will not be proven and available in time to make a contribution to the additional 100,000MW targeted for installation in India by 2012. As the UNDP et al. state, the window of opportunity for making the significant policy and behavioral changes that are required to determine whether an energy system continues to evolve along current lines or achieves a transition to a more sustainable development path is a decade or two (2004, p. 59). If appropriate technologies are not available in that period the opportunities for pursing the more sustainable path are more limited. Whilst power plant infrastructure can be retrofitted with new technologies, such changes "take much longer to affect average system performance, as they occur at the much slower rate of replacement investments" (UNDP et al. 2004, p 59).

Nuclear generating technology is increasingly touted as an option that can make a significant contribution to a sustainable energy system. Interest in adding nuclear plant is strong in many developed countries as well as LDCs. As noted in Chapter 3, India has targeted an additional 10,000MW of nuclear power by 2012, the same amount as from

RETs. As at 31 January 2005 the installed wind generating capacity was 2488MW and nuclear generating capacity was 2720MW (Table 10). On current forecasts wind and nuclear generating capacity in India will continue to make a similar contribution to India's overall power needs – a marginal contribution. If the targeted additional 10,000MW of nuclear capacity is installed by 2012 there will be approximately 13,000MW of nuclear power in India, little more than 6 per cent of the targeted total installed capacity of 215,544MW. Currently four projects with an aggregate generating capacity of 3420MW are due to be operational by 2008, less than half of the targeted additional capacity (NPCIL, Status of Projects).

A restriction on India's capability to develop significant nuclear capacity is that it has limited uranium reserves. Although it has extensive thorium reserves and is working on developing reactors that can use that as a fuel stock the UNDP et al. state that such alternative breeder concepts "would take decades to develop with no certainty about prospective costs, safety and proliferation-resistance features" (2004, p.54). This suggests that the 350,000MW generating potential of nuclear power quoted by the Indian government is largely illusionary. India's potential nuclear generating capacity is also constrained by the massive capital sums required to build a nuclear power station, the complexity of such a system and the lead time from commencement of project development to operation, which historically can be ten years of more.

In conjunction with question marks over the real contribution that nuclear power can make to India's energy challenge serious questions have to be raised in relation to nuclear power from a sustainability perspective. Whilst current light water reactor models have a good safety record compared to Chernobyl-style reactors, the specter of a nuclear disaster remains. Although work continues, no safe mechanism has been arrived at for the disposal of radioactive waste from nuclear generation. Whilst there is optimism within the technology community that solutions will be found eventually, no timeline for getting to "eventually" is provided. Even in the most advanced countries "operating depositories remain decades away" (UNDP et al. 2004, p55).

It is only in the context of the concern with greenhouse gas emissions as the most pressing global environmental issue of the day that nuclear power appears to offer a step forward from a sustainability perspective. However, whilst the operation of nuclear plants produces no such emissions, on a life-cycle basis the activities involved in the construction and decommissioning of nuclear power plants are significant contributors to greenhouse gas emissions. Finally, in the same way that the price of fossil fuel generated electricity does not reflect the negative health and environmental externalities associated with such generation, the price of nuclear fuel generated electricity does not reflect the considerable decommissioning and waste-product handling costs. These are usually absorbed by the consumer indirectly as governments underwrite such costs through taxation.

For the reasons outlined clean coal technologies and nuclear technologies are unlikely to make a significant contribution to a sustainable energy system in India for the foreseeable future. Nonetheless, as part of the existing energy establishment in India they are not subject to some of the structural constraints that exist in relation to wind power and other RETs. However, a separate issue arises in relation to these and all other advanced energy technologies. This issue is the question of India's ability to develop such technologies indigenously or its ability to access such technologies from developed countries on terms that it can afford. The cost of a clean coal power plant is currently in excess of a billion dollars, a nuclear power plant several multiples of that. Within developed countries much of the relevant technology has been developed by private sector organizations, albeit with government help in some instances. Whether these technologies will be made available to India or other LDCs at a price they can afford is not clear or certain.[82]

The assumptions that underlie the premise of the "win-win" approach to sustainable development appear no better founded for other technologies than they do for wind. India continues to face structural hurdles to introducing a fully-fledged market-orientated policy framework in its power sector. Perhaps the most significant of these is the continued near insolvency of the dominant state power sector. This poor financial position makes it difficult for the state to afford to make necessary investments in the power sector or to be able to purchaser power from private-sector developers without continued government financial support. Such support diverts valuable resources away from other development priorities and, given the sums required, can only ever be small fraction of the total amounts required. These structural hurdles and the resultant shortcomings in India's policy framework leaves the question as to whether such a framework, if properly implemented, could deliver the components of a sustainable energy system a moot point. Although market enthusiasts can use policy shortcomings as the explanation for the failure of the market to achieve the technological advances required for the "win-win" scenario this rather misses the point if such shortcomings cannot be overcome.

Where necessary technologies are not yet available, such as clean coal technologies, the question of whether a market-orientated policy framework can promote the adoption of such technologies is somewhat redundant. It is a different question as to whether a market-orientated policy framework can promote the development of such technologies. In the Indian context, it is worth noting that the state was responsible for all of the early technological developments in the wind power sector through its demonstration projects, wind resource mapping initiatives and the establishment of C-WET. Nuclear power generation and research remains dominated by the state as do the thermal and hydropower generating sectors. It is an interesting question for future research whether, in an LDC context, the state rather than the market should have the greater role in technology and infrastructure development generally and for energy specifically.

Finally, it is not at all clear that the alternative technologies touted by proponents of a sustainable energy system can make a significant contribution to such a system even where such technologies exist. The case of the potential of nuclear power in India is a case in point. The assumption that such technologies will enable industrialization to proceed within environmental limits is thus not well founded. Given the long lead time for power infrastructure development and the long shelf-life of such infrastructure, the prognosis for India is that through at least the first half of the 21st century its energy system will continue to be dominated by conventional power generating technologies.

4.4 Implications of the Indian Case

In the absence of alternatives, the continued expansion of an energy system primarily based on conventional technologies will undermine the sustainability of the development model of industrialization in India. It can be expected that emissions of particulates and other pollutants will continue to grow contributing to increasing environmental damage at a national and regional level and have adverse health consequences for local populations. Significant increases in Indian greenhouse gas emissions (currently 5 per cent of global carbon dioxide emissions (Thakur et al. 2005, p.1196)) will undermine international attempts to reduce global emissions and tackle the issue of climate change. As outlined in Chapter 2, there is a broad consensus that LDCs will suffer disproportionately from the adverse impacts of climate change, not least because of their limited capacity to adapt and react to such impacts.

Current assessments of the global energy patterns suggest that the case of India is being replicated in other LDCs. Particularly significant are the similarities in China. With their combined populations and high rates of economic growth, India and China dominate global energy scenarios. The EIA notes that energy demand in Asia is predicted to more than double between 2002 and 2025 (2005, p. 7). World net electricity consumption is forecast to nearly double by 2025, with 59 per cent of this increase coming from "emerging economies". Coal and natural gas are forecast to remain the dominant fuels until 2025 to 2030, accounting for 85 per cent of the increase in primary world energy demand, two-thirds of which will come from LDCs (IEA 2004, p.30). As a result of the continued reliance on fossil fuels, carbon dioxide emissions are forecast to rise from 24.4 billion metric tonnes in 2002 to 38.8 billion metric tonnes in 2025. The International Energy Agency forecasts an increase in carbon dioxide emissions of 60 per cent by 2030. LDCs are projected to account for 68 per cent of the increase, largely a result of fossil fuel use (EIA 2005, pps. 4-5; IEA 2004, p.30).

The "win-win" approach to sustainable development is premised on the ability of market-orientated policy frameworks to shift these trends to a sustainable path. The case of wind power in India casts substantial doubts on the prospects of this happening in other LDCs given that none of the three assumptions that underlie the premise of the "win-win" approach is adequately supported in this case. The extent to which the obstacles to a sustainable energy system in India apply in other LDCs is a question for further research. However, the case of India suggests that a lack of capacity to introduce market-orientated policy frameworks, the insufficiency of such frameworks by themselves to lead to a transition to sustainable energy technologies and the limited contribution that such technologies can currently make are starting points for research on this issue in other countries.

China, with its high economic growth rates, huge population and soaring energy needs, would be a priority country for such research. The recent development trajectories of India and China present some similarities. In the energy context the state dominates energy infrastructure, development and policy-making in both countries. Whether China's more authoritarian government can be more successful in advancing sustainable energy technologies than the democratic government of India would be an interesting question.

The Indian case and current aggregate trends within the energy sectors in LDCs suggest that a development model based on industrialization in LDCs is unsustainable. Although the adverse environmental consequences of conventional energy generating technologies can be mitigated to some degree, the scope of this mitigation is marginal. The use of an "IPAT equation" is useful for illustrating whether an alternative conclusion regarding the industrial economic growth development model can be reached (Huesemann 2003). In this equation the cumulative environmental impact ("EI") is estimated as the product of technological factors ("T") and societal factors being per capita affluence ("A") and population growth ("P") such that: **EI = P x A x T.** Changes to any of the variables T, A or P has the potential to increase or decrease the cumulative environmental impact, EI.

In relation to T, the Indian case has demonstrated the limited scope for currently available energy conversion technologies to establish a sustainable energy system. Of course, the allure of the technological optimist perspective is that a major technological breakthrough enabling the establishment of a sustainable energy system could be just around the corner. The strength and weakness of this is that whilst it can never be certain that such a breakthrough will be achieved, it cannot be foreseen that it will not. As the UNDP et al. say, a "prerequisite for achieving an energy future compatible with sustainable development objectives is finding ways to accelerate progress of new technologies along the energy innovation chain" (2004, p. 12). Technology is an important ingredient for achieving sustainability and efforts to develop appropriate technological solutions should continue and be encouraged by the right policy frameworks. However, the uncertainty around the ability of technology to deliver sustainability in any meaningful time frame makes it far from prudent or rational to rely on technology alone for a sustainable future (Constanza et al. 2000; UNDP et al. 2004).

Uncertainty regarding future technological innovation is not the only flaw in relying on technology for a sustainable future. As has been discussed previously, where technologies exist they may not be available to LDCs or affordable. Advocates of the "win-win" approach to sustainable development argue that LDCs can "leapfrog" the environmentally damaging phase of industrial economic growth by adopting state of the art environmentally benign technologies that were not available to developed countries when they industrialized. If such technologies exist, this presupposes a massive transfer of technology to LDCs by developed countries. How and on what basis such a transfer would occur and who would bear the cost are questions that are not addressed. Such advanced technologies are supposed to delink economic growth and its environmental consequences. However, historically, technological development has been used to increase industrial production, consumption and economic growth. Any material input efficiencies that are achieved are then outweighed by increased economic activity (Hueseman 2003).

If technology cannot by itself deliver sustainable development the variables of population and affluence need to be considered. Whilst the Malthusian nightmare has not yet come to pass, population increases do put pressure on the sustainability of development. In India, population growth continues to put a strain on its development objectives and is a major driver behind forecast increases in energy consumption. Various critics of the mainstream development model have emphasized the importance of population growth as a threat to the prospects of sustainable development (for example, Hardin 1973; Ehrlich and Holden 1973). Whether population can or should be controlled and, if so how, are important social questions with development implications.

On an aggregate global basis, population growth is expected to level off by the mid 21st century. Although this outcome will reduce pressure on global resources from that time on, without some form of significant population control in the meantime, the population variable can only have a negative impact on sustainability outcomes. Proponents of the mainstream development model point out that increased prosperity leads to a reduction in family sizes. This is a chicken and egg situation with development success needed to reduce future population growth and existing population growth undermining development gains. On a global scale, declining populations in developed countries may be expected to offset, to some degree, increases in population in LDCs, although the decline is much slower than the growth. However, this will not further the cause of sustainability in any particular LDC without the ability for their populations to emigrate to developed countries relieving the pressure on local and regional resources. In the present international climate immigration policies in many developed countries are becoming more restrictive rather than less so, closing off this potential.

If the contribution of technology is uncertain and population difficult to control, the remaining variable of the "IPAT equation" is A, measured as GDP per capita. Unless technology can decouple economic growth from consumption, a development model based on industrialization increases A, which in turn, it is suggested, increases the environmental impact of such growth, EI. If technology cannot fully control for increases in population and consumption, as suggested by the technological optimist perspective that underlies the "win-win" mainstream approach to sustainable development, such approach appears to invite increasing environmental degradation, undermining the sustainability of such development. The practical conclusion is that there is no "win-win" scenario and that, broadly speaking, a choice has to be made between development and the environment at the national level in LDCs and, consequently, at a regional level and at a global level.

Given this conclusion, the question thus arises whether any other models for sustainable development provide a more attractive alternative to the "win-win" industrialization development model. As outlined in Chapter 1, such alternatives include restricting industrial growth, restructuring the industrial growth model and implementing an alternative development model entirely. It is not within the scope of this discussion to analyze the strengths and weaknesses of these alternatives, the broad outlines of which have been mentioned in Chapter 1 but a few observations will be made.

The first such observation is that the first two alternatives, which both operate within the growth paradigm, are both essentially redistributive, making the chances of their implementation remote. If aggregate global industrial, economic growth is to be constrained and yet development objectives met in LDCs, growth must be disproportionately limited in developed countries, a form of redistribution. There is no indication that developed countries are ready to volunteer any significant transfer of wealth to LDCs. This disinclination is evidenced by, for example, outcries over the outsourcing of jobs to LDCs (whether service jobs such as call centers or the loss of manufacturing jobs to the low cost labor pools in LDCs) by a failure of the developed nations to make more concessions in the Doha round of trade liberalization talks on farming subsidies and tariffs and the inability nearly all developed countries to contribute a minimum of 0.7 per cent of their GDP to development aid.

The second observation is that the contours of an economy based on limited or no-growth are not clear. The concept appears to be contradictory to an economic system based on capitalist principles in which the accumulation of capital is a principal objective. Brody notes that since humans moved from being hunter-gatherers to agriculturalists they have been engaged in a continuous process of accumulation (2001). If accumulation lies at the heart of the capitalist system it is destined to ultimately exhaust itself, to be inherently unsustainable. Sklair talks about capitalism's ecological crisis of unsustainability (2002). Advocates of no or limited growth couple this approach with the need for population control. As already noted, this is problematic. Without a static population over time a no growth approach cannot keep all members of society productively engaged.

If the existing capitalist socio-economic system is inherently unsustainable, an alternative system is required. Unfortunately, as with the limited or no growth model, the details of what such a system would look like are not clear. Such a system may be based on co-operative or communist principles and many development initiatives focused at a local level have some of these characteristics. Whether such a system could be established successfully beyond a local level is doubtful. Experiments with such systems at a national level do not have a happy history. In addition, what many of these alternative development models seem to ignore is that reducing or eliminating poverty on a national, regional or global basis requires an increase in economic activity in order to provide people with livelihoods and meet their minimum material needs. Whatever development model is used to achieve this, such expansion of economic activity will challenge any sustainability goals. This is particularly true in urban settings of any significant size where families do not have the luxury of self-sufficiency.

A final observation relates to the need for governance. If any alternative system is to be implemented, it will require some form of international governance. Just as regulations are required at a state level to preserve the environmental commons, so will they be needed at the global level. No state will be prepared to abide by rules and regulations or introduce radical changes to its socio-economy if to do so puts its population at a disadvantage as a result of other states not taking the same approach. The Kyoto Protocol is an example of how difficult this is. The failure to get some of the biggest emitters of greenhouse gases to sign up to the Protocol has significantly weakened it. As Pearce puts it by way of considerable understatement, the prospects for an effective and concerted international effort "would seem fancifully remote" (2004).

The prognosis for achieving sustainable development thus appears gloomy. On the one hand, the examination of energy and wind power in India in this thesis suggests that the key premise of the "win-win" mainstream approach to sustainable development in LDCs is founded on false or, at least questionable, assumptions. On the other hand, the three generic alternatives that are on offer, limiting growth, achieving growth differently or pursuing a non-growth development model all lack definition and their implementation on anything other than a local scale appears fanciful given the hegemony enjoyed by the current growth-orientated development paradigm. Without a radical change in the structure of socio-economies and the value systems that underlie them the most realistic conclusion is that industrial growth and increased consumption will remain the basis for "development" in LDCs for the foreseeable future. This in turn means that, contrary to the blithe promise of the "win-win" approach, environments and ecosystems will continue to be over-taxed at local, national, regional and global levels.

The broad, if somewhat over-simplified, choice for policy-makers in LDCs is thus between prioritizing the pursuit of development objectives or the preservation of the environment and ecosystems. It is no surprise that development is preferred over the environment given that the alleviation of poverty is an immediate and pressing concern whilst the implications of environmental degradation are, for the most part, in the future. How far in the future is uncertain, but as Pasek notes, if the implications manifest themselves at some subjectively determined point that is sufficiently far in the future, the issue of sustainability becomes a philosophical rather than a practical, development issue (1992). The conflict between this preference and that of developed countries to preserve the environment has been a consistent them in sustainable development debates at the international level, particularly notable at the "Earth Summit" in Rio de Janeiro in 1992. It is precisely this conflict that the mainstream approach to sustainable development serves to gloss over.

The risk for LDCs of pursuing the mainstream development model is precisely that its environmental consequences will undermine the development gains brought by such models. Although the regional and global reach of certain of these consequences will impact developed countries as well, as outlined in Chapter 2 LDCs will be much less able to mitigate the adverse impacts of such consequences and to adapt their socio-economies to deal with them. Since developed countries control the greatest proportion of the worlds' resources they are much better able to manage their socio-economies in the face of adverse environmental events. The critical question is whether LDCs will be able to reach a stage of development that allows them to cope with the adverse environmental impact of such development before they are potentially overwhelmed by them. To assist in this, policy-makers in LDCs need to focus on the trade-offs between growth and the environment that are most appropriate in any given circumstance. Although preference will be given to development goals overall, this need not be a blanket preference.

In the energy context, expansion of access to modern energy services is a clear development priority. However, much more attention needs to be paid by policy-makers in LDCs to ensuring that such expansion is on as sustainable a basis as is possible, even if an entirely sustainable energy system is not currently possible. This requires a significant emphasis and on demand-side management and the development of technologies that allow greater efficiency in energy production and use. Considerably more attention needs to be paid and investment made in alternative, "clean" generating technologies, such as RETs, clean coal, hydrogen and in dealing with radio-active waste from nuclear power plants. Whether the market-orientated policy framework advocated by the mainstream sustainable development scenario is the most appropriate for achieving these goals in LDCs is an open question. At a minimum, the Indian case suggests that if this is the case, much greater support needs to be provided to developing the requisite institutional capacity in LDCs and softening the financial impact on vulnerable populations of the introduction of market prices for energy.

Given the costs associated with developing the necessary energy technologies and the greater cost of generating power using them, a key policy priority for developed countries has to be creating or improving mechanisms for appropriate energy technology transfers from developed countries to LDCs. In addition, developed countries need to provide significant financial assistance to LDCs to subsidize a transition away from a relatively cheap conventional fossil-fuel dominated energy system to a diversified system that optimizes the use of advanced, cleaner generating technologies. A final energy policy priority has to be a continuing search for a framework that controls or limits aggregate emissions of greenhouse gases and other harmful emissions from energy generation or use until such time as technology can reduce such emissions to negligible levels. Work is under way in the international community on a framework to replace the Kyoto Protocol when it expires in 2012. A more effective replacement is essential.

The implementation of policies to pursue the priorities outlined above will help mitigate and delay but not eliminate the adverse environmental consequences of pursuing a mainstream development model based on industrialization. The extent of such mitigation will depend on the ability of LDCs and developed countries to pursue such polices given the political and institutional realities that exist in each of them. Much work continues to need to be done on communicating the perils of a "business-as-usual" approach to the mainstream development model and building a network of stakeholders that can take on the incumbents with a vested interest in preserving the existing energy status-quo.

A key area for further research is an examination of how differing institutional and political frameworks in LDCs support or undermine efforts to transition to a sustainable energy system. In the Indian case this thesis has suggested that concurrent federal and state jurisdiction over power generation, the dominance of the policy-making framework by institutions aligned with the existing fossil-fuel dominated energy system and the potency of power as an electoral issue for politicians all served to obstruct efforts to advance wind-power as a key RET within the national energy system. Further research on the political economy of decision-making within the energy policy arena in India will determine the extent to which these suggestions are borne out. An additional priority for further research is the case of China. Like India, its aggressive pursuit of industrialization and accompanying rapid increase in energy consumption taken together with its population mean that is a major influence on global energy scenarios. Given its authoritarian rather the pluralist, democratic system and statist rather than market-orientated approach to development, it should provide an interesting comparison to the Indian case.

4.5 Conclusion

Any meaningful conception of sustainable development involves the idea that there are environmental limits that need to be observed if development is to be sustained. Some degree of growth is needed in LDCs to ensure that the present-day standard of living is one that is worth sustaining. Within the mainstream development discourse sustainable development has been defined so as to remove any constraints on growth and to avoid the hard choices that such constraints present. According to this discourse, rather than impose constraints, the environment simply presents challenges that can be managed and overcome by technological means, promoted within a market-orientated policy framework.

The case of wind power in India demonstrates that there are serious flaws in the assumptions that underlie this "win-win" approach to sustainable development. It is clear that wind power will not be a significant component of a sustainable energy system in

India within the foreseeable future. Investments in energy-related infrastructure last for 40 to 50 years, or longer. Accordingly, although further research is needed on the ability of other energy-conversion technologies, such as clean coal, to contribute to a sustainable energy system, it is also unlikely that a sustainable energy system is possible for the foreseeable future in India since investments are being made based on existing technologies. It is suggested that the obstacles that confront the creation of a sustainable energy system in India will have generic application, with some variation, in LDCs, rather than being specific to India. A priority for such further research into this question is China.

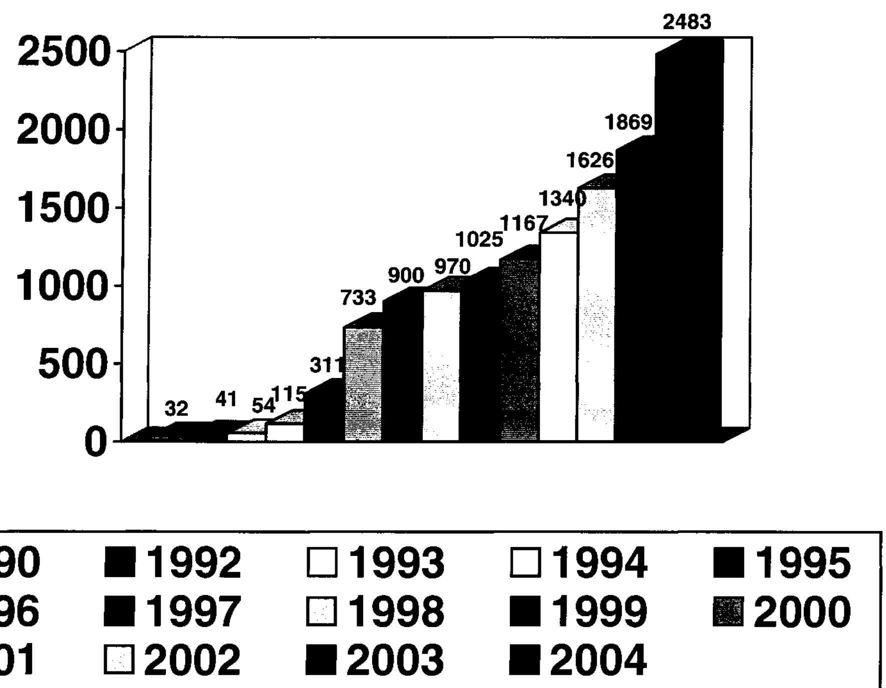
If a sustainable energy system is not available, a development model based on industrialization can only proceed on an unsustainable basis, unless such growth is limited in some aggregate sense. Whatever alternative is examined, such a limit implies redistribution from developed countries to LDCs if LDCs are to be able to achieve their development goals. As Phaelke puts it "short of improbable technological breakthroughs of magical proportions in energy supply, many will need to learn to do with less private, motorized transportation and heated and/or cooled indoor space if all are to have a reasonable minimum" (2001, p.14). Until the populations of developed countries are prepared to support and countenance a transfer of resources to LDCs the redistribution necessary to allow industrialization to proceed in LDCs within national, regional and global environmental limits is not going to happen. Sustainable development boils down to the age old question of distribution and therefore power and politics. Development will not follow a sustainable path until there is a fundamental shift in values. To quote Phaelke again:

"some proportion of the problem of sustainability – it is difficult to say how much – lies in the overall level of comfort, convenience and prosperity that many of us enjoy. That is the real challenge of sustainability, potentially going to the heart of economy and society – producers and consumers, private and public sectors, - and calling into question, aspects of contemporary life that environmental politics has not recently challenged. Sustainability politics conceived of in this way would seem to be an impossible task" (2001, p. 18).

Given these realities, the best that policy-makers can do is to attempt to institute policies that will encourage reduced consumption of energy and technological development and innovation within the energy sector so as to reduce and mitigate so far as is possible the adverse environmental impacts of increased energy use. The more aggressively that such policies can be pursued and implemented the longer the adverse environmental consequences of the mainstream development model may be delayed and development gains perhaps secured. How long these consequences can be delayed is uncertain and, in the face of such uncertainty, urgent action is the prudent course.

Figures

Figure 1: Year-Wise Installed Wind-Power Capacity In India 1990-2004 (MW)



Source: Adapted From Table 5.2 "Wind Power Development" in GOI, MNES, Annual Report 2001-2002 and Table 5.2 "State-Wise & Year-Wise Wind Power Installed Capacity as on 31.03.2004" in GOI, MNES, Annual Report 2003-2004.

Tables

Table 1: Developed Versus Less-Developed Country Electricity Consumption

Country	Population (millions)		Total Electricity Consumption (TWh)	Electricity Consumption (KWh)/ Capita	GDP per Capita (US$)
	2001	2015			
USA	288	329	3687	12896	34,320
Germany	82	82	560	6806	25,350
Japan	127	127	1006	7907	25,130
China	1285	1402	1397	1093	4020
India	1033	1246	421	408	2840
Brazil	174	202	309	1794	7360
Nigeria	117	161	11	86	850

Sources: UNDP 2003 and IEA 2003

Table 2: Energy Consumption By Source And Sector (Source: Data from WRI: Energy & Resources, Country Profiles)

Country	Consumption By Source - 1999 (thousand metric tonnes of oil equivalent)				Consumption By Sector - 1999 (thousand metric tonnes of oil equivalent and percentage of total)					
	Fossil Fuels	Hydro-electric	Nuclear	Renewables [1]	Industry	Transport	Agric.	Commercial and public services	Residential	Other
USA	1,942,807	24,813	202,722	83,372 (63,894)	357,829 (24%)	601,275 (42%)	13,473 (1%)	182,774 (12%)	254,209 (17%)	65,944 (4%)
Germany	286,465	1,671	44,304	2,075 (1,361)	69,989 (30%)	68,286 (28%)	2,703 (1%)	23,569 (10%)	63,515 (26%)	11,680 (5%)
Japan	416,131	7,432	82,512	8,325 (4,332)	134,846 (39%)	93,639 (27%)	9.978 (3%)	43,827 (13%)	49,630 (15%)	10,070 (3%)
China	854,743	17,527	3,896	212,938 (211,705)	314,374 (43%)	69,176 (9%)	30,652 (4%)	18,497 (2%)	289,487 (38%)	31,854 (4%)
India	271,806	7,004	3,409	198,107 (198,018)	97,859 (27%)	44,475 (12%)	9,741 (4%)	2,737	200,781 (56%)	5,309 (1%)
Nigeria	14,410	486	0	72,390 (72,390)	9,035 (11%)	5,867 (7%)	0	255	64,815 (80%)	1585 (1%)
Brazil	107,150	25,188	1,036	43,060 (35,645)	64,317 (42%)	48,112 (32%)	7,500 (5%)	7,753 (5%)	20,407 (13%)	4,113 (3%)

[1] Renewables excludes hydroelectric but includes primary solid biomass, the figure for which is given in brackets to indicate the percentage of renewables that it constitutes.

Table 3: CO2 Emissions (Source: Data from World Resources Institute: Atmosphere and Climate – Country Profiles)

Country	CO_2 Emissions 1998 (in thousand metric tonnes CO_2)		Emissions By Source as a percentage of total			CO_2 Emissions by Sector 1998 as a percentage of total				
	Total[1]	Per Capita	Solid Fuel	Liquid Fuel	Gaseous Fuel	Electricity generation	Energy Industries	Manu-facturing and construction	Transport	Residential
USA	5,447,640 (22.5%)	19.9	36	42	21	45	5	11	32	7
Germany	825,162 (3.4%)	10.1	40	38	20	37	3	15	21	14
Japan	1,133,468 (4.7%)	9.0	30	54	12	35	4	22	22	6
China	3,316,760 (13.7%)	2.5	72	18	2	42	5	33	7	7
India	1,061,050 (4.4%)	1.1	67	24	5	54	2	23	14	6
Nigeria	78,455 (0.3%)	0.7	-	32	14	14	15	22	36	7
Brazil	299,556 (1.2%)	1.8	16	72	4	9	6	29	41	6

[1] With percentage of global total shown in brackets.

Table 4: Climate Change Impacts (Source: Adapted from Table SPM-2, IPCC, 2001 p.15)

Project Changes During the 21st Century in Extreme Climate Phenomena and their Likelihood	**Representative Examples of Project Impacts**
Higher maximum temperatures, more hot days and heat waves over nearly all land areas (*very likely*)	Increased incidence of death and serious illness in older age groups and urban poor. Increased heat stress in livestock and wildlife. Increased risk of damage to a number of crops. Increased risk of cooling demand and reduced energy supply reliability.
Higher (increasing) minimum temperatures, fewer cold days, frost days and cold waves over nearly all land areas (*very likely*)	Decreased cold-related human morbidity and mortality. Decreased risk of damage to some crops and increased risk to others. Extended range and activity of some pest and disease vectors. Reduced heating energy demand.
More intense precipitation events over many areas (*very likely*)	Increased flood, landslide, avalanche and mudslide damage. Increased soil erosion. Increased flood runoff may increase recharge of floodplain acquifers. Increased pressure on government and private flood insurance systems and disaster relief.
Increased summer drying over most mid-latitude continental interiors and associated risk of drought (*likely*)	Decreased crop yields. Increased damage to building foundations by ground shrinkage. Decreased water resource quantity and quality.
Increase in tropical cyclone peak wind intensities, mean and peak precipitation intensities (*Likely over some areas*)	Increased risk to human life, risk of infectious disease epidemics. Increased coastal erosion and damage to coastal infrastructure. Increased damage to coastal ecosystems like coral reefs and mangroves.
Intensified droughts and floods associated with El Niño events in many different regions (*likely*)	Decreased agricultural and rangeland productivity in drought and flood-plain regions and decreased hydro-power potential in drought-prone regions.

Table 5: Renewable Energy Potentials (Exajoules a y ear)

Resource	Current Use	Technical Potential	Theoretical Potential
Hydropower	10.0	50	150
Biomass Energy	50.0	>250	2,900
Solar Energy	0.2	>1,600	3,900,000
Wind Energy	0.2	600	6,000
Geothermal Energy	2.0	5,000	140,000,000
Total	**62.4**	**>7,500**	**>142,992,500**

Source Adapted from: Johansson et al. Table 1, p.3

Table 6: Estimated Annual Wind Energy Resources

Region	Land Surface with wind class 3-7		Wind energy resources without land restriction[2]	Wind energy resource if less than 4% of land is used[2]
	%	Land Area[1]		
North America	41	7,876	126	5.0
Latin America and Caribbean	16	3,310	53	2.1
Western Europe	42	1,966	31	1.3
Eastern Europe and FSU	29	6,76 3	109	4.3
Middle East and North Africa	32	2,566	41	1.6
Sub-Saharan Africa	30	2,209	35	1.4
Pacific Asia	20	4,166	67	2.7
China	11	1,056	17	0.7
Central and South Asia	6	243	4	0.2
Total	**27**	**30, 200**	**483**	**18.7**

1 **Thousands of square kilometers**
2 **Thousands of terawatt hours**

Source: Adapted from UNDP et al. Tables 5.20 and 5.21, p. 164

Table 7: Comparative Development Indicators For India (2002)

Country	Life expectancy at birth in years	Adult literacy rate[1]	Enrolment ratio for schooling (%)[2]	GDP per capita (PPP US$)	Life expectancy index	Education index	GDP index	Human Development Index Value
India	63.7	61.3	55	2670[3]	0.64	0.59	0.55	0.595
China	70.9	90.9	68	4580	0.78	0.83	0.64	0.745
Least Developed Countries	50.6	52.5	43	1307	0.43	0.49	0.42	0.446
South Asia	63.2	57.6	54	2658	0.64	0.57	0.55	0.584
OECD	77.1	-	87	24904	0.87	0.94	0.92	0.911
World	66.9	-	64	7804	0.70	0.76	0.73	0.729

1 % of 15 year olds and over
2 Combined gross enrolment ration for primary, secondary and tertiary
3 Economist Intelligence Unit 2003 estimate is US$2834

Source: Adapted from UNDP 1992 and 2004.

Table 8: Changes in Patterns Of Energy Consumption in India

Year	Primary Energy(%)		Final Commercial Energy (%)				
	Commercial	Non-Commercial	Coal	Petroleum Products	Natural Gas	Electricity	Total
1953-1954	28.4	71.6	80.1	16.7	0.0	3.2	100
1960-1961	34.7	65.3	75.3	19.9	0.0	4.8	100
1970-1971	40.6	59.4	56.1	34.1	0.6	9.2	100
1980-1981	46.9	53.1	47.9	40.3	1.1	10.7	100
1990-1991	59.3	40.7	35.9	43.6	5.5	15.0	100
1996-1997	65.9	34.1	28.9	47.7	6.3	17.1	100

Source: Adapted from GOI, 9th FYP, vol. 1, Table 6.7

Table 9: Electricity Production And Consumption In India

Millions kWh	1985	1990	1995	1999	2000
Production	183390	289439	394800	481055	501204
Consumption	183299	290817	419565	482394	502506

Source: Adapted from Asian Development Bank, "Key Indicators"

Table 10: India's Installed Electricity Generating Capacity in MW as at 31 January 2005[1]

	Total	Hydro	Thermal				Wind	Nuclear
			Coal	Gas	Diesel	Total		
State	65314	23510 (20%)	37877 (33%)	3260 (3%)	598 (0%)	41736 (36%)	68 (0%)	0
Private	12294	876 (0%)	4241 (4%)	4160 (4%)	597 (0%)	8998 (8%)	2419 (2%)	0
Center	37935	5749 (5%)	25047 (22%)	4419 (4%)	0	29466 (26%)	0	2720 (2%)
Total	115544	30135 (26%)	67165 (58%)	11839 (10%)	1195 (1%)	80201 (69%)	2488 (2%)	2720 (2%)

Source: Adapted from GOI, Ministry of Power "Installed Capacity"

1 Percentages given are of the particular fuel source as a percentage of the total state, private and central generating capacity of 115544MW rounded to the nearest whole number.

Table 11: State-Wise Wind Power Installed Capacity and Potential (MW)

State	Potential Capacity		Installed Capacity		
	Gross	Technical	Demonstration	Private Sector	Total
Andhra Pradesh	8275	1920	5.44	93.4	**98.8**
Gujarat	9675	1780	17.3	184.7	**202.0**
Karnataka	6620	1180	4.6	204.6	**209.2**
Kerala	875	605	2.0	0.0	**2.0**
Madhya Pradesh	5500	845	0.6	22.06	**22.6**
Maharashtra	3650	3040	8.4	399.0	**407.4**
Rajasthan	1700	780	6.4	172.1	**178.5**
Tamil Nadu	3050	1880	19.42	1342.21	**1361.6**
West Bengal	450	450	1.1	0.0	**1.1**
Total	**45,195**	**13,390**	**65.28**	**2418.03**	**2483.3**

Source: Adapted From Table 5.1 "State-Wise Wind Power Installed Capacity (as on 28.02.2004)" in GOI, MNES Annual Report 2003-2004 and MNES "Wind Power Potential".

Table 12: Wind-Power Policies in States

State	Wheeling	Banking	Third Party Sale	State Purchase	Price Escalation	Other
Andhra Pradesh	Yes – charge 2% of energy wheeled	Yes –for 12 months	Not allowed	Rs3.48/kWh	At 5% per annum with 1994-45 as base year	20% capital subsidy to max. Rs 25 lakh (approx. US$57,000)
Gujarat	Yes – charge 4% of energy wheeled	Yes – for 6 months	Not allowed	Rs2.60/kWh	At 5% per annum with 2002-2003 as base year	Exemption of 30% of the installed capacity from electricity duty
Maharashtra	Yes – charge 2% of energy wheeled	Yes – for 12 months	Allowed	Rs3.50/kWh	At Rs0.15/kWh per annum	30% capital subsidy to max. 20 lakh (approx. US$46,000).
Tamil Nadu	Yes – charge 5% of energy wheeled	Yes for 5.5 months	Not allowed	Rs2.70/kWh	No escalation.	None

Source: Adapted From GOI, MNES, AR 2003-2004, Table 5.4

Table 13: Summary of Central and State Government Market Development Policies (Compiled from data presented in Chapter 3)

	Open Access, Minimum Prices or Purchase Obligations	Financial Incentives	Industry Standards	Education, information and dissemination
Central Govt.	• MNES guidelines provide for wheeling of power and third party sale allowing access to transmission and distribution networks • Electricity Act 2003 mandates non-discriminatory access to transmission network and phased introduction of open access to distribution networks. • MNES guidelines provide for minimum purchase tariffs by SEBs with annual escalation. • Electricity Act 2003 mandates that SERCs provide for a minimum percentage of electricity consumption to be generated by renewables, such percentage to increase progressively.	• Fiscal incentives include accelerated depreciation, income tax holidays and concessional rates of custom and excise duty. • Indirect financial support includes government payments for demonstration projects and wind resource assessment program, data from which is made available to wind project developers at nominal cost. • IREDA provides concessional rates of financing and is supported by, amongst other things, central government financial contributions.	• Industry standard initially those of international certification bodies. • With development of indigenous manufacturing base and the establishment of C-WET, MNES has created an Indian certification program – TAPS -2000. This is a provisional scheme but a final scheme is expected soon.	• MNES, in conjunction with the SNAs, runs an Information and Public Awareness Program. This includes promotion in print, television and radio and at public events and the organization of conferences and exhibitions. Has also instituted an information program in Hindi. • Special Area Demonstration Program promotes establishment of energy parks in states demonstrating operation of RETs.
State Govt.	• Wheeling allowed in most states. Third party sale generally not – although it is in Maharshatra. See Table 13. • Tamil Nadu has drafted regulations to implement the provisions of the Electricity Act for open access and revisions to its Grid Code to detail the necessary operational matters that need to be taken care of.[1]	• States provide further indirect fiscal incentives including exemptions from sales and other taxes. • Some states provide direct financial support through the provision of capital subsidies and favorable purchase tariffs. See Table 13.		• See Central Govt. above. Programs are jointly financed, organized and run by MNEs and the SNAs and other state bodies such as the SEBs and state governments.

Table 14: Public Outlays on Energy Sectors Under 7th – 10th Five Year Plans[1]

	7th FYP		8th FYP		9th FYP		10th FYP (Projected)	
	Rs Crores	**US$ (millions)**	**Rs Crores**	**US$**	**Rs Crores**	**US$**	**Rs Crores**	**US$**
Power (Thermal and Hydro)	34,273 (99%)	7,215	79,588 (96%)	16,755	45,591 (79%)	9,598	143,399 (78%)	30,189
Atomic Energy	-		1,800 (2%)	379	8,217 (14%)	1,730	32,370 (18%)	6,815
Non-Conventional Energy Sources	520 (1%)	109	1,465 (2%)	308	3,800 (7%)	800	7,167 (4%)	1,509

Source: Adapted from GOI, 7th FYP, vol. 1, Table 3.4(b); 8th FYP, vol. 1, Table 3.18; 9th FYP, Annexures 3.4A and 3.4B; 10th FYP, Annexure 3B

1 Rupee figures are given as a percentage of total public outlay in the energy sector for the relevant FYP rounded to the nearest whole number.

Table 15: Gross Subsidies from SEBs to Agricultural and Domestic Consumers in Rs Crore

91-92	96-97	97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05	05-06
7,449	20,147	24,515	30,345	33,314	34,428	34,587	30,568	33,154	34,311	36,002

Source: Adapted from GOI, MOF, Economic Surveys 1997-1998 to 2004-2005

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NOTES

1 In this thesis "development establishment" means the main multilateral development agencies, such as the World Bank and the International Monetary Fund, the regional development banks, development-related UN agencies such as the UNDP and UNEP and the national development agencies of OECD countries such as USAID and the Canadian International Development Agency. These organizations operate within the context of an agreed development framework based on market-oriented principles and with the Millennium Development Goals as umbrella objectives.

2 "Establishment appropriation" is a process through which "dominant institutions subvert legitimate external challenges by appropriating or embracing the symbols promoted by the opposition force" (Lawn 2001, p. 13).

3 See the summit's official communiqué at http://www.fco.gov.uk/Files/kfile/PostG8_Gleneagles_Communique.pdf (downloaded 20 July 2005).

4 An energy system comprises the energy supply sector and the end-use technology necessary to deliver energy services. The supply sector includes energy extraction, conversion and delivery processes and mechanisms. Physically the system is a combination of technology, infrastructure, labour, materials and energy carriers (UNDP et al. 2000, p. 32).

5 For the purposes of this thesis RETs include solar, geothermal, marine, small-scale hydro, wind and modern biomass energy conversion technologies. Traditional biomass energy sources such as fuel-wood are excluded because they

are inefficient and their use is associated with a variety of environmental, health and social problems. Nuclear and large-scale hydro projects are excluded because of the environmental and social concerns arising out of their construction and operation. This categorization of RETs is widely adopted in the literature that discusses them. See, for example, RETF 2001, p. 12 and Goldemberg 2004, p. 2.

6 Pearce, Markandya and Barbier cite some 25 different attempts to define the concept (1989, pps. 173-185).

7 The attempt to link development, largely the realm of economics and the social sciences, and the environment, largely the realm of the natural sciences, is seen by several commentators to be a significant factor in the difficulty of reaching a clear, operational definition of sustainable development (Redclift 1987, p. 33; Hettne 1990, p. 182; Adams 1990, p. 9).

8 For a detailed exposition of mainstream development theories and the centrality of economic growth to them see Hunt (1989) and Parpart and Veltmeyer (2003).

9 Parpart and Veltmeyer note that, notwithstanding a "major shift" in development theory in the 1970s followed by a "radical turn" in the 1980s the vision of development as economic growth did not change (2003, pps. 2 and 5).

10 See, for example, the national economic goals set out in the Poverty Reduction Strategy Papers of Vietnam and Ghana, ranked 109th and 129th out of 175 countries in the UNDP's Human Development Report 2003 (229). Ghana's goal is average GDP growth of 8 percent per annum by 2010 and agricultural development is seen as a steppingstone to widespread industrialization that is equated with a "mature" economy (Government of Ghana, pps. 36-37). Vietnam

states that its strategy is based on achieving high and sustainable growth to lay the "foundation of the country's industrialization and modernization" (Socialist Republic of Vietnam, p. 4).

11 Concern with the impact of development and industrial processes on the environment was voiced by various environmental movements, which emerged in the 1960s in developed countries (Arndt 1978). These environmental movements and disillusionment with development programs provided the context for and impetus to early articulations of sustainable development within the development establishment, such as in the declaration of the UN Conference on the Human Environment in Stockholm in 1972 and the International Union for the Conservation of Nature's World Conservation Strategy in 1980 (Arndt, 1978, p. 80; Adams 1990, pps. 16, 23 and 27).

12 See Daly 2001, p. 397 for arguments against the substitutability of natural and human-made capital that underpins the "weak" and "very weak" versions of sustainability.

13 Proponents of a dynamic view of natural resources point out that, for example, the predictions of the exhaustion of non-renewable resources are continually confounded (Beckerman 1974, pps. 215 and 220-221, Ardnt 1978, p. 133; Anderson 2004, p. xix). This is partly due to the feedback mechanism provided by price and technological development but also because the full extent of reserves of any particular non-renewable resource is never known at any point (Beckerman 1974, p. 218). Reserve figures only reflect the highly probabilistic reserves estimated by exploration companies based on existing world prices and

the technology available to recover them. Reserves only represent a portion of a resource. See, for example, UNDP et al. 2000, p. 138 for a discussion of reserve classifications in the oil industry and what they mean.

14 For a discussion of the contribution of technology to the achievement of development goals see, for example, Degregori 2002, p. xi. Notwithstanding this contribution, it is not assumed that technology is automatically benign. See, for example, UNDP 2001, p. 67; WCED 1987, p. 217; Degregori 2002, p. xviii.

15 For a critique of technology and science's ability to deliver solutions to the problems of environmental sustainability see Huesemann (2003) and Ludwig et al. (1993) generally and Meadows et al. 1992, p. 161 and Daly 1973a, p. 5.

16 For a general critique of Meadows et al. (1972) see, for example, Cole et al. 1973.

17 For a good introduction to a number of other perspectives on sustainable development based on absolute environmental limits see, for example, the essays in Herman E. Daly (Ed.) *Toward A Steady State Economy* San Francisco: W. H. Freeman and Company (1973).

18 Although both environmental sources and sinks are seen to have finite limits some argue that it is the limits to sinks, not sources that are most likely to constrain growth (Mishan 1993, p. 7; Daly 1973a, p. 16).

19 This community has been said to represent a "counterpoint" to the mainstream discourse of growth. Such counterpoint reflects a profound unease with the shape and soul of industrial, capitalist society. It has been held to include conservative and romantic elements looking back to an idealized, pre-industrial arcadia,

utopian socialists, anarchists and populist elements (Hettne 1990, pps. 155-158; Belshaw 2001, pps. 27-32; Adams 1990, pps. 76-86).

[20] See also Hardin 1973, p. 135 and Ehrlich and Holdren 1973, pps. 76-87 in relation to the need for population control.

[21] There are significant similarities between this and the eco-development advocated by, amongst others, Sachs (1974).

[22] See Veltmeyer 2001 for a summary of other alternative development models which implicitly or expressly lay claim to being more sustainable than the mainstream model.

[23] This definition has been much criticized for its vagueness (Lélé 1991, p. 617). Others have seen such vagueness as a strength (Adams 1990, p. 66).

[24] The definition was cited in Principle 3 of the Declaration on the Environment and Development at the UN Conference on the Environment and Development in Rio in 1992 and reaffirmed and endorsed in the Johannesburg Declaration On Sustainable Development at the World Summit on Sustainable Development in Johannesburg in 2002 (UN 1992a and 2002). The World Bank has also adopted and endorsed it (1992, p. 34).

[25] See, for example, the discussions in Beckerman 1974, pps. 122-123 and 132 and Lovelock 1987, p. 114 relating to the importance of regulations for pollution control.

[26] See IEA 2002, p. 15 for an illustration of the correlation between lack of access to modern energy services in the form of electricity and poverty.

[27] Electricity consumption is only part of total primary energy consumption but is a good proxy for overall energy use as it is usually the largest energy sector in developed countries and LDCs. See, for example, the figures given at IEA 2001, p. 27 regarding primary energy consumption.

[28] China and India both needed to be included in any realistic discussion of energy scenarios given their present and predicted populations and economic growth rates and relatively low per capita energy usage. Brazil and Nigeria are included as the representatives for Latin America and Africa. They have the largest populations in each region making them statistically significant on a per capita basis and they both have relatively industrialized economies.

[29] A TeraWatt hour is equivalent to one thousand GigaWatt hours or one billion Kilowatt hours. A Kilowatt hour is the amount of electricity consumed by a one thousand watts load operating for one hour. A sixty watt light bulb consumes 60 watt hours every hour.

[30] See McGranahan and Satterthwaite and UNDP et al. 2000, pps. 54 and 56 for a discussion of the relationship between population growth, urbanization and increased energy demands in LDCs. See Table 1 for examples of forecast population increases that, even without increases in GDP per capita, will drive increased energy consumption in LDCs.

[31] The world consumed 450 billion barrels of oil, 90 billion tonnes of coal and 1100 trillion cubic meters of natural gas between 1970-1990 (Meadows et al. 1992, p. 66).

[32] This optimistic view of the world's fossil fuel resource base is predicated on a dynamic view of fossil fuel resources. For the UNDP history has proven this "dynamic" view over the "static" view (UNDP et al. 2000, pps. 139-143). For a critique of the view that fossil fuel reserves can be continually extended in this way see Lovins 1979, p. 4.

[33] Political instability is a key factor in certain oil supplying countries which has frequently led to higher oil prices owing to fears of supply disruption. On a current basis this has included events in Iran, Iraq, Saudi Arabia, Venezuela and Nigeria. National disasters such as the 2005 hurricane Katrina which closed down most of the oil production and refining operations in the United States Gulf of Mexico Coast also led to significant price increases.

[34] Greenhouse gases include carbon dioxide, methane, nitrogen oxide and trophosperic ozone.

[35] See, for example, Hammons 2001, pps.859-861; Beckerman 1992, p. 484; Beckmann 1989, pps. 40-41.

[36] In the Millennium Ecosystem Assessment it is noted that 60 percent of the increase in the atmospheric concentration of CO2 since 1750 has occurred since 1959 on account of fossil fuel combustion and land use changes (UN 2005, 18).

[37] WCED states that even the lower range forecasts of energy growth would require an "energy efficiency revolution" (WCED 1987, 170). The IEA's "Reference Scenario" assumes that "current technologies will become more efficient but that no new breakthrough technologies beyond those known today will be used" (IEA 2002, p. 39). For a contrary view of the magnitude of the contribution that energy

efficiency measures could make to reducing future energy use whilst continuing economic growth see Goldemberg et al. 1987, p. 12.

38 For a perspective that assumes much less significant negative impacts from global climate change see Beckerman 1992, pps. 484-488.

39 This is presented as a "robust finding" by the IPCC , being one which holds under a variety of approaches, methods, models and assumptions and is not expected to be significantly affected by any of the principal uncertainties relating to global climate change and its impact.

40 Although techniques for carbon dioxide sequestration are developing (including by re-injection of CO2 into depleting oil wells which increases well pressure and improves oil recovery), it is not currently believed that a sustainable energy system can be based on fossil fuels alone (IPCC 2001, pps. 23-28).

41 However, on a lifecycle analysis nuclear facilities are significant emitters of greenhouse gases due to the construction and decommissioning activities.

42 RETs are not however entirely free from environmental impacts (see UNDP et al. 2000, p233; Johannson et al. 2004, p. 11) in relation to the acoustic emissions of turbines, bird-kill and the visual impact of turbines.

43 The scenarios include those of the IPCC, the World Energy Council, Shell Corporation, the Renewables Intensive Global Energy Scenario and the International Institute for Applied Systems Analysis.

44 For an alternative taxonomy of policy instruments for the promotion of wind power, see Enzensberge, Wiethschel and Rentz, 2002.

45 See, for example, UNEP and IEA, 2002 and Pershing and Mackenzie, 2004 for a detailed discussion of energy subsidies and their impact on the development of markets for RETs. Such subsidies have been estimated to be worth approximately US$150 billion a year globally (UNDP et al. 2000, p. 424). .

46 See Hoogwijk et al. for a more detailed discussion of factors limiting geographical potential and issues relating to suitable wind regimes and technical potential

47 See UNDP et al. 2000, pps. 164-165 for a discussion.

48 Although some 70 percent of this capacity is in developed countries, there is installed capacity in 45 countries worldwide. India, with 1,300MW of installed capacity as of 2002, is the leading LDC developer of wind-power whilst China also has significant programs (Sawin 2003, p. 90; Martinot et al. 2002, p.322).

49 For a discussion of the cost-reduction learning curves in relation to wind power, see Ibenholt. For discussion relating to the economic competitiveness of wind power, see WEA 2000, p. 230. Operating and maintenance costs are relatively low.

50 This compares with 4,280MW in the USA, 3,175MW in The Netherlands, 2,471MW in Denmark and 8,100MW in Germany (Ackermann and Söder 2002).

51 For example, the "Directive Principles of State Policy" enshrined in the Constitution. These include the principle of securing a social order for the promotion of the welfare of the people and the principle that raising the level of nutrition and the standard of living and improving public health are amongst the primary duties of the state.

52 Poverty figures in India are largely based on the National Sample Survey Organization national household surveys, beginning in 1951. See World Bank 2000, p. 11, footnote 2 for a discussion of the Indian poverty measures.

53 See, for example, statements in the 1st FYP that the GOI's overall planning objectives were maximum production and full employment together with economic equality and social justice and in the 9th FYP that rapid economic growth leads to an improvement in the quality of life provided that it is accompanied by policies orientated to social justice and equity ((GOI, 1st FYP, chap. 2, para. 1; 9th FYP, vol. 1, para 1.5).

54 For illustrative purposes, Indian Rupee figures have been converted into US$ at the prevailing exchange rate as of November 20, 2005 of Rs 45.7 to US$1. US$ figures have been rounded up. The unit of one crore is equivalent to 10 million in standard international numerical representations. The unit of one Lakh is equivalent to 100,000. See, for example, http://www.kshitij.com/utilities/LnCtoMnB.shtml for conversions of Crores and Lakhs.

55 Non-commercial primary energy is principally traditional biomass such as fuel-wood and agricultural residues and animal dung. Commercial primary energy sources include petroleum products, natural gas and electricity.

56 Currently an average of 56.5 percent of rural households are electrified, ranging from under 10 percent of households in some states to more than 90 percent in others. The Tenth Five Year Plan calls for the electrification of the remaining 80,000 unelectrified villages by 2011-2012.

57 Earlier assessments only considered sites to have commercial potential if they had a wind density of 150 watts/ m^2 at a hub height of 30 meters. With new turbine capabilities sites are also considered to have commercial potential if they have a wind density of 200 watts/m^2 at a hub height of 50 meters, expanding the universe of possible sites for wind power projects.

58 Under the Indian constitution, electricity falls under the concurrent jurisdiction of the central and state governments.

59 The use of RETS would also reduce the need for diesel generators and thus diesel. There were some 5.5 million such generators consuming 4.5 million tonnes of diesel by the time of the 8th FYP (GOI, 8th FYP, vol. 3, para. 8.69.1).

60 For a detailed discussion of India's stabilization measures and structural adjustment reforms post the 1990-1991 fiscal crisis see Joshi and Little (1996).

61 See Tongia 2004 for a discussion of reforms in the power sector since 1991. In addition, in 1991 India introduced a "private power policy" which allowed private investors into the power sector for the first time (GOI, 9th FYP, vol. 2, paras. 6.62 and 6.85).

62 In Tamil Nadu 65 percent of wind power generated is wheeled for captive generation and 35 percent is sold to the Tamil Nadu Electricity Board. Only two categories of high-tension industrial customers are permitted to wheel (GOTN, Consultative Paper). Extension of the ability to wheel to all HT customers has been highlighted as an important issue in TN (My Tamil, 2005).

63 The setting of a minimum price is known as a "feed-in tariff". An alternative price support policy is the renewable portfolio standard which would require a

utility or, in India's case, SEB to purchase a fixed percentage of its power from renewable sources. See Hasan and Vipradas, 2004 for a discussion of some of the issues relating to the minimum purchase provisions of the Electricity Act. See Sawin and Flavin, 2004 for a discussion of the advantages and disadvantages of feed-in tariff and minimum purchase obligations for promoting renewable energy markets.

64 Subsidies to conventional energy generation keep the unit price of their electricity artificially low. Subsidies to electricity consumers encourage over-use and also make the unit cost of RET generated electricity appear higher than it is as against the true unit cost of conventionally generated electricity.

65 For more details of IREDA's current lending policies see IREDA, Wind Energy.

66 For example, the ICICI Bank benchmark lending rate at the time of writing is 11 percent per annum and the Standard Chartered benchmark lending rate is 12 percent.

67 This drive included, for example, the establishment of a Ministry of the Environment. For an overview of the principal developments in environmental and sustainable development policy following the UN Conference in Stockholm attended by Prime Minister Indira Ghandi in 1972 see Ganguly, 1996.

68 MNES's mandate for renewable energy includes solar, wind, hydro, biomass, geothermal and tidal energy sources. Non-conventional energy sources that it includes in its programs are related to the development of hydrogen energy, fuel cells and other alternative energy solutions for transportation (GOI, MNES, Ministry, Mandate http://mnes.nic.in/frame.htm?ministry.htm).

[69] See Rubin et al. for a discussion of the importance of learning curves for environmental technology.

[70] See Shikha, Bhatti and Kothari, 2004 and GOI, MNES, AR 1999-2000, p. 57 for more details of the earlier wind-pumping demonstration programs.

[71] BHEL is India's largest manufacturing and engineering enterprise in the energy-related/infrastructure sector. See http://www.bhel.com/bhel/about.htm.

[72] Leading manufacturers include Vestas RRB India Limited, which derives its wind power generating technology from Vesta Wind Systems A/S of Denmark, Enercon (India) Ltd a joint venture between Enercon GmbH, a leading German wind turbine manufacturer, NEG-Micon (India) Pvt Ltd, which is a wholly-owned subsidiary of the NEG Micon Denmark, another global leader in wind technology. BHEL partners with NORDEX of Denmark. Suzlon Energy Ltd appears to be one of the few 100 percent Indian manufacturers. See http://www.suzlon.com/.

[73] When wind turbines start to operate, they pull more power from the grid than they supply. Reducing this draw on "reactive power" clearly improves operational efficiency of the turbines.

[74] See Rajsekhar, Van Hulle and Gupta (1998) for a discussion of the impact of weak grids in India on the performance and economics of wind turbines.

[75] For example, Suzlon is recently reported as having entered into an agreement with John Deere of the United States to supply 31 turbines to wind power projects that it is developing (Wind Farmers Network 2005).

[76] According to MNES's 1997 guidelines for the wind power sector, certification could be provided by any of Riso National Laboratories, Denmark, Det Norske Veritas (DNV), Germanischer Lloyd, CIWI, The Netherlands and Lloyds Register. See GOI, MNES, Wind Programme, Guidelines For Wind Power Projects for further details regarding the development of MNES's certification requirements at http://mnes.nic.in/frame.htm?majorprog.htm.

[77] India's nuclear energy program is directed at developing a fast breeder reactor, of which a 500MW prototype has been built and then a heavy water reactor which can utilize its thorium reserves.

[78] Artificially low electricity prices have also encouraged excessive irrigation in the agricultural sector, contributing to the depletion of aquifers, a reduction in the availability of drinking water and distorting crop profiles, all knock on effects that can only be considered detrimental to development and its sustainability (World Bank 2000, p. 66).

[79] The subsidy to agricultural and domestic consumers in 2004 totaled Rs196 crores (US$40 million) and Rs910 crores (US$200 million) respectively.

[80] See Hasan and Vipradas, 2004 for a discussion of the some of the detailed issues relating to the operational integration of wind power into grids. See Rajesekhar, Van Hulle and Gupta, 1998 for a discussion of some of the technical issues.

[81] In Tamil Nadu, the electricity board's poor financial position led to a reduction in the tariff offered to Rs2.70/kWh, of which only Rs2.25/kWh is currently paid (GOTN, Policy Notes 2002-2003).

[82] At the time of writing the Prime Minister of India and President of the United States concluded an agreement whereby the US agreed to provide India with access to its civilian nuclear technology, provided certain safeguards are provided in relation to the military nuclear technology use and proliferation. If ratified by the US Congress, this might provide a favorable framework for the transfer of nuclear technology to India for power purposes.