Sustainability Transitions:

Exploring the Transformation of Nicaragua's Electricity System from Fossil Fuels to Renewable Sources

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"Our dependence on nature to provide the materials for our consumption and our concern for the health of our planet sets us into an uneasy contradiction."

- Edward Burtynsky/OIL Photo Exhibit

This study has been carried out within the framework of the Minor Field Study (MFS) Scholarship Programme, funded by the Swedish International Development Co-operation Agency (Sida).

The MFS Scholarship Programme gives Swedish university students the opportunity to carry out fieldwork in a Third World country. The extent of the work can lead to Bachelors or Masters Degree. The studies focus on areas and issues of relevance for development problems, and are conducted in countries supported by Swedish development assistance.

Sida's main purpose with the MFS Scholarship Programme is to stimulate the students' interest in, and increase their knowledge about, as well as their understanding for, developing countries and development issues. The MFS scholarships provide the students with practical experiences of the conditions of development. A further aim for Sida is to strengthen co-operation between Swedish University Departments, Institutes and organisations in countries in Africa, Asia and South- and Central America.

The Department of Social and Economic Geography at Lund University is one of the departments that administer MFS Programme funds.

ABSTRACT:

Our current energy system provides essential services for human prosperity, however, the continued dependence on non-renewable and ill-distributed fossil fuels as the primary source for energy results in increasing green house gas emissions with detrimental environmental consequences and mounting threats for long-term sustainable development, making it critical to understand and promote transitions towards more sustainable energy systems. This thesis uses a qualitative study case methodology to investigate an on-going transition to renewable energy in the Nicaraguan electricity sub-sector, using transition theory to analyze drivers, barriers and actors involved in the process and explore governance issues that affect the transition process. The study found that, although sustainability is a growing concern at the landscape and niche levels, the principal motivation behind the goal oriented transition in Nicaragua stems from economic concerns and the sustainability commitments of the transition remain unclear. The hierarchical top-down governing structure characterizing the Nicaraguan transition faces difficulties as the transition process is characterized by diffused power and rests on multiple actors to push the transition forwards. The paper concludes with a discussion on governance aspects surrounding the practical difficulties of implementing a more reflexive and interactive mode of governance, akin to the ones put forward in current research into transition governance and governance for sustainable development.

KEY WORDS: *Renewable energy, electricity systems, transition theory, sustainable development, governance, Nicaragua*

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Finally, note to self, congratulations for completing this challenging project!

Emili Pérez

TABLE OF CONTENTS:

FIGURES AND TABLES:

LIST OF APPENDICES:

Word count: 14,940

ACRONYMS:

ANPPER	Nicaraguan Association of Producers and Promoters of Renewable Energy
BCN	Central Bank of Nicaragua
CABEI	Central American Bank for Economic Integration
CDM	Clean Development Mechanism
CNDC	National Load Dispatch Center (Centro Nacional de Despacho de Carga)
CNE	National Energy Comission (Comisión Nacional de Energía)
EIA	Environmental Impact Assessment
ENATREL	National Transmission Company (Empresa Nacional de Transmisión Eléctrica)
ENEL	Nicaraguan Electricity Company (Empresa Nicaraguense de Electricidad)
GEF	Global Environmental Facility
GHG	Greenhouse Gases
GIER	(Support Group for Renewable Energies of the Municipality of Leon),
INE	National Electricity Institute (Instituto Nicaraguense de Electricidad)
IPCC	Intergovernmental Panel on Climate Change
kWh	Kilowatt(s)-hour
MARENA	Ministry of Environment and Natural Resources (Ministerio del Ambiente y Recursos Naturales)
MEM	Ministry of Energy and Mines (Ministerio de Energía y Minas)
MW	Megawatt(s)
MWh	Megawatt(s)-hour
NIS	National Interconnected Electricity System
PPA	Power Purchase Agreement
PNSER	Programa Nacional de Electrificación Sostenible y Energía Renovable para Nicaragua
RE	Renewable Generated Electricity
ROR	Run-off-the River hydropower
SHP	Small Hydropower Plants
SIEPAC	Central American Interconnected Electricity System (Sistema de Interconexión Eléctrica de los Países de América Central)
SMEs	Small and Medium Enterprises
UNFCC	United Nations Framework Convention on Climate Change
UF	Union Fenosa-Gas Natural

KEY TERMS:

CONCESSIONS: Refers to electric distribution concessions. *Distribution* is the process through which low-voltage energy (under 69 kV) is transported from the high-voltage transmission lines to the end-costumer, be it a house, office or industry.

LICENSES: Refers to electric generation and transmission licenses. *Transmission* is the process through which high-voltage (over 69 kV) energy is transported from the generation plants to distribution nodes around the country.

I. INTRODUCTION

Energy is an essential constituent of human prosperity as energy services in the shape of, for example electricity, have become closely inter-webbed with many aspects of socio-economic development. Strong and positive correlations between modern energy services and human well-being suggest that access to energy services is vital to improve life quality, increase productivity and sustain economic growth (IPCC, 2007:256,263; Bilgen and Kyguzus, 2004:1128). The current socio-technical structure built to provide these critical energy services, however, is plagued by negative environmental and social impacts, stemming from a strong dependence on finite and ill-distributed fossil fuels as our prime source of energy. Fossil fuels supplied 80% of world primary energy demand in 2004 and their role in the existing global energy system is expected to continue increasing in absolute terms over the next 20 to 30 years (IEA, 2010:4; IPCC, 2007:265). The electricity sector is not an exception to this trend, with 67% of world electricity generated from fossil fuels in 2005, and electricity demand estimated to rise between 110 and 260% by 2050, quicker than any other forms of primary energy demand (IPCC, 2007:263). The high dependence on fossil fuels makes energy-related GHG emission responsible for around 70% of total emissions, these are expected to continue rising by over 50% by 2030 as carbon intensive energy markets meet the ever-rising energy demand (Ibid: 253).

These carbon intensive trends embody important threats to sustainable development - understood as the path to sustainability, a three pillar concept recognizing the links between economy, environment and society and the importance of meeting our current needs without sacrificing those of future generations – with climate change as the more notorious manifestation (Kemp et al. 2005:13; Kemp and Martens 2007:6; IPCC, 2007:100). The recognition of the critical link between fossil fuels, climate change and sustainable development was expressed in the 1997 Kyoto Protocol and more recently in the 2009 Copenhagen Accord which set non-binding commitments to keep global temperature increase within a 2◦C above pre-industrial levels (IEA, 2010:1). Reducing GHG emissions to meet this target, however, will require a transformation of the global socio-technical energy system and increased participation of renewable energies, particularly in the electricity sector, is considered a critical step "*to move the world onto a more secure and sustainable energy path"* (Ibid:9,12; IPCC, 2007:310).

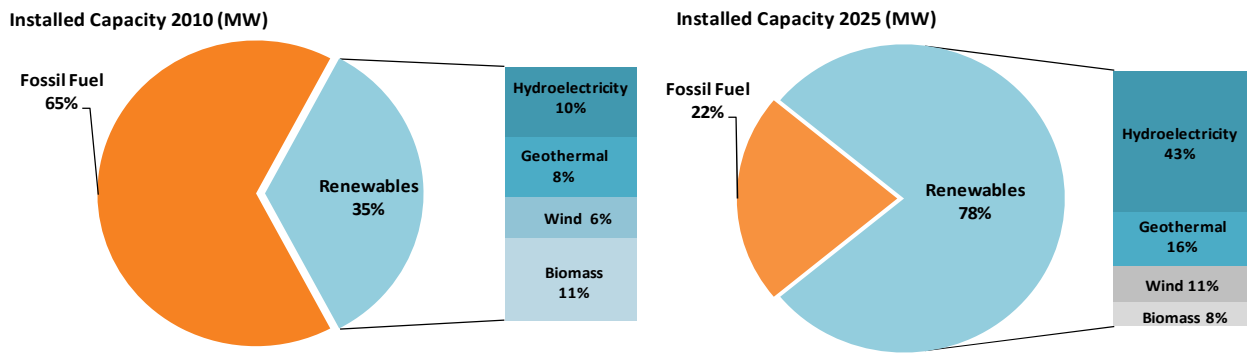
A successful transformation of the energy sector towards a more sustainable system entails drastic changes in numerous dimensions to overcome a multiplicity of barriers and constraints, involving diverse actors and altering entrenched institutions and market structures (Geels, 2002:1258; IPCC, 2007:254). The energy sector exemplifies what Rotman (2005) and Loorbach (2010) refer to as persistent societal problems, characterized by elevated complexity, as they are deeply embedded in our social and economic structures; high degree of uncertainty since knowledge is limited and diffused; difficult to manage given the multiplicity of players and hard to grasp as they have strong interrelationship to other social problems. Given the complexity of the energy sector and its intrinsic relationship to sustainability, a transition towards more sustainable energy systems embodies profound challenges and opportunities for sustainable development (Kemp et al 2007:317; Meadowcroft, 2009:324).

a) AIM OF THE STUDY

Nicaragua - the second poorest economy in Latin America[1] - is a small developing country with a vast renewable energy stock[2] (MEM 2011a:21; Mostert 2007:1), currently estimated at 4,500 MW[3] (*Ibid* MEM). Ironically, just about 5 % of this abundant potential is currently exploited for electric generation and instead, the country relies heavily on oil, a non-autochthonous resource, to generate approximately 70% of the electricity it consumes (Ibid: 64). With international oil prices on an escalating trend at the turn of the 21st century and a stunted export sector, scarce and badly-needed foreign currency was being unsustainably spent on bunker and diesel to feed the country's thermal plants (AN, 2004:Decree 13-2004; MEM 2011a:20).

The strong fossil fuel bias of the electricity sector coupled with rising fuel prices; bought the country into a deep electricity crisis, with prolonged black-outs and rationing in 2005-2008. The inability of the existing electricity system to solve the situation finally convinced the State that overhauling its current electricity system, to create a sovereign, efficient and reliable electricity system, had to become a priority (MEM, 2011a: 35, 54, 62; Kinloch, 2008:365). Diversification of the electricity matrix towards autochthonous RE sources is at the heart of the Government strategic plan to solvent the crisis of the sub-sector. The dimension and speed of the suggested change in the generating matrix of the country – going from 34.2% installed capacity of RE in 2010, 73% by 2017 and stabilize at 78% in 2025, as illustrated in Figure 1 below – will entail a substantial transformative process in one of the most fundamental societal subsystems, requiring considerable political effort and financial and human resources.

FIGURE 1 Installed Capacity Electricity Sub- Sector 2010 and 2025 (MW)



Source: Prepared by author based on MEM (2011a) and MEM (2010).

This thesis aims at exploring the transition in the Nicaraguan electricity sub-sector using Geels (2004), Verbong and Geels (2007) and Rotmans et al. (2001) socio-technical multi-level and multi-phase theory on transitions to identify and explore the drivers and barriers affecting this conversion process and identify the key actors and relationships in the transition process. The findings of this analysis will be used to discuss governance issues surrounding the transition, focusing on how the governing strategy in Nicaragua relates to the on-going debate on governance of transition processes and governance for sustainable development, as discussed by, for example, Loorbach (2007; 2010), Kemp et al. (2005), Duitt and Galaza (2008); Duitt et al. (2010) Meadowcroft (2007; 2009). The author recognizes that a socio-technical system includes both producers and users of a technology and a systemic approach should be followed to look at the system as a whole, however, the scope of this study will be restricted to the supply-side of the electricity system, that is generation, transmission and distribution, thus demand side aspects, such as energy efficiency and access, are not the focus of the study. The following questions where established to guide the research:

[1] With a GDP per capita of USD 2,623 (PPP), only Haiti ranks lower in the region. (UN HDR 2010)
[2] In Central America, Nicaragua has the largest geothermal and wind energy generation potential (CABEI 2009:14)
[3] The current demand of energy in Nicaragua is of less than 600 MW, so the potential in RE is almost 8 times the value of the current demand (MEM 2010:10).

i. Research Questions

1. *What are the key endogenous and exogenous drivers and barriers affecting the transition from a predominantly fossil fuel based electricity system to renewable energy generation in Nicaragua?*

2. *Who are the central actors influencing the transition of Nicaragua´s electricity system towards renewable energies?*

3. *What critical governance challenges are facing Nicaragua in its electricity system transition to renewable sources?*

b) RATIONAL AND RELEVANCE OF THE STUDY

Given the critical importance of developing an efficient electricity sector for the attainment of the manifold goals of sustainable development, it becomes essential for sustainability science to comprehend and analyze how transition processes in this sector are initiated, developed and managed. By exploring an on-going transformation process in this sector the thesis hopes to provide relevant insights into the nature and dynamics of such transitions, these findings can provide a source of insight for small oil-dependent developing countries undergoing similar transitions.

Although transition theory has been used to analyze transitions in socio-technical systems the application has been limited to developed economies, in particular to European countries (see for example Kemp et al. 2007; Verbong and Geels, 2007; Geels 2001). Research into socio-technical transitions in developing countries using transition theory, specifically in the energy sector, remain scant (Loorbach, 2007:295). The aim of this thesis is thus novel as it seeks to use the transition theory frame to examine a forthcoming transition in a small developing country and explore governance issues of a transition process that is embedded in a developing countries institutional context.

II. CONTEXT

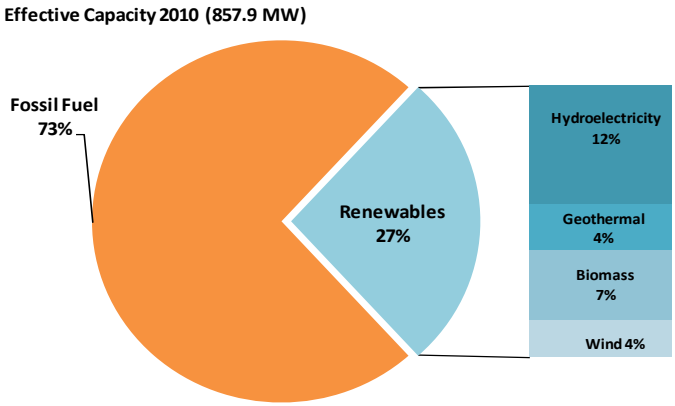
Nicaragua, located at the heart of the Central American isthmus, with a population of 5.7 million (BCN 2010) - over 40% of them living under the line of poverty - and a GDP per capita of USD 2,632[4] (UNDP 2010), is the second poorest economy in the Latin America region. A more comprehensive indicator, such as UNDP's *Human Development Index (HDI)* situates Nicaragua, with an HDI of 0.565, in a similarly unfavorable position compared to the rest of the region, which averaged 0.706 in 2010 (UNDP 2010). In a country as socio-economically vulnerable as Nicaragua, necessities abound and resources are scarce. Throughout the last two decades, budgetary gaps have been recurrently covered by foreign aid, which has poured into the country, making Nicaragua the most aid-dependent countries in the Americas and one of the most aid dependent in the world, with aid flows averaging 30% of the country's GNI during the 1990s and of 18% during the 2000-2008 period (WB, 2010). For comparative purposes, the second-most aid dependent country in the Latin American and Caribbean is Honduras, which averaged aid levels at 10.7% of its GNI in the 1990s and 6% in 2000-2008. Economic growth had been slow, averaging 3.8 % for the last decade, and the primary sector is the largest economic sector, with 20% of GDP in 2009, and the main source of employment and exports, with coffee and beef at the lead (BCN, 2009). Inequality is high with GINI coefficient of 52.3 in 2009 (UN, 2009: 197).

After a decade of armed conflict following a popular revolution in 1979, Nicaragua transitioned to peace and democracy in the 90's, though public institutions remain weak, corruption is endemic and political polarizations remain strong, resulting in confrontation and discontinuity between governments (Kinloch,

[4] At *Purchasing Power Parity* (PPP). In current USD, the GDP per capita comes down to USD 1,070.8 (BCN 2010)

2008:350). In the 90's the country underwent substantial transformations in the context of aggressive structural adjustment programs informed by neoliberal principles, resulting in privatization, economic liberalizations and a drastic reduction of the state (Kinloch, 2008:340). The energy sector was not an exception to this trend. Electrification remains the lowest in the region at 64% concentrated in urban areas and the effective generation is dominated by fossil fuels (mainly fuel oil and diesel), as illustrated in the graph below, despite an abundance of autochthonous renewable potential detailed in Figure 2 and Appendix 3.

Figure 2 Effective Capacity 2010 and Renewable Energy Potential



Type of Generation	Available Potential (MW)	Installed Capacity / Nominal (MW)	Effective Capacity* / Real (MW)	Resource Utilization (%)
Hydroelectric	2,000	104.4	100	5.00%
Geothermal	1,500	87.5	37.9	2.50%
Wind	800	63	30	3.80%
Biomass**	200	121.8	60	30.00%
TOTAL	**4,500.00**	**376.7**	**227.9**	**5.10%**

Source: Prepared by author with data from (MEM, 2011a:21) and (MEM 2010:9)
* Effective capacity is affected by seasonality of energy production (e.g. in dry months, hydroelectric generation goes down as rain diminishes) and off-time due to plant maintenance requirements.
**The biomass category refers only to sugar-cane.

For commercial and industrial consumers, Nicaragua offered in 2010 the second most expensive electric energy of the Central American region, at approx. USD 0.23/ kWh (INE 2010), which is over 30% more expensive than the price offered to the same niche of consumers in neighboring Costa Rica. Costa Rica's lower cost structure for the provision of energy is intimately linked to the fact that over 90% of its annual net generation of energy comes from processing autochthonous, renewable resources, while Nicaragua generates over 70% of its energy by processing imported fossil fuels in obsolete thermo-electric plants (Barcenas 2004; ECLAC 2010; Barcenas 2008; Jimenez 2009:279).

An indicator that measures well the impact of electricity prices on the welfare of households is the percentage of the minimum wage that is required to acquire a certain amount of energy in a specific country. For residential users in Costa Rica, acquiring 250 kWh in 2009 meant allocating 5.2% of their minimum wage (minimum wage in Costa Rica is USD 562.1), while in Nicaragua the same allotment of energy demanded 33% of a citizen's minimum wage, which in Nicaragua is less than one fifth of Costa Rica's, at USD 104.7 (BCN 2010:4-5). The regional average is approximately 16% (Jimenez 2009:222). Although this indicator reflects, on one part, the small size on the Nicaragua's economy, it also illustrates the potential impact that lowering electricity prices would have for Nicaraguan families and how this objective is essential to support the country's poverty reduction strategy. The country's *Energy Intensity of its Gross Domestic Product*, which in the case of Nicaragua is twice (2X) the average of the region, suggests that economic sectors make unproductive use of the electric service and inefficiencies in the system are high (ECLAC 2010).

III. METHODOLOGY

The aim of this thesis is to explore and understand social behavior and dynamics, with the aim of arriving at an explanation of their causes, paths and consequences. Thus, in regards to the author's approach towards knowledge development, the main objective is to interpret and articulate social phenomena (Bryman 2008:15).

When opting for a research strategy, mainly qualitative methods were favored to allow the author to explore people's views in regards to other people and their changing socio-economic and environmental context (Bryman 1988, p. 103).

Throughout the study, the author maintained a deductive relationship with theory, meaning that relevant theoretical frameworks were chosen prior to the beginning of the study, in order to allow for the formulation of appropriate research questions, and set-up of a clear structure for data collection and analysis (Bryman 2008:13). As the basis for the theoretical foundation of the study are embedded in transition theory and sustainability science, the author tried to pursue a research strategy informed by non-linear knowledge, also referred to as Mode 2, in which knowledge is developed by scientists in co-production with societal actors and draws on multiple disciplines to redefine and analyze complex problems (Rotmans, 2005:20; Gibbons et al., 1994: 2).

a) RESEARCH DESIGN

A single case study was deemed appropriate as the research questions where of an exploratory nature, the researcher had limited control over events and the study is focused on contemporary phenomenon within a real-life context (Yin, 2002:1). The relevance of the particular contextual conditions as determinants to answer the research questions and the need to establish operational relationships over time also favored a case study approach (Ibid: 6). As the study departed from a theoretical frame based on system and complexity thinking, a holistic design, as discussed by Yin (2002:45), was adopted to enable the author to acknowledge and explore the multiple levels, phases and spheres linked to the transition process under scrutiny. Based on Bryman (2008: 56-58), this case study can be considered a representative case for the broader category of small, oil dependent developing countries with similar political and socio-economic structures and a revelatory case as the theoretical and analytic framework underpinning the research questions have been predominantly studied and applied in the context of developed countries (Loorbach, 2007:295).

When designing qualitative case studies, special care should be put in enhancing the validity of one's findings (Yin, 2002:34), both in relation to the strength of the inferences, propositions and conclusions of the study (internal validity) and the ability to generalize those inferences, propositions or conclusions to other settings (external validity). To ensure that the groups of actors that were interviewed and the phenomena that was explored got portrayed and analyzed in a consistent and accurate manner (improving internal validity and reliability), senior experts' opinions were consulted (directly and via secondary sources) and findings were recurrently confronted with available theory, in order to gage the reasonability of the author's arguments (Yin, 2002:99, 100). In regards to external validity, it must be noted that transitions are dynamic processes significantly shaped by historical and circumstantial arrangements. Therefore, the conclusions in this study specifically address very particular elements of the Nicaraguan case, which might or might not be present in other developing countries. Therefore, the generalizability of this study is only analytical, serving as a practical guide to apply a systemic and institutional approach to the analysis of similar transitions in developing country settings.

b) RESEARCH METHODS

The study adopted qualitative research methods based on the guidelines presented by Bryman (2008) and Yin (2002). Data collection was carried out *in situ* from January until March 2010[5] and a case study database was built to formally assemble all the evidence that served as input for the final report, thus increasing the reliability of the case study (Yin, 2002:83, 103).

[5] Field data collection was carried out in collaboration with Danilo Valle Kinloch, student at the International Masters Program in International Development and Management at the University of Lund.

i. Interviews

Interviews were based on semi-structured, open-ended protocols, which provided flexibility to not only collect pre-identified data, but also personal views, opinions and spontaneously shared information that had not been anticipated. A total of 21 in-depth interviews proved vital in order to map out the themes and processes that were most relevant in the transition process, including *(i) the interviewee's role in the transition process, (ii) their relationship with other key stakeholders in the transition process* and *(iii) critical factors, current or potential, that could drive or block the transition process.* Interviews were carried out in Spanish and digitally recorded with the consent of the interviewee, for later analysis in search of emergent patterns, themes and narratives. See Appendix 1 for a list of interviewees.

The sampling of interviewees was strategically done so that it fulfilled the author's triangulation requirements (Bryman 2008:183-184,458), and was facilitated by advice from field-experts and the feedback of the own interviewees (i.e. snowball sampling). Selection criteria targeted interviewees considered stakeholders in the energy sector based on trajectory, affiliation and influence, seeking a diverse sample to represent the array of actors and assist with issues of recollection and bias. As needed, group discussion was also employed as an interview method (Bryman 1988: 49). The appropriateness of the study sample is attested by the variety of stakeholder groups that were included and the clarity of the patterns that can be observed in the data (Bryman 1988:116). Respondent validation of the author's inferences and propositions was used (*Ibid*: 77).

ii. Field Visits & Direct Observation

Direct non-participatory observation was also used to provide the author with relevant insights of the complex social relationships and construct a qualitative contextual picture RE projects, (Bryman, 1988: 109). Field-visits were always complemented by interviews at the place of destination, allowing the author to contrast evidence from different sources, see Appendix 2 for areas of these visits.

iii. Literature Review

As a third source of evidence, a systematic literature and archival records review was carried out to provide exact, detailed information regarding the context of the issue being explored. Documents and archives where crucial to gather quantitative and longitudinal information and provided an unobtrusive method for data collection (Yin, 2002:86). Given the novel nature of the study, the author had access to a limited set of comparable studies to draw upon thus forcing the author to consult a broader set of documents and records.

c) ETHICAL CONSIDERATIONS

The key principles that guided ethical behavior during this study were: *honesty, openness, orderliness, consideration and impartiality* (Gustafsson et al 2006:6). Face-to-face interviews were carried out with explicit approval from the interviewees and the principle of anonymity of sources was respected when making references in the final report.

d) LIMITATIONS:

Given the novel nature of the study the author had a relatively limited set of prior studies to draw focused on transition theory in developing countries and the choice of study case also proved to be problematic as there are few published academic studies on the country and sub-sector, leading the author to rely on material from an array of sources.

IV. THEORETICAL FRAMEWORK

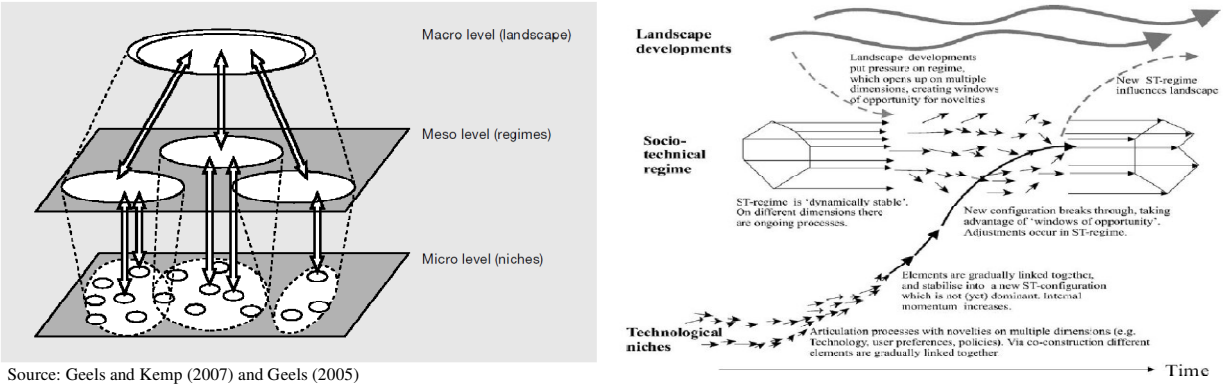
Transition theory provides a valuable structure to analyze comprehensive, long-term processes of societal change, focusing on the elements that spark these processes, how they develop, accelerate and subsequently stabilize. Transitions are understood as gradual processes of change where the structural character of a complex sub-system of society transforms, involving a shift from one socio-technical system to another and a fundamental modification of the dominant rules of the game, established technologies and societal practices (Rotmans et al., 2001:16; Meadowcroft , 2009:324; Geels and Kemp, 2007:446). Socio-technical systems refer to the configuration of a cluster of elements including institutions, technology, markets, and networks to fulfill socially valued functions, such as electricity end-services or transport, for example (Geels 2005:681; Geels 2004:900). Socio-technical systems can be understood as regimes of relatively stable assemblages, the *interrelated and interlocking* aspects of socio-technical regimes make them resistant to change and path dependent (Berkhout, 2002:2; Smith et al. 2005:1493). Transition processes in socio-technical systems are non-linear and come about through co-evolutionary changes in multiple domains, levels and phases (Rotmans et al. 2001:16). Transition can be discussed in terms of evolutionary transitions that do not have a pre-determined outcome and goal oriented transitions which aim at certain goals or desired end-states of the system (Rotmans 2005:15). The framework consists of two basic analytical tools used to portray and understand transition processes, the multi-level perspective (MLP) and the multi-phase perspective (MPP).

Multi-Level Perspective (MLP)

Processes of change in complex socio-technical systems are influenced by cross-level drivers and constraints, affecting a diverse constellation of actors and their relationships. The MLP distinguishes between three social organization levels: micro, meso and macro (Duitt and Galaza., 2008:311; Rotmans et al. 2001:19). These levels are akin to the niches (micro), regime (meso) and landscape (macro) classification used by Geels (2002) to analyze technological transitions and the terms will be used interchangeably in the course of this thesis (Rotmans et al. 2001:19; Verbong et al. 2007:1026).

The *socio-technical landscape* refers to the exogenous environment that is beyond the direct influence of the actors within the system. The landscape includes aspects related to the economic system, general political conditions, institutions, worldviews and dynamics of the natural environment (Geels and Kemp, 2007:443; Rotmans et al. 2001:19). Changes in the landscape are slow and filter down to the meso and micro level exerting pressure and constraints on development trajectories (Verbong and Geels, 2007:1026). The *regime or meso level*, refers to a conglomerate of structure (institutional and physical setting), culture (prevailing perspective and paradigms), and practices (rules, routines, and habits) (Rotmans and Loorbach, 2009:185). Through the alignment between these heterogeneous elements, the regime accounts for dynamic stability in the socio-technical system, with incremental innovations geared at optimizing the dominant technological configuration. A regime is characterized by path-dependence and potential lock-ins due to vested interest, sunk investments, technical complementarities between system components and regulations and standards in force (Verbong and Geels, 2007:1026). The *micro level* comprises individuals and organizations involved in innovation practices that deviate from the existing regime, important processes at this level are network building, learning processes and development and experimentation with new technology and social organization (Ibid:1026; Geels, 2004:912). The relationship between the levels is a nested hierarchy and system innovations and transition processes take place through the interaction between developments at different levels as illustrated in Figure 3 bellow.

FIGURE 3 Multi-Level Perspective on Dynamic Socio-Technical System Innovation



Source: Geels and Kemp (2007) and Geels (2005)

Multi-Phase Perspective (MPP)

Transition theory distinguishes between four transition phases altering between periods of slow and fast development spanning long time horizon (Rotmans et al. 2001:17). Given the complexity of transitions and the high degree of uncertainty, alternative transition paths may lead to a stabilization point while path dependence, due to previous investments, may lead to lock-in, system resistance and lack of flexibility, which in turn can result in system backlash or overshooting and the inability of a system to respond can eventually lead to system breakdown (Rotmans, 2005:22). The four distinguished phases in a transition process are as follows (Rotmans et al., 2001):

- *Predevelopment:* Dynamic equilibrium where the status quo does not appear to change.
- *Take-off*: Process of change gets under way because the state of the system begins to shift.
- *Breakthrough:* Visible structural changes through buildup of socio-cultural, economic, ecological and institutional changes that react to each other.
- *Stabilization:* Speed of change decreases and a new dynamic equilibrium is reached.

Transitions in socio-technical systems have inherent complexities as they require significant changes involving multiple actors, domains and resources, interacting at various levels (Walker and Shove, 2007:219). A socio-technical transition aimed at pursuing sustainable development faces compounded complexities as sustainability goal setting is subject to heterogeneous perceptions and controversial interpretations resulting in ambiguity, knowledge of the dynamic relationships between society, nature and technology is uncertain and the power to control change in societal systems is vertically and horizontally diffused amongst an array of actors and domains, steering transitions thus, entails a substantive challenge for traditional linear governing approaches based on hierarchical power, predictability and control (Newig et al. 2007:187; Walker and Shove, 2007:214; Meadowcroft, 2007:306, 2009: 323; Duitt et al. 2010: 311; Kemp et al. 2005:16).

The term governance has been put forward as an alternative to traditional hierarchical governing and refers to a mode of social coordination or a "*shared responsibility of representatives from the state, the market and civil society dealing with societal problems*" (Kemp et al. 2005:17; Glasbergen et al. 2002 cited in Zeijl-Rozema et al. 2008:412). There is an array of classifications of governance ranging from *hierarchical governance* – which is not dissimilar to traditional governing – and *deliberative governance* – in which societal actors shape societal goals through dialogue and social learning hierarchical (Zeijl-Rozema et al. 2008:413-414). In the context of socio-technical transitions, reflexive and interactive governance has been put forward as governance strategies that purposefully employs interactions with alternative power centers to define visions and goals and encourages reflection in government and society to reassess and adjust development paths (Meadowcroft 2009:308; Loorbach 2007:82). Transition management is a concrete

example of a reflexive governance approach for transitions where steering takes place through *transition arenas*, which are platforms for interactive consensus building and strategy and vision development, and emphasis is placed on experiment portfolios, social learning and reflection and adaptation at all levels (Vob et al. 205; Loorbach 2007; Smith et al. 2005: 1502; Rotmans 2005: 44; Rotmans and Loorbach, 2009: 185; Rotmans et al. 2001: 22).

V. DATA ANALYSIS

a) DEVELOPMENT AND CURRENT STATE OF THE SYSTEM

Nicaragua's electricity sub-sector has undergone substantial reforms during the last two decades, aimed at creating a competitive and attractive market where private investors participate in the countries distribution and generation, while the government answers for part of the generation, transmission, policy making and regulation (AN, 1998: Law 272). Though renewable generation has been on the agenda since the early 2000's, it did not become an explicit priority until 2005, when the unbalanced development of the sector materialized in a national electricity crisis (CNE, 2003:6; MEM, 2011a:36). To understand what has inhibited a larger participation of RE and what has triggered the current political impetus for RE, it's important to examine the key reforms and trends in the sub-sector over time.

i. Key Reforms and Development of the Electricity Sub-sector (1990-2003):

During the 1980s, the state - represented by INE - exercised complete control over the energy sector and its activities from planning, policy making, regulation and monitoring, to generation, transmission, distribution and commercialization of energy (AN, 1979:Decree 16-1979; Decree 189-1979; AN, 1985:Decree 87-1985). The most crucial restructuring of the electricity sub-sector takes place in 1994-2000, when power sector reforms create ENEL, which absorbs all commercial activities, meaning generation, transmission, distribution and commercialization of electricity from INE, which is temporarily left in charge of the planning, policy making and regulating aspects of the sub-sector (AN, 1994:Decree 46-1994). The vertically integrated state monopoly ENEL is subsequently horizontally and vertically segmented in 1998 and the principles of an open and competitive wholesale electric market are laid out (AN, 1998: Law 272; Law 271, Decrees 42-1998; AN, 1999: Decree 128-1999). Planning and policy-making activities are taken from INE and passed onto a new entity called CNE, leaving INE in charge of approving commercialization tariffs, monitoring, and emission of licenses and concessions in the sector (AN, 1998: Law 271).

Under the new sectoral organization, generation, transmission and distribution are vertically separated within the NIS. The transmission system is operated by the state owned ENATREL, which is responsible for managing the NIS and administering the bulk power market. To foment a competitive structure for bulk market bidding, ENEL's generation capacity is separated into several public and private companies. The bulk power market is made up of generators, authorized large consumers (≥1 MW) and distributors and the price is set under a free market price regime (CABEI, 2009:46). Power sales can take place through PPA contracts between generator, distributor and large consumers, spot market sales and short term market capacity sales. PPA bids from thermal power producers include an automatic adjustment for imported fuel prices while RE bids are not entitled to premiums for long-term price stability (Mostart, 2007:11).

In 2000, the national distribution system was geographically split to create two distribution companies, however, the international bidding process results in UF winning both contracts, thus creating a far-from-optimal scenario where a private monopoly controls market demand[6] (Dussan 2004:3; ODG 2009:17). With

[6] Though the geographical division of the national distribution system (DISSUR and DISSNORTE) was conceived to avoid a national monopoly of distribution, the imminent approval of the HIPC initiative conditioned to the privatization and segmentation of the electricity market accelerated the need to rapidly privatize assets (BCN 2005:37; Acevedo 2005).

the privatization of the distribution, the technical and non-technical losses of the system become crucial; estimated at 31.9% in 2000[7], they are the highest in the region (ECLAC, 2009:10; CABEI, 2009:20). Structural factors, including obsolete distribution infrastructure, entrenched electricity theft, corruption and a lack of legal instruments allowing the distributor to take legal action against theft, make it difficult to reduce losses (Mostart 2007:10). Together with regulated commercialization tariffs that acknowledged losses substantially below their real value and where not automatically adjusted to reflect real electricity market costs, the distributor's financial situation became precarious, affecting its credibility to enter long-term contracts and conveying increased uncertainties for potential investors in the electricity market (CABEI, 2009:30; MEM, 2011a: 43; Mostart 2007:12).

Peak Load electricity demand and Net Electricity demand increase in this period from 253 MW in 1990 to 483 MW in 2005 (CABEI, 2009:20; MEM, 2011a:35). On the supply side, the nominal generation capacity increases from 363 MW to 758 MW, however, the nominal capacity share of RE declines from 47.7% in 1990 to 42.1% in 2005 and the share in net generation decreases from 61.2% to 33.5% for the same period (CABEI, 2009:20; ECLAC, 2009:59). These negative RE supply trends are counter to the competitive prices estimated for RE projects in Nicaragua - US$65-70/MWh for geothermal; US$60/MWh for ROR and US$54-66/MWh for wind – compared to average rising electricity prices in the bulk power market of U$ 74.2 in 1998, US$65 MWh between 2000-2003 and US$88 in 2005 (Mostert, 2007:2; ECLAC, 2008:57).

At this point it's important to pause and analyze the features of the reformed electricity market, as many aspects of the regulatory and institutional environment favored an increasing dependence on oil, helping to explain the establishment of the dominant oil regime in Nicaragua despite abundance of RE sources. Under the new electricity market reforms, the desired segmentation of distribution and generation to create a competitive and attractive investors market was not successful. The establishment of a monopolistic distributor constituted a far from optimal scenario for RE investors. As serious lags in the adjustment of commercialization tariffs to match bulk-market prices accumulated, and high levels of losses prevailed in the distribution system, the distributor faced an increasingly weak financial position, discrediting it as a reliable counterpart to enter long-term PPAs which are critical for the large capital investments required by RE projects (Cosep, 2008:22; Mostert, 2007:10; MEM, 2011a:43; Sanden and Azarb, 2005:1565). As a result, the power sector was biased towards less capital-intensive oil-based generation which sold through short-term contracts with automatic price adjustments for fuel costs and spot-market sales.

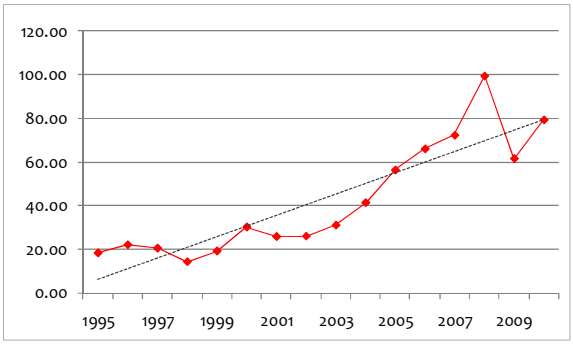
Another outcome of the electricity sub-sector reforms influencing the establishment of thermal plants instead of RE was the unclear organization of the sector, the regulatory fuzziness regarding RE projects and the lack of sectoral targets for RE to stimulate and guide investors, defining aspects of the institutional context which are considered critical for RE and technology adoption (Jacobsson and Johnsson, 2000:630,632; Bergek et al. 2008:408). The substantial and accelerated reforms resulted in an unclear division of work between INE and the CNE, with overlapping functions in the emission of licenses and concessions for RE projects, power struggles between the institutions and inefficient coordination, making transactions thorny and costly for investor (Mostert 2007:xvi). Though several laws where approved to regulate RE explorations and generation licenses, multiple and uncoordinated reforms to these laws has resulted in a myriad of regulatory documents, making it difficult to get a clear overview of the regulatory framework for renewables. The key laws and policy documents for the period contain no specific RE targets and no economic incentives based on the perception that the market alone will produce desirable economic results (AN, 1998: Decree No. 13-2004). This *laissez-faire* approach to technology adoption has been widely refuted and research shows that the institutional *milieu* and active goal setting for RE adoption is critical to foster up-take of renewable technologies (see Burki and Perry, 1998; Sanden and Azarb, 2005; Geels, 2005; Bergek et al. 2008, for example).

[7] The first available data discriminating between technical and non-technical estimate 10% and 18%, respectively, in 2007 (CABEI, 2009: 20).

ii. Crisis of the Electricity System (2004-2010):

The unfavorable development of the sub-sector towards an electricity system locked into fossil fuels became evident as oil prices escalated, see Figure 4. Recognizing the problem, the State formulated a National Energy Policy, which for the first time explicitly stated the importance of transforming the generation matrix in favor of autochthonous RE (AN, 2004: Decree 13-2004; Decree 12-2004). In 2005, the Nicaraguan State declared an energetic crisis, through the *Energetic Stability* law, as long as the WTI reference price for oil exceeded US$50/barrel or the electricity generation in the country depended by more than 50% on oil (AN, 2005: Law 554, AN, 2006: Law 600). The deteriorated state of the system, with deviations between generation costs and end-consumer tariffs accumulating as oil spiked and increasingly tight supply-demand constraints left the NIS with insufficient contingency reserves, resulting in a 150 MW deficit and extended power black-outs and rationing in 2006-2008 (MEM, 2011a:3-37).

FIGURE 4 West Texas Intermediate US$/barrel

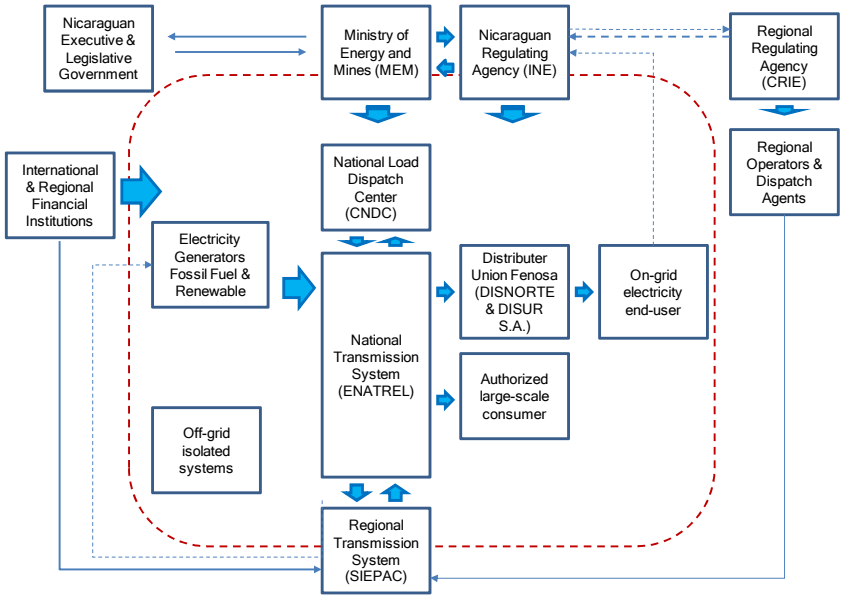


Source: Prepared by author with data from Wall Street Journal (2011).

Recognizing the acute need alter the existing path dependence on oil, several laws were passed in 2005-2008 to promote RE through tax exemptions, PPA's for 10 years through tender processes and direct negotiation, grid priority within a fixed price range, extension of RE licenses (AN, 2005:Law 532, Law 531; AN, 2006:Law 594). A minimum price boundary was set for Fuel Oil so that, regardless of oil market behavior, any cost-benefit analysis made in the electric sub-sector could not use a cost for oil that was lower than USD 85 per barrel[8] (AN, 2009: Decree 08-2009). To deal with the sub-sectors acute financial tribulations, the government acquired 16% of the distributor's social capital in 2008 to improve its credibility as contractual counterpart and approved a law penalizing electricity theft (AN, 2008: Decree 29-2008; Law 661; Cosep, 2008:28). The former CNE was elevated to the status of ministry through the creation, in 2007, of the MEM explicitly in charge of policy making, planning, concession and license management with the goal of centralizing functions to give the sector clear guidance, efficient response and improved institutional structure (AN, 2007:Law 612). The resulting organization of the electricity system can be seen in Figure 5 bellow.

[8] If the average market price of the last 12 months was higher than USD 85 per barrel, then the market price would be the one used in the analyses.

FIGURE 5 Organization of the Electric Sub-Sector of Nicaragua



Source: Prepared by author based on legislation and sub-sector policy.

iii. State of the System and the Transition:

Going back to transition theory, the established technology and dynamic equilibrium of a system involve inertia and relative stability around a system attractor (Loorbach, 2007:56). An accelerated one-off event, such as a landscape shock, can become a disrupting force that generates momentum and maneuver room to create a new system attractor; however, the multilevel aspect of transitions implies that a transition can only breakthrough if developments at one level coalesce with changes in other domains (Rotmans, 2005:10, 17, 20; Loorbach, 2007:168; Geels and Kemp, 2007:446; Bergek et al. 2008:415). The energetic crisis detailed in the previous section, which peaked in 2007-2008, became a consequential moment for the Nicaraguan electricity sector, exposing the accumulated system failures of the electricity sector and the existing socio-technical regimes limitations to supply the electricity needs at a stable price (AN, 2005: Law 554; MEM, 2011a:35-45). This compelled the Government to actively pursue a solution, expressed in the political intention to revamp the electricity matrix laid out in the Strategic Energy Plan 2007-2025 and the Generation Expansion Plan 2011-2025, summarized in Table 1 and expanded in Appendix 4.

TABLE 1 Electricity Generation Expansion Plan 2017-2025

Installed Capacity (MW)	2010	2017	2020	2025
Renewable Electricity Generation	**376.7**	**948.9**	**1133.9**	**1273.9**
Hydroelectricity	*104.4*	*453.6*	*603.6*	*703.6*
Geothermal	*87.5*	*233.5*	*268.5*	*268.5*
Wind Power	*63*	*140*	*140*	*180*
Biomass	*121.8*	*121.8*	*121.8*	*121.8*
Fossil Fuel Electricity Generation	**716.5**	**359.5**	**359.5**	**359.5**
Withdrawal	*0*	*357*	*0*	*0*
Addition	*0*	*0*	*0*	*0*
Total Electricity Generation	**1093.2**	**1308.4**	**1493.4**	**1633.4**
% Renewable	***34.5%***	***72.5%***	***75.9%***	***78.0%***
% Fossil Fuel	***65.5%***	***27.5%***	***24.1%***	***22.0%***

Source: Prepared by author based on MEM (2010; 2011a).

At a niche level, bottom-up pressures also strained the regime. In 1990-2004, only 10 MW of geothermal and 70 MW of biomass derived energy entered the grid and the handful of awarded exploration licenses were dropped based on financial non-viability (MEM, 2011c; Mostart 2007:22, 25). From 2005 onwards, the position of niche actors changed. Nicaragua's first wind power park, Amayo, came into operation in 2009 (40 MW) and a second phase in 2010 (23 MW), with competitive PPA prices of US$86/MW and US$92/MW respectively, demonstrating wind power's technical and financial viability (INE, 2007a; 2009b). After the demonstrative success of Amayo, the EOLO (37 MW) and San Martin (40 MW) wind power projects where awarded generation licenses and secured PPAs to start operations in 2012. What could become the country's largest hydroelectric plant, Tumarín (253 MW)[9], gave its initial steps in 2009, when the national assembly approved the project and authorized the developer to proceed with feasibility studies and 11 hydro projects (≈ 694 MW) received licenses for studies and generation in 2008-2011[10]. Eight off-grid SHPs (3.7 MW) entered operations in 2007 and their cost-effectiveness has made ROR community-based enterprises the Government's strategy for off-grid rural electrification, through a U$ 23million project to install 4.6 MW, see Appendix 5 for a more detail on this modality of SHPs (AN, 2010:Law 695; MEM, 2011d). An additional 37 MW of geothermal energy will enter operations in 2011 and another 37 in 2012, and exploration licenses have been awarded for another 140 MW. This increasing dynamism and support of RE actors suggests that coalescing trends at landscape (*oil prices*), incapacity of the incumbent regime (*electricity crisis*) and niche level (*demonstrated capacity*) have created a window of opportunity for a substantial trajectory shift (Geels and Kemp, 2007:446; Rotmans et al. 2001:16).

As the government is playing an active and decided role in the promotion and enablement of the transition, we can talk about a goal oriented transition which is currently in a pre-development phase, as projects are still maturing. Reaching the Government's planned take-off phase in the next 5 years, where enough momentum is gathered for the process to accelerate, will require substantial political effort, given the complex dynamics of large transitions (Geels and Kemp, 2007:554). Identifying key drivers and barriers and the central actors in the transition is important to reveal tensions and potential conflicts that emerge in the process.

b) MULTI-LEVEL DRIVERS AND BARRIERS OF THE TRANSITION

i. Drivers and Barriers at Landscape/Macro-level:

Global Oil Market:

Developments at the landscape level exert pressure on the dominant regime, both driving and inhibiting the transition (Geels, 2002: 1263). With an energy sector highly dependent on oil derivates for electricity generation, Nicaragua is extremely vulnerable to developments in the global oil market (MEM, 2011a: 35; BCN, 2010: 24). As presented in the introduction, fossil fuels supplied 80% of world primary energy demand in 2004 and their role in the existing global energy system is expected to continue increasing in absolute terms over the next 20 to 30 years, with oil being the single largest fossil fuel consumable (IEA, 2010:4; IPCC, 2007:265; Shafiee and Topal, 2009: 182). Estimates indicate that oil prices will most probably continue rising, reaching U$ 113/barrel in 2035 (constant 2009 dollars) due to demand-supply inelasticity (IEA, 2010:4-6). According to IEA, oil supply stabilizes in 2020 and, depending on methodology and assumption regarding policy and demand, depletion of reserves could be reached in 35 to 40 years[11] (IEA, 2010: 6, Shafiee and

[9] Now only pending closure of PPA negotiations.

[10] Larreynaga (17 MW), Hidropantasma (12 MW), Salto Y-Y (25 MW), La Sirena (17 MW), El Barro (68 MW), Pajaritos (30MW), Valentín (25 MW), Proyecto Brito (180 MW), El Carmen (100 MW), Boboké (70 MW), Copalar Bajo (150 MW).

11 Estimates regarding oil peak and proven reserves depend on fluctuating economic conditions, given the positive correlation between economically recoverable reserves and prices (Owen et al. 2010: 4744; Shafiee et al. 2009: 182).

Topal, 2009: 188; Iwaro and Mwasha. 2010:705). For net oil importers with energy sectors highly dependent on oil, this panorama makes it critical to seek alternative energy sources.

Sustainable Development Paradigm:

Mounting evidence of environmental degradation and the need to take action to assure the provision of critical resources for future generations translated into a shift in the international development discourse after the milestone publication of *Our Common Future* in 1987 (Kemp et al., 2005: 13-14; Kates et al, 2001:641). The recognition that socio-economic progress has to go hand-in-hand with environmental sustainability has influenced international agendas and 'postmodern' social values and attitudes, bringing sustainable development to the table in both global, national and local arenas (Kate and Parris, 2003:8064). An important outcome of this evolution, with immediate consequences on the energy sector, has been the UNFCC and signing of the Kyoto Protocol in 1997, aimed at reducing GHG emissions (Jacobsson and Johnson, 2000:625). These international tendencies influence the development policies at national and regional levels, as reflected in the Central American Sustainable Energy Strategy 2020, signed by Nicaragua, which sets targets to reduce GHG emissions by 20% and increase participation of renewable electricity in 11% by 2020, and the possibility of using, for example, CDM and GEF as funding mechanisms (SICA, 2007:11, 98).

Renewable Generation Technology:

System innovations and up-take of new technology can be inhibited by lack of deployment, testing and diffusion of technologies, increasing its relative costs due to low economies of scale, performance uncertainty and entrenched technological trajectories (Sanden and Azarb, 2005:1559; Jacobsson and Johnson, 2000:626; Geels, 2001:1259). The renewable technology market has developed considerably in the last decades; for example, wind electricity production increased 48 times between 1990-2008 and solar PV has grown on average 41% between 2000-2008, resulting in reduced uncertainty and increasingly competitive costs per installed MWh (IEA, 2009:78; Jacobsson and Johnson. 2000:627-628; Martinot et al. 2002:310; IEA, 2009:78). These developments, together with rising oil prices, have made renewable energy commercially interesting, reflected in an increase of RE participation in global electricity generation, in absolute terms, and an expected tripling of the global renewable generation over 2008-2035 (IEA, 2010: 9; IEA, 2009: 70).

ii. Drivers and Barriers at Regime/Meso-level:

Macro- and Microeconomic Aspects:

At regime level, the most important drivers behind the transition to RE stem from macro- and microeconomics, as stated in the sector's policy documents and consistently expressed by interviewees (MEM, 2011a:19; MEM 2011b:22). Nicaragua's high dependence on oil imports has negative consequences for the country's commercial balance, foreign exchange availability and inflation. In 2009, the country spent 49% of its income from exports on oil (BCN, 2010:31-33). Escalating oil prices affect the economy through cost-push-inflation, in the case of Nicaragua, where oil imports represent 15% of the country's GDP (2007), compared to 7.4% in the region, increasing oil prices accounted for 3% inflation in 2007 compared to 1.5% in Costa Rica (BCN, 2008:21). The detrimental macroeconomic consequences of oil dependence in the landscape context, described earlier, have made it evident that continuing with the incumbent oil dependent technology will bring increasing detrimental impacts for the national economy (MEM, 2011a:19).

Another important transition driver relates to economic competitiveness in the context of a country that struggles to achieve sustained economic growth and industrialization. Energy, in the form of useful work, is considered a critical input for long-term economic growth and increasing energy conversion efficiency is critical to decrease input costs, increase productivity and enhance the development of an industrial base (Moe, 2010:1731; Ayres, 1996:572-573; Kanagawa and Nakata, 2007:322; MEM, 2011a:51). The electricity crisis of 2005-2008 and comparatively high electricity costs, discussed earlier, are seen as some of the prime

barriers for continued industrialization and regional competitiveness of the country. With renewable generation, the expectation is that electricity prices will decrease and the provision of electricity will be more reliable as expressed in all interviews (MEM, 2011a: 62). This reasoning lies at the core of the Government's goal-oriented transition to renewables and has been voiced by important economic sectors as a *sine qua non* condition for the country's future socio-economic development (MEM, 2011a:51, El Nuevo Diario, 05/04/2011; MIFIC, 2008:13).

Energy Independence:

The limited exploitation of endogenous resources for electricity generation, which could provide substantial autonomy in electricity provision, reducing oil imports and economic exposure to volatile oil prices, has brought to light the failed evolution of Nicaragua's electricity sector. Developing endogenous RE projects provides an alternative for a comparatively autonomous electricity sector with a renewable resource base and predictable prices (MEM, 2011a:48).

Technology Lock-In:

An important barrier for the break-through of technological innovation is the existing dominant technology and infrastructure regime (Geels, 2005:685). Technical change is *sticky and path dependent,* with positive feedback mechanisms increasing returns on adoption and prevalence, making new technology uncertain in terms of costs and performance (Sanden and Azarb, 2005:1559). Nicaragua's electricity sector has been structured around oil technology and this has translated into a techno-institutional complex that has favored thermal power plants and is now struggling to adapt to renewable technology.

The existing national grid has been concentrated in the densely populated Pacific region and does not penetrate areas with optimal hydroelectricity potential and good wind power resources (see Appendix 6 and 3). For existing generators, incumbent actors and niche investors, the lack of grid access represents additional costs for renewable projects in remote areas, making them less cost effective *vis-a-vis* thermal plants. The technical obsoleteness of the grid also limits the speed at which new projects can be incorporated, since it needs to be upgraded to take on more power and be prepared to deal with the unfamiliar variability associated to some renewables, particularly wind power (CABEI 2009: 22; MEM, 2011b: 25, 34). In light of this situation, the Government is striving to assemble sufficient financial resources to modernize and extend the grid in the medium term to prevent it from becoming a substantial obstacle.

At an institutional level, the lack of experienced and prepared professionals in renewable electricity represents a substantial barrier for both niche and regime actors, as discussed by Bergek et al. (2008) for example. The acquired know-how of all incumbent actors in the electricity sector stems from fossil fuel based electricity and promoters of the transition to renewable energies face technical short-comings in the conceptualization, design and implementation of projects.

iii. Drivers and Barriers at Niche/Micro-level:

Institutional Context:

For niche actors the institutional context of the sub-sector is fundamental via a two-fold relationship with the transition process as regulatory reforms in the sector during the late 90's and 2000's, have translated into both drivers and barriers for niche actors. Important legal reforms enacted in 2005-2009 have financially benefitted RE projects, improved the organization of the sub-sector and set clear RE priorities, as discussed before, providing substantial incentives and security for RE projects. Several interviewed developers expressed that large projects face favorable regulatory conditions and, together with the more competitive prices of RE technology at a landscape level, returns on investment for RE are estimated as the highest in the region, making it a significant driver for the private sector (CABEI 2009:9; Mostert, 2007:8).

For small-scale projects and technology providers though, particularly those in isolated areas, the regulatory reforms have not addressed some issues critical for their sustainability. Regulation of commercialization tariffs determines that off-grid systems are not benefited by the subsidies for end-users connected to the grid. Their small scale increases cost per MWh and, without subsidies, their electricity is higher-than-national-prices, resulting in discontent in their concessionary areas, of which many are poor rural regions. The existing legal framework doesn't contemplate net-metering either, thus small-scale RE projects or private RE technology solutions that can occasionally feed the grid face a legal void when negotiating contracts with the sole distributor on the NIS. As the grid expands to the interior of the country, this problem is perceived as an increasing risk for small isolated systems.

Market Size and Project Scale:

Project scale and market size represent defining factors for the deployment of RE. Interviews with projects developers highlighted the difficulties recovering investments without affecting the competitiveness of their electricity prices, given the large fixed investment costs *vis-à-vis* power output. The limited market size is also a barrier considering the limited grid coverage and restricted consumer income levels. For capital-intensive projects this can affect their price competitiveness as substantially larger scales may be necessary. The expected entry into operations of the regional electricity market, SIEPAC, will assist in decreasing this barrier and interviewees suggested that this is even perceived as a potential driver as Nicaragua will be optimally located at the heart of the regional interconnected grid (MEM, 2011a:61).

Sustainable Development:

While profit stands out as an incentive for larger projects, small-scale projects and local technology developers expressed sustainable development as their primary driver, reflecting an important link to landscape drivers. Their focus on renewable electricity provision to isolated off-grid areas comes accompanied with a broader set of goals aimed at improving local living conditions, involving local communities and the promotion of parallel activities to enhance rural development and sustainable use of natural resources.

Information Asymmetries and Limited Participation:

All interviewed niche actors manifested limited knowledge and access to relevant details of the national generation expansion plan and the Government sub-sector strategic plans. For potential project developers this becomes an important barrier as it limits their capacity to foresee the Government planned development for the sub-sector and prioritized areas of action, as well as planned expansion of the grid, regulatory reforms under consideration and currently approved projects. When adoption of technology relies on private investors, as it does in this case, having defined national goals and a clear direction for the sector has been cited as a critical aspect for investors to be willing to take-on risks in new projects (Newell, 2011). Without an appropriate diffusion of the sub-sector strategic plan uncertainty increases for niche actors and inhibits or delays decisions.

Perceived Risks and Limited National Capital Market:

For investors, the undertaking of renewable technology in larger projects has been deterred due to the elevated initial investment, including feasibility studies, and the long-term recuperation compared to thermal plants, as cited in several interviews (Mostert, 2007:59). The development of the sub-sector discussed above has led risk-adverse investors to opt for more liquid assets. The elevated risk perception demands high rent margins for large renewable projects to raise capital and find co-investors. Summed to this, the limited national capital market and the inability of the government to provide public financed alternatives make it difficult to find financing options for larger projects and these are relying heavily on regional and multilateral banks (CABEI, 2009:108).

c) ACTORS, RELATIONSHIPS AND NETWORKS

To analyze a socio-technical transition it's important to identify who the key actors are, their potential role in the transition and how the different actors relate to each other through formally or loosely constituted networks, as this can shed light on the internal dynamic of the system, revealing cooperation opportunities, tensions and conflicts (Bergek et al. 2008:408). Transition theory calls for a broad range of actors to be considered in the socio-technical system analysis, conceptualizing them as social groups based on strong coordinating principles within the group (Geels, (2004) in Coenen and Diaz, 2010: 1152).

Given the accelerated transition time-frame proposed, the MEM is focusing on medium and large generation projects (10+ MW) due to their substantial contribution in terms of individual installed capacity to fast-track the conversion of the NIS generation mix (MEM 2011:61,63,64). Several interviews corroborated the importance of large scale private project developers as they are considered to have the capacity to mobilize the required multi-million dollar financial resources, while the State takes on multilateral and bilateral grants and loans to attend the complementary components of the solution: reduction of technical and non-technical losses in the system, improvement of the transmission infrastructure, connection to the SIEPAC, extensions of electrification coverage and funding of national pre-investment studies for 384.5 MW of hydroelectricity. Small-scale RE projects are seen primarily as a solution for rural off-grid systems, as they are not considered to provide a significant source of capacity to impact the NIS and net-metering is not yet covered by existing regulations. Small-scale RE projects are mainly implemented by NGO's and through the national rural electrification program FODIEN; using SHPs solutions that are operated through community owned private companies. This has created two social groups at the niche level where, though they both share the Governments goal for RE in Nicaragua and interact through formal and informal networks, differing drivers and barriers translates into different priorities and relationships to the MEM.

The MEM is a fundamental actor as it provides guidance for the transition process, approves concessions and licenses, formulates policy and law proposals; all critical factors for a transition take-off and acceleration. Its institutional structure makes it both a regime and niche actor as it oversees incumbent oil generation and provides support for niche actors. Important niche activities developed by the MEM include development of experiments and pilot projects to determine technical and commercial viability, including micro-turbine ROR technology, small-scale wind solutions, up-scaling of SHPs for isolated systems and a 90 kW solar panel pilot connected to the grid. Support these experiment portfolios in transitions is important for knowledge development and learning, both critical for innovation and technological diversity (Kemp et al., 1998:186; Jacobsson and Johnson, 2000:633). The outcome of these projects could ideally provide feedback for development of local technological solutions, insight to the interaction of small-scale RE with the NIS and potential up-scaling of successful pilots. Since efficient approval of licenses and concessions are essential to push projects through the bureaucratic pipelines, the MARENA has also received increasing public pressure as they emit approvals for environmental studies. Tensions between the MEM's priority to get projects on-grid rapidly and the MARENA cautious emission of EIA approvals are also clear and the smooth resolution of any power arrangements between them is critical to assure that RE projects get on their way, but that the environmental impacts of RE projects are known and mitigated.

At the regime level, the distributor is a key actor, being the counterpart in the negotiation of PPA contracts. With the Government's participation in UF after 2008, it is reasonable to assume that they can now influence - to a certain degree - the negotiation process, thus being able to push for the alignment of negotiation outcomes with Government priorities. A manifested source of tension in the PPA negotiation process is the profit interest of the private project developers *vis-a-vis* the Government's interest in keeping electricity prices down, since lower electricity costs have been presented to the public as the main benefit from a transition to RE. Navigating the line between providing sufficient rent margins to private investors to overcome risks, while delivering on the public commitment to lower electricity prices, will prove a difficult challenge and, given the political weight the Government has invested in the RE transition, several interviewees consider the

outcome of the transition as being critical for the political future of the party in power. The public participation in UF will also be incidental in the regulation of commercialization tariffs, ideally preventing a repeated accumulation of deviations in respect to generation costs. As a preemptive measure, legal reforms where approved in 2010, dictating that INE should annually review and adjust the commercialization tariffs based on the real market prices[12] (AN, 2010: Law 278). ENATREL is a second key actor at the regime level, since the planned expansion of RE rests on the extension and adaptation of the existing NIS (MEM, 2011a: 61). Though ENATREL has voiced no objection to increasing the RE on grid, it has entered controversies with future wind power projects regarding the ability of the system to deal with variability of wind. The solution to this rests on improvements to the grid, which are to be financed as part of a multi-million dollar public investment project, PNSER, which is expected to start operations in 2011 (MEM, 2011b: 34).

Looking at the government from a multi-level perspective, the municipal governments are key agents in the transition. Municipalities emit land-use permits for projects to enter the approval pipeline, endorse environmental studies and emit construction licenses (AN, 1998:Law40). Considering the critical role of municipalities for RE, it's surprising that they are not involved in the MEM's planning process and there is no consistent effort from MEM to coordinate the electricity sector's strategic plans with the municipal development plans, which take into account land-use planning, as confirmed in interviews with municipalities and MEM. Interviewed municipalities had incomplete knowledge of the national strategic electricity plan and MARENA, instead of MEM, has been more active in the diffusion of information on RE to local and regional governments. The MEM recognizes the importance of municipalities, however, they point out significant local capacity deficiencies in the area of energy and high rotation of personnel after municipal elections. Past experiences with municipal enterprises managing SHPs projects, El Wuawule and Las Canoas, failed due to the municipalities' inability to administer the watershed area (e.g. diversion of water from the reservoir for irrigation) and mismanagement of the projects' finances (El Nuevo Diario, 25/02/2004; El Nuevo Diario, 23/02/2044; La Prensa, 06/05/2010). The MEM has not pursued a more proactive strategy by trying to incorporate municipalities in the sub-sector's planning and promote training programs in RE topics for municipalities. The disconnect between central and municipal governments could translate into potential tensions as municipalities have the legal ability to stop the implementation of RE projects within their jurisdictions.

Networks are critical in technological niche formation and socio-technical transition processes, as they constitute effective channels for transfer of tacit and explicit knowledge, identification and solution of problems and development of trust and collective identity between niche actors, thus contributing to niche momentum and size to compete with the prevailing socio-technical regime (Schot and Geels, 2007: 613; Jacobsson and Johnson, 2000: 630, 632, 634; Meadowcroft, 2009: 326). *RENOVABLES*, the largest network in Nicaragua, is a formally-constituted network agglomerating approximately 50% of organizations working with RE, including private sector, non-profit organizations and capacity building entities working with diverse RE technologies (RENOVABLES, 2011). Member base is predominantly constituted by small-scale generators, but also includes the most important large-scale developers in various technologies. The network was developed to unify and channel the voices of a dispersed number of actors who felt the need to approach policy makers in a more consistent and effective manner. Although the members share a common agenda to push the RE transition forward, small-scale generators are largely concerned with the regulations of net-metering, bilateral contracts between concessions and the approval of a tariff structure that will enable subsidies for off-grid systems in order to decrease end-user costs. For large-scale projects this is not a critical issue as they have more leverage in the negotiation of long-term PPA's with the distributer. Stand points on the importance of environmental aspects also diverge as small-scale project developers are driven more by concern for sustainable development and natural resource conservation while, as expressed in interviews, larger projects perceive environmental permits as administrative costs.

[12] Aware of the heated public responses to increasing electricity prices, legal measures have also been taken to extend the subsidy to ≤150 kWh consumers to be covered by VAT.

Despite these diverging points, the network has been successful in presenting a common agenda on key issues for RE projects and the MEM has formally recognized the network as a strategic ally. In practice, however, the relationship to the MEM was expressed as tricky and the network has incomplete knowledge of the Governments strategic plans for the sector and has been sidelined in the MEMs planning process. Although the MEM law (AN, 2007:612) dictates the establishment of a participatory consultative commission to engage an ample array of actors in strategic planning and policy debates, this commission has not functioned, creating a substantial vacuum felt by interviewed niche actors. A stronger relationship has been established between the SHP projects, where both Government and NGO financed projects have created a tightly knit network through RENOVABLES for experience exchange and common problem solving.

Other efforts towards a formal agglutination of actors in the system can be traced back to 2003, when two groups were formed. The first one was a municipally-organized group called GIER, now participating as one the members of the *RENOVABLES* network. GIER harnesses the efforts of two local universities and one technical formation center, four local enterprises, the municipality, a central government entity that supports SMEs and coordinates the relationship with international aid partners (e.g. ECODES, Municipality of Hamburg). The last one, ANPPER was intended to be a broad, national-level network, but within two years it had gone dormant and has not been able to fulfill its original purpose since then. Today, ANPPER has been re-launched, but due to its slim member base and vertical governance structure, it fits more the nature of a private interest group than that of a network.

Knowledge development is also a critical aspect of transitions, where universities and research centers constitute central actors (Jacobsson and Johnson, 2000:30; Schot and Geels, 2007: 219; Foxon, 2007:2 in Atkinson et al. (Ed.) 2007). One of the important barriers and potential mid-term constraints, as stated before, for both niche and regime alike is the lack of local human resources trained in RE technology. In fact, what has already begun to take place, as a result of the referred human capacity limitation, is that valuable well-trained technical personnel working for the Government is being attracted by private firms to work on the implementation and management of their RE projects, as expressed in interviews. This type of brain-drain weakens the State's capacity to plan and assist the transition at hand and can therefore be counterproductive for the sub-sector as a whole. A positive sign though is the recent substantial increment in the offer of national training programs for RE, reflecting that education entities have reacted to the call for knowledge development in the RE market and, if these programs are well promoted and maintained, it should not be long before the present technical capacity limitations in the labor force are overcome. An aspect that was repeatedly highlighted in several interviews was the universities' active organization and promotion of RE forums and conferences, making them a critical partner in the diffusion and promotion of increased networking and experience exchange between a diversity of RE actors.

Having mapped out the central actors involved in the transition process, it becomes relevant to look at the key emerging tensions between regime and niche levels:

Watershed Management: For hydroelectricity projects, the protection of watersheds is a critical aspect for their long-term sustainability and was expressed as central concern for existing and planned projects. Nicaragua's net annual deforestation rate for 1983-2000 was 1.17%, equivalent to a 20% loss of forest cover in less than two decades, and is expected to lose an additional 1.5 million hectares by 2020 (FAO, 2006: 100; INAFOR, 2004: 16). The author visited communities benefitted with RE in the North-Atlantic region of the country, and was able to personally corroborate the extent and severity of the effects that indiscriminate deforestation has brought. A lethal combination between *a) ungoverned and unplanned soil use, which has allowed for a boundless expansion of the agricultural frontier, characterized by unsustainable agricultural practices and extensive cattle farming activity, b) the intensive and inefficient use of wood resources as cooking and lighting fuel by a predominantly poor rural population, and c) indiscriminate precious wood extraction in detriment of forest cover,* has turned formerly lush landscapes and healthy river basins, into eroded fields and dry water channels (INAFOR, 2004:17,53-54). The critical importance of forests for

watershed protection and the State's incapacity to enforce regulations on forest use, bring uncertainties regarding the long-term viability of hydroelectricity projects as river water levels can substantially decrease (FAO, 2006: 20).

Existing SHPs are attempting the difficult task of halting deforestation and reforesting surrounding areas that are currently being used for cattle ranching and slash-and-burn agriculture. Strategies range from purchasing land upstream, promoting alternative crops such as shadow coffee and cacao, which benefit from forest cover, and paying upstream owners to reforest. However, given the difficulty of the challenge and the financial constraints of these projects, their maneuvering capacity is limited. Larger hydroelectricity projects, which feed from multiple river systems, face an even more complex situation, as their watershed areas cover a multiplicity of land-owners, agricultural activities and municipal boundaries. The pressure from these niche actors on the regime (particularly on UF, MEM and INE) is centered around issues of securing funding for payment of environmental services, inclusion of an environmental charge in the electricity tariff for watershed protection and the central and local Governments' support in the control of wood extraction and extensive cattle ranching. Although the MEM and MARENA attempt to assist hydro projects in this task, murky land tenure, unclear responsibilities in watershed management between the project developers and the Government, limited resources and the lack of an integral and coordinated hydroelectricity watershed management and environmental strategy between MEM and MARENA has limited their impact.

Transmission and Distribution Lines: Given the current limited coverage of the NIS and its planned expansion in the coming years through PNSER funds, RE projects face both an opportunity and potential threats. To connect to the grid, several kilometers of low tension distribution lines need to be installed and un-clarities persist as to who should absorb the cost and responsibility. Although the concession contract with the distributor stipulates the extension of distribution lines, the company perceives a low income opportunity in small projects, as expressed in interviews, and the only small project that has been successfully connected to the grid has financed part of the distribution lines themselves, together with the Government. The elevated cost of installing electric lines makes this a conflicting issue, particularly for smaller projects that have a low-leverage bargaining position. A second issue with the extension of the NIS relates to the price of electricity in small-scale project concession areas as their scale results in higher electricity prices and, as the national grid gradually penetrates the country, consumers have voiced their preference to be on-grid and benefit from subsidized electricity, which might bring potential complications in the future for current isolated RE systems.

Legislation and Regulatory Aspects: From a regulatory perspective, interviewed large-scale developers considered that the legislative actions that have been taken in the last 5 years have created an attractive environment for investors and, with the improved position of the distributer to take on long-term PPAs, one of the main barriers has been addressed. For smaller projects and small-scale technology providers (i.e. solar, mini-hydro) though, a significant regulatory issue with the regime persists regarding net-metering and the negotiation of bilateral electricity contracts between concession areas. For smaller concessions that face electricity deficits during the dry season, due to low river flows, this has become critical, as the distributor, has no incentive to negotiate reasonable tariffs with small-scale generators, placing them in a difficult financial position; for example, ATDER-BL purchases electricity from the grid at 0.98₡/kWh and must resell to its consumers at 0.21₡/kWh. INE has not intervened actively in the negotiation of these agreements as they are seen as bilateral private contracts, raising discontent amongst isolated RE concessions. On the issue of net-metering, the MEM expressed that its resistance stems from equity issues. With the alternative of net-metering, in conjunction with current high electricity prices for larger consumers, the MEM fears that larger and wealthier consumers will procure their own generation solutions decreasing the purchase from the grid, thus affecting the intra and inter sectoral subsidy scheme, particularly the residential subsidy to poorer households. Further studies are necessary though to assess the dimension of the impact net-metering would have on cross-subsidies.

Feasibility Studies and Demonstration Projects: Taking into account the costs and risks of investing in feasibility studies and demonstrative pilot projects without certainty that they will be commercially or technically viable, niche actors considered that more resources should be assigned by the State to support pre-investment efforts. Currently, the MEM's experiment and pilot portfolio, discussed earlier, suggests a recognition that experiments and demonstration pilots play an important role to provide spaces for learning, institutional adaptation and constituency building (Coenen and Diaz, 2010:1155-56; Sanden and Azarb, 2005:1564). For larger studies, the Government has committed to the funding of pre-feasibility mapping of hydroelectricity projects but maintains the position that costs of detailed feasibility assessments belong to private project developers.

VI. DISCUSSION

The exploration of Nicaragua's transition to RE has brought to light the complex and difficult hurdles countries face when trying to make significant changes in large socio-technical systems. The multiplicity of actors and levels, and the substantial financial and human resources required to push the transition forward at the desired speed and scale, represents a real challenge for a developing country, which faces significant financial restrictions amidst pressing investment needs to advance socio-economic development and reduce poverty. Though many specific policy issues emerged in the research and have been discussed above, this section will focus on governance aspects considered critical by the author and relevant to the broader discussion on governance in transitions and governance for sustainable development briefly reviewed in the theoretical framework of this research.

A first issue for critical analysis is the definition and clarity of Nicaragua's electricity system vision and transition goals, as these provide guidance to the numerous actors in terms of desired direction and outcome of the transition (Vob et al. 2007:202; Loorbach, 2007:107). Although Nicaragua's strategic plan refers to sustainable development as a guiding principle and the pursuit of a sustainable electricity system, the sectoral strategic plan is very ambiguous regarding what this sustainable development entails and, with the key drivers behind the transition stemming from economic factors, the commitment and ultimate desired outcome of the transition process to RE is not clear (MEM, 2011a:51). At a landscape level, as discussed before, sustainable development has become an important driver pushing for transitions to 'greener' systems in several domains. This has permeated development aid and financing options, such as CDM, Joint Implementation, GEF and conditionality aspects for bilateral and multilateral aid; given Nicaragua's heavy reliance of foreign aid, sustainable development is included in the sectoral plans and the national development plan but, whether it's only *lip service* or actually reflects a larger national commitment remains questionable.

To illustrate, the strategic plan places importance on the on-going oil exploration in Nicaragua (see Appendix 7) and the cooperation between Nicaragua-Venezuela under the regional ALBA, as a possibility for Nicaragua to access oil supplies at better prices for both transport and electricity, develop its refineries and, in the future, be part of an interconnected oil pipeline (Ibid: 66). These potentially contradictory strategic goals, added to the low relevance of environmental sustainability as a driver for the transition, reflect the lack of a normative commitment to a strong sustainability vision. This incoherence leads to ambiguity and uncertainty regarding the direction and commitment towards a transition to a more sustainable electricity system, potentially affecting the actors who are expected to undertake substantial resource mobilization.

A source of tension brought up earlier between the niche and the regime, and a perceived barrier for niche actors, stems from the lack of access to information and participation in the development of strategic sub-sector plans. It has been widely discussed that socio-technical transition processes, particularly those aiming at furthering sustainable development and which rely on a multiplicity of actors, benefit from a sense of direction, diffusion and knowledge of transition goals and joint agenda setting with the critical actors for the transition process (for example Loorbach, 2007:143; Vob et al. 2007:202-203; Meadowcroft, 2007:309).

Besides the instrumental value of increased participation in a socio-technical transition, participation holds intrinsic value in the strengthening and formation of a democratic society (Meadowcroft 2009; Sen 1999).

The highly centralized sectoral strategy adopted by the government reflects the perceived urgency of the transition and the desire to fast-track the process by adopting top-down incentive-based steering, as discussed by Vol et al. (2007:201), that bypasses difficult and time consuming negotiation processes. This strategy may backfire though, as lack of participation and access to the sectoral plans can make investment difficult for niche actors through increased risk perception and reduced ability to anticipate opportunities and threats; in the long run, it can also undermine the legitimacy and support for the government expansion plans from implicated social groups at the niche and the regime levels. A centralized strategy also encounters difficulties as the transition rests on numerous actors and domains, diffusing power horizontally (i.e. several ministries, utilities, technology and project developers, consumers) and vertically (i.e. multi-level government), thus no actor, including the MEM, has a hierarchical position that allows it to unilaterally determine the actions of others (Vob et al. 2007:198; Meadowcroft, 2007:308). This suggests that a more interactive governance strategy may be more appropriate to incorporate actors and provide flexibility to adjust scale, speed and goals based on the conditions and capabilities of those involved (Walker and Shove, 2007: 220).

Notwithstanding, the MEM's urgency of pushing the transition to RE forward is a reality, and participative consensus-building processes can be difficult and costly, particularly in a setting where knowledge is limited and positions and priorities vary between and within niche and regime. Although theory suggests transition visions as a steering strategy are more effective when developed together with the heterogeneous actors of the system, even strategic visioning with selected players and key State actors, similar to the transition arena put forward by transition management, could be important to raise critical questions regarding plausible development paths, critical actors and what a sustainable electricity system for Nicaragua could be (Smith et al. 2005: 1506). The diffusion of a vision that gathers these aspects could be important to provide a narrative for resource mobilization, clarify the desired future state of the system and strengthen the collective identity of the involved actors.

This process is not conflict-free and though transition management presupposes a collaborative and co-operative environment with 'post-political' common interests, reality is very different. Given the MEM's focus on larger projects as the main leverage to push for the conversion to RE, a transition arena or inclusive governance approach promoted by them would very likely exclude those actors' that work with smaller projects, pioneering technology or lack the political and economic capital to have pull in the sector, thus focusing on those project developers with large capacity and demonstrated technology. The innovative outcome and legitimacy in terms of representativeness of the sector in such a vision building arena could of course be questioned.

An alternative to this could be for the MEM to approach the existing RENOVABLES network, which gathers a substantial and varied number of actors, and engage the network's board of directors[13] and relevant regime actors (distributor, transmission and regulator) in a discussion process to develop a coherent sub-sector's strategy that recognizes and tackles barriers and provides clearer guidance as to the desired future vision of the electricity sector and the responsibilities of different actors in the process. Besides providing room for a consensus building and agenda setting, networks could assist in the diffusion of the existing strategic plan and goals to a diversity of niche actors, without having to go through a public participation and diffusion process, perceived as time-consuming and conflictive for the MEM. By recognizing the importance of networks and strengthening their role in the sector, the Government could improve the degree of connectivity between actors, increasing the amount of information and knowledge diffused in the niche, a process considered

[13] The network is structured so that no specific renewable technology enjoys more steering power by depositing decision-making responsibility on a board of directors, in which each of the main technologies (wind, hydro, geothermal, solar, biomass) are represented, and includes – at least - one large developer (+ 10 MW) and one education entity (Renovables 2010).

critical to further innovation and strengthening of niche actors (Jacobsson and Johnson, 2000:643). The political will to pursue these alternatives, however, seems limited, and entrenched centralized practices and a perception that engaging actors leads to complications or delays, make the viability of a more inclusive governance approach difficult and unlikely.

The vertical diffusion of power between levels of government is also an important governance aspect for the steering of Nicaragua's transition, as municipality approval of projects is critical. The decentralization process in Nicaragua has led to democratic decentralization, where municipalities are recognized as autonomous democratically elect political structures with competence and authority over matters that affect their development, use of natural resources, population needs and land-use, *inter alia*, and manage their own municipal budgets and administrative structures (AN,1998:Law 40). This democratic decentralization, conversely, has not been subsequently followed by an appropriate administrative-financial decentralization and capacity building at municipal levels to endow local governments with capable human resources and participation in decision making regarding the provision of critical public services, like electricity (Robins 2008: 689; Espinoza et al. 2004:28). In the electricity sector, the centralized planning and decision making of the MEM has been slow to institutionalize a formal and consistent cooperation strategy with municipalities, despite the power they hold to approve or reject important RE projects.

Lack of coherence between municipal development plans and strategic energy plans can result in differences, as reflected in the interviewed municipality of Rivas regarding the development of wind power (≈60-80 MW) and strategic hydroelectricity projects (Brito 180 MW). Rivas municipal development plan is focused on tourism as the fundamental economic activity of the region and expressed in interviews with the author a growing resistance to approve further electricity projects that can compromise the aesthetic and ecological attractiveness of the region. For hydroelectricity this is also a critical issue in the North Atlantic region of the country, as downstream municipalities that will be affected by diversion and damming of water can voice substantial resistance. This could put the transition to RE in a difficult position as the central government has no authority to override municipal decisions. Although the MEM holds that municipalities lack the technical knowledge to design and implement strategic electricity plans and projects, this does not limit the municipalities with high RE potential from being informed and included in a consultative manner to seek synergies in municipal and electricity sub-sector planning. De-concentration of the ministry could also aid in bringing ministry and municipalities closer and bridging knowledge gaps between central and municipal administration. The MARENA has pursued this strategy by creation of regional delegations that work closer with municipalities, although they administratively respond to the central ministry.

A second aspect that has been voiced by the MEM and large project developers for not openly including municipalities in the sectoral plans has to do with lack of clarity in land tenure and a tendency for local land-grabbing in areas that are planned for development as a mechanism to seek monetary compensation. Though this was voiced repeatedly in interviews with different actors, the author was unable to find hard evidence to back this up. Land tenure is a heated issue in Nicaragua, particularly in the interior and Atlantic regions, where titling is informal and cadastre is incomplete. This brings an additional complexity to RE projects in general, and the multiple domains at central and municipal levels involved in land-tenure activities further calls for a multi-domain governance strategy that seeks to join efforts with other government and non-governmental actors working in this subject area.

An aspect that requires special attention, and has important governance implications, is the management of watersheds, as it is critical for the long-term viability of hydroelectricity projects and has been voiced already by installed SHPs and hydroelectricity plants as a growing concern. Rapid deforestation and conversion of forest for extensive cattle farming and agricultural purposes, however, is a problem that stretched across multiple domains involving rural economic development, natural resources management and land-tenure issues, amongst others. For the MEM to be able to succeed with a transition to RE that counts on getting approximately 43% of electricity from hydro sources, refer to Figure 1, it becomes important to think in terms

of an integrated watershed management strategy that coordinates activities across a diverse field of institutions and actors and promotes systemic thinking to understand the relationships between economic, social and environmental needs, actions and priorities at both local and national levels.

The legal framework surrounding water use in Nicaragua does provide some valuable governance tools. The national water law establishes a national hydrological resource council, the creation of public watershed organizations and the formulation of a national water use plan and watershed management plans (AN, 2007: Law 620; Decree 106-2007). The resource council includes several of the important agents that influence watershed management (i.e. ministry of environment, municipal mayors, ministry of agriculture and forestry, watershed organizations, the MEM, amongst others) thus spanning several domains that affect the sustainable management of watershed areas that cross regional and municipal boundaries. This multi-domain and –actor character of the organisms created by the water law provides an opportunity for an integral approach to watershed systems where both the MEM, and niche actors developing hydroelectric projects, can stress the importance of assuring water levels for electricity production. Coordination between the national water use plan and the approved and planned hydroelectricity projects should ideally exist; however, the national water use plan has not been completed thus there is little clarity as to what it could contribute in terms of financial or human resource assistant to deal with upstream problems and how the responsibility for watershed protection in the case of hydroelectricity projects will be defined.

To conclude this discussion section, it's important to reflect back on the governance issues for transition processes that were highlighted in the theoretical frame of this paper. The case study the author explored echoes the complexity, power diffusion and multi-player aspects of large socio-technical systems and illustrated many of the difficulties that rise when trying to steer such a process. The reflective and adaptive governance approaches that have been put forward by sustainable development and transition thinking could provide assistance in resolving some of the tensions between actors by, for example, providing space for participation, joint agenda setting, diffusion and a more flexible governing approach from the State. However, such a governance strategy does not grow organically in transition processes and, in the case of a goal oriented transitions as this one, a precondition for a reflexive and inclusive governance approach is that the Government steering the process is receptive to a less centralized governing culture.

VII. CONCLUSIONS

This thesis research set out to explore an on-going transition process in Nicaragua's electricity system, aimed at shifting from strong fossil fuel dependence to renewable sources for electricity generation in the coming decade. The author found that an ill-structured electricity market reform in 1990s, marked by unclear institutional arrangements, lack of a solid contractual counterpart for electricity contracts and lack of sectoral goals and direction has favored short-term investments in thermal plants over long-term renewable projects. Confirming theoretical propositions of transition theory, the findings indicate that landscape pressures – rising oil prices and maturing renewable technology markets – together with bottom-up niche developments – demonstration of renewable technical and financial viability – coalesced to exert pressure on the regime and create a 'window of opportunity' for a new development path as the system entered a state of crisis marked by electricity shortages and rationing. The exploration of drivers and barriers found that, although sustainability is a growing concern at the landscape and niche levels, the principal motivation behind the goal oriented transition in Nicaragua stem from economic concerns.

This last finding has important implications as it can bring uncertainties regarding the long-term commitment to the transition process as economic conditions are variable and suggests that, although a normative underpinning is desirable for stronger sustainability commitments, making 'a business case' for transitions to 'greener' socio-technical systems can be effective to mobilize actors. This does not resolve the wider issues of transitioning towards sustainability or provide grounds to evaluate trade-offs between electricity needs for economic growth and environmental and social impacts. If sustainable development is to be understood as a

three pillar concept resting on social, economic and environmental well-being then a transition to sustainable socio-technical systems should embody all three aspects at its core.

As the thesis looks at a transition process in a pre-development phase, the question of whether the transition will reach take-off is relevant. Though the time-plan for the conversion of the generation matrix is ambitious, it rests on several key projects that will inject sufficient generation capacity to transform the electricity systems mix. Many of these projects are already under construction or at an advanced feasibility study and PPA negotiation stage, suggesting that they will materialize in the next few years. Given that the transition has been portrayed as an emblematic project for the Government, a lot of political prestige rests on its take-off and the actors responsible for steering and assisting the process have considerable political pressure and sway. Though a change the party in power in the 2011 elections could be a threat, support for RE adoption has been vocally expressed by both parties and RE legislation has received wide approval in the national assembly, suggesting this should not become a barrier. As the transition rests on key large investors, the centralized top-down governing strategy adopted by the State can create enabling conditions for these actors and prioritize their projects in the approval and negotiation pipeline.

The use of transition theory to analyze a transition in a developing country, which faces socio-economic conditions that differ greatly from industrialized countries, were a significant amount of transition research has focused, is a novel contribution by the author to the transition theory school. As transitions are deeply embedded and conditioned by their context, the political and socio-economic features of Nicaragua, particularly high levels of poverty, limited financial and qualified human resources, high external dependence and a government structure still struggling for coherence and legitimacy, permeate and define the dynamics of the process. It became evident for the author that in a country facing the development challenges Nicaragua has, the definition of priorities and the willingness to accept trade-offs between socio-economic progress, conservation of the environment and public participation are marked by the perceived urgency to push economic growth forward as a poverty reduction strategy.

Despite the particularities of the case study, the transition theory framework was relevant and provided a useful taxonomy, method and structure to guide the analysis. The theoretical background provided the author with a useful body of knowledge derived from almost two decades of research on technological transitions from a systems' perspective. The author feels convinced that, only when studying transitions through these full-spectrum lenses, can we understand what different agents in the system contribute, how they relate to each other and in which ways transition steering can be optimized. Theoretical propositions on transition governance and governance for sustainable development were more difficult to apply as the preconditions for this type of governance strategies where not found. Further research on transitions in developing countries could provide material for comparative assessments between socio-technical transitions taking place under comparable socio-economic conditions, shedding light on how steering strategies could be improved to better respond to the barriers and limitations particular to these contexts.

VIII. REFERENCES

Acevedo, A. (2005): *Nicaragua - Crisis energética - aquí está el detalle,* Revista Envio, No. 279, July 2005. [Online], Available at http://www.envio.org.ni/articulo/2957 , [Accessed on 4 Apr, 2011]

Asamblea Nacional, (1979) Decreto 16-1979, Transformación de la Empresa Nacional de Luz y Fuerza en Instituto Nicaragüense de Energía (INE), Gobierno de Nicaragua.

Asamblea Nacional, (1979) Decreto 189-1979; Nacionalización de las Compañías Eléctricas Privadas, Gobierno de Nicaragua.

Asamblea Nacional, (1985) Decreto 87-1985, Ley Orgánica del Instituto Nicaragüense de Energía (INE), Gobierno de Nicaragua.

Asamblea Nacional (1994), Decreto 46-1994, Creación de la Empresa Nicaragüense de Electricidad (ENEL), Gobierno de Nicaragua.

Asamblea Nacional, (1998), Decreto No. 42-1998, Reglamento De La Ley De La Industria Eléctrica, Gobierno de Nicaragua.

Asamblea Nacional, (1998), Ley 272 Ley De La Industria Eléctrica, Gobierno de Nicaragua.

Asamblea Nacional, (1998), Ley 271 Ley de Reforma a la Ley Orgánica del Instituto Nicaragüense de Energía (INE), Gobierno de Nicaragua.

Asamblea Nacional, (1998) Ley 40 Ley de Municipios, Gobierno de Nicaragua.

Asamblea Nacional, (1999), Decreto 128-1999 Reglamento de la Ley de la Industria Eléctrica, Gobierno De Nicaragua.

Asamblea Nacional, (2004) Decreto No. 12-2004 Política Especifica de Apoyo al Desarrollo de los Recursos Eólicos y Hidroeléctrico de Filo de Agua, Gobierno de Nicaragua.

Asamblea Nacional, (2004) Decreto 13-2004 Establecimiento de la Política Energética Nacional, Gobierno de Nicaragua.

Asamblea Nacional, (2005) Ley 554 Ley de Estabilidad Energética, Gobierno de Nicaragua.

Asamblea Nacional, (2005) Ley 532 Ley Para La Promoción De Generación Eléctrica con Fuentes Renovables, Gobierno de Nicaragua.

Asamblea Nacional, (2005) Ley 531: Ley de Reforma a la Ley No. 467, Ley de Promoción al Sub-Sector Hidroeléctrico, Gobierno de Nicaragua

Asamblea Nacional, (2006) Ley 600 Ley de Reformas y Adiciones a la Ley No. 554, Ley De Estabilidad Energética, Gobierno de Nicaragua.

Asamblea Nacional, (2007) Ley 612 Ley de Reforma y Adición a la Ley No. 290, Ley de Organización, Competencia y Procedimientos del Poder Ejecutivo, Gobierno de Nicaragua.

Asamblea Nacional, (2007) Ley 620: Ley General de Aguas Nacionales, Gobierno de Nicaragua.

Asamblea Nacional, (2007) Decreto 106-2007 Reglamento de la Ley No. 620 Ley General de Aguas Nacionales, Gobierno de Nicaragua.

Asamblea Nacional, (2008) Decreto 29-2008 De Aprobación del Protocolo de Entendimiento Entre las Empresas Distribuidora de Electricidad Del Norte, S.A. (Disnorte), Distribuidora de Electricidad Del Sur, S.A. (Dissur), el Grupo Unión Fenosa Internacional S.A., Y el Gobierno de la República de Nicaragua, Suscrito el 29 de Mayo del año 2008, en la Ciudad de Managua, Nicaragua, Gobierno de Nicaragua.

Asamblea Nacional (2008) Ley 661: Ley Para La Distribución y el Uso Responsable del Servicio Público de Energía Eléctrica, Gobierno de Nicaragua.

Asamblea Nacional, (2009) Ley 695: Ley Especial para el Desarrollo del Proyecto Hidroeléctrico Tumarín, Gobierno de Nicaragua.

Asamblea Nacional, (2010) Ley 728 Ley de Reformas a La Ley No. 272, "Ley de la Industria Eléctrica" y a la Ley No. 554, "Ley de Estabilidad Energética", Gobierno de Nicaragua.

Atkinson, G., Dietz, S. and Neumayer, E. (Eds.), (2007) Handbook of Sustainable Development, Chapter 22 Technological lock-in and the role of innovation, Edward Elgar Publishing, United Kingdom, pp. 489

Ayres, R. (1996) Technology, Progress and Economic Growth, European Management Journal Vol. I4, No. 6, pp. 562-575.

Banco Central de Nicaragua (2005): *Nicaragua en la iniciativa HIPC*, [Online], Available at http://www.bcn.gob.ni/publicaciones/eventuales/investigaciones/HIPC/default.html , [Accessed on 4 Apr, 2011]

Banco Central de Nicaragua (BCN) (2008), Boletin Trimestral Ene-Marzo 2008, Volumen XX, No 1, Nicaragua.

Banco Central de Nicaragua (BCN) (2010), Anuario Estadisticas Economicas Nicaragua 2010, Nicaragua.

Barcenas, F. (2004) *La Factura Petrolera y el Costo de la Energía Eléctrica,* El Nuevo Diario, [Online], Available at http://archivo.elnuevodiario.com.ni/2004/septiembre/03-septiembre-2004/opinion/ , [Accessed on Feb 12, 2011]

Barcenas, F. (2008) *Se Propone una Arma Represiva Brutal,* El Nuevo Diario, [Online], Available at http://www.elnuevodiario.com.ni/opinion/10877 , [Accessed on Feb 13, 2011]

Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S. and Rickne, A. (2008) Analyzing the functional dynamics of technological innovation systems: A scheme of analysis, Research Policy Vol 37, pp. 407–429

Berkhout, F., (2002) Technological regimes, path dependency and the environment. Global Environmental Change 12 (1), pp. 1–4.

Bilgen, S. and Kaygusuz, K. (2004) Renewable Energy for a Clean and Sustainable Future, Energy Sources, Vol. 26, pp. 1119–1129.

Bryman, A. (1988) Quantity and Quality in Social Research. Taylor & Francis e-Library, Available as E-book 2004.

Bryman, A. (2008) Social Research Methods. New York, Oxford University Press Inc., 3rd ed.

Burki, S. and Perry, G. (1998) Beyond the Washington Consensus: Institutions Matter, World Bank Latin American and Caribbean Studies, The World Bank, Washington D.C.

Central American Bank for Economic Integration (CABEI) (2009) Análisis del Mercado Nicaragüense de Energía Renovable; Honduras.

Coenen, L.; Dias Lopez, Fernandez, J. (2010) Comparing systems approaches to innovation and technological change for sustainable and competitive economies: an explorative study into conceptual commonalities, differences and complementarities. Journal of Cleaner Production Volume 18, Issue 12, pp. 1149-1160.

Comision Nacional de Energia (CNE) (2003) Plan Estrategico para el Sector Electrico, Nicaragua.

Consejo Superior de la Empresa Privada (COSEP) (2008) Revista COSEP, Vol. 3, Mayo-Junio 2008, Nicaragua, pp. 1-51.

Consejo Superior de la Empresa Privada (COSEP) (2008) Revista COSEP, Vol. 4, Julio-Agosto 2008, Nicaragua, pp. 1-57.

Duitt, A. and Galaza, V. (2008) Governance and Complexity—Emerging Issues for Governance Theory. Governance: An International Journal of Policy, Administration, and Institutions, Vol. 21, No. 3, pp. 311–335.

Duitt, A.; Galaza, V., Eckerberga, K., Ebbessona, J. (2010) Governance, complexity, and resilience Global Environmental Change Vol. 20, pp.363‑368

Dussan., I., M. (2004): *Nicaragua - Opciones de Política para la Reforma del Sector Eléctrico*, Banco Interamericano de Desarrollo, Depto. de Desarrollo Sostenible, [Online], Available at http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=1442016 , [Accessed on Jan 15, 2011]

Economic Commission for Latin American and the Caribbean (ECLAC), (2008) Istmo Centroamericano: Estadísticas del Subsector Eléctrico (Datos actualizados a 2007, Mexico.

Economic Commission for Latin American and the Caribbean (ECLAC), (2009) Istmo Centroamericano: Estadísticas del Subsector Eléctrico, Mexico.

Economic Commission for Latin America and the Caribbean (ECLAC) (2010): Centroamérica / Estadísticas del Subsector Eléctrico 2009, Mexico.

El Nuevo Diario, (23/02/2004), "Grave daño a pobladores y al ecosistema: Secan embalse Timal", El Nuevo Diario, Managua, Nicaragua.

El Nuevo Diario, (25/02/2004), "Rompieron mangueras y perforaron tuberías: Caos y depredación en embalse "Las

Canoas", El Nuevo Diario, Managua, Nicaragua.

El Nuevo Diario, (23/11/2004), "Superintendencia de Servicios a debate", El Nuevo Diario, Managua, Nicaragua.

El Nuevo Diario, (25/11/2004), "Reforman Estado", El Nuevo Diario, Managua, Nicaragua.

El Nuevo Diario (05/04/2011) "Nicaragua rezagada en competitividad en el área", El Nuevo Diario, Managua, Nicaragua.

Espinoza, G., Palacios Mayorga, J., Carrion Lopez, N. (Ed), (2004) Descentralización y desarrollo económico local en Nicaragua, Friedrich Ebert, 1st ed., Nicaragua, pp. 216.

Food and Agriculture Organization of the United Nations (FAO) (2006) Tendencias y Perspectivas del Sector Forestal en América Latina y el Caribe; FAO, Rome, pp. 1-178.

Geels, F.W. (2002) Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. Research Policy 31, pp. 1257–1274.

Geels, F.W. (2004) From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. Research Policy 33, pp. 897–920

Geels, F.W. (2005) Processes and patterns in transitions and system innovations: Refining the co-evolutionary multi-level perspective. Technological Forecasting & Social Change Vol. 72, pp. 681–696.

Geels, F.W., Kemp, R. (2007) Dynamics in socio-technical systems: Typology of change processes and contrasting case studies. Technology in Society Vol. 29, pp. 441–455.

Gibbons, M.; Nowotny, H.; Limoges, C.; Schwartzman, S.; Scott, P. and Trow, M. (Ed). (1994) The New Production of Knowledge: The dynamics of science and research in contemporary societies. London Sage.

Gustafsson, B.; Hermerén, G. and Petersson, B. (2006) Good Research Practices - What Is It? Views, guidelines and examples. The Swedish Research Council. Stockholm. 2006. This report can be ordered at www.vr.se

International Energy Agency (IEA) (2009), IEA Scoreboard 2009: 35 Key Energy Trends over 35 Years, Available at: http://www.iea.org/textbase/nppdf/free/2009/scoreboard2009.pdf

International Energy Agency (IEA) (2010), World Energy Outlook 2010: Executive Summary, IEA, Available at: http://www.worldenergyoutlook.org/docs/weo2010/WEO2010_ES_English.pdf

Intergovernmental Panel on Climate Change (IPCC) [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (Eds.)], (2007) Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA., pp. 851.

Insituto Nacional Forestal (INAFOR) (2004) Estudio de tendencias y perspectivas del sector forestal en América Latina al año 2020: Informe Nacional Nicaragua; Gobierno de Nicaragua, pp. 1-103.

Instituto Nicareguense de Energia (INE), (2005) Estadísticas Desvíos Costos Mayoristas 2005, Nicaragua.

Instituto Nicareguense de Energia (INE), (2006) Estadísticas Desvíos Costos Mayoristas 2006, Nicaragua.

Instituto Nicareguense de Energia (INE), (2007a) Estadísticas Desvíos Costos Mayoristas 2007 y Desvíos Pliego Tarifario Ley 627, Nicaragua.

Instituto Nicareguense de Energia (INE), (2007b), Contrato de Suministro de Energia entre Energia Eolica de Nicaragua S.A. y Distribuidora de Electricidad del Sur S.A. (DISSUR), Available: http://www.ine.gob.ni/DGE/contratos/CONSORCIO_EOLICO_AMAYO/CONTRATO_ENISA-AMAYO_DISSUR.pdf

Instituto Nicareguense de Energia (INE), (2008) Estadísticas Desvíos Costos Mayoristas 2008y Desvíos Pliego Tarifario Ley 627, Nicaragua.

Instituto Nicareguense de Energia (INE), (2009a) Estadísticas Desvíos Costos Mayoristas 2009, Nicaragua.

Instituto Nicareguense de Energia (INE), (2009b) Contrato de Suministro de Energia entre Consorcio Eolico Amayo (Fase II) S.A. y Distribuidora de Electricidad del Norte S.A. (DISNORTE), Available at: http://www.ine.gob.ni/DGE/contratos/CONSORCIO_EOLICO_AMAYO_FASE_II/CONTRATO_AmayoII-DISNORTE.pdf

Instituto Nicaraguense de Energía (INE) (2010) *Resumen de los Principales Indicadores del Subsector Electricidad* 2010, [Online], Available at http://www.ine.gob.ni/DGE/estadisticas/2010/Trimestre/Resumen_May10.pdf , [Accessed on Feb 13, 2011]

Iwaro, J. and Mwasha, A. (2010) Towards energy sustainability in the world: the implications of energy subsidy for developing countries, International Journal of Energy and Environment, Volume 1, Issue 4, pp.705-714

Jacobsson, S. and Johnson, A. (2000) The delusion of renewable energy technology: an analytical framework and key issues for research, Energy Policy Vol. 28, pp. 625-640

Jimenez, G., Roberto (2009) *Análisis del Proceso de Formulación de Políticas para la Reforma del Sector Eléctrico y su Potencial Incidencia en el Marco Institucional y la Producción con Fuentes Renovables*, Doctoral Thesis for Universidad de Costa Rica, [Online], Available at www.eumed.net/tesis/2009/rjg/, [Accessed on Feb 2, 2011]

Kates, R., Clark, W., Corell, R., Hall, M., Jaeger, C., Lowe, I., McCarthy, J., Schellnhuber, H., Bolin, B., Dickson, N., Faucheux, S., Gallopin, G., Grübler, A., Huntley, B., Jäger, J., Jodha, N., Kasperson, R., Mabogunje, A., Matson, P., Mooney, H., Moore, B., O'Riordan, T., Svedin, U. (2001) Sustainability Science Science, New Series, Vol. 292, No. 5517, pp. 641-642.

Kates, R. and Parris, T., (2003) Long-Term Trends and a Sustainability Transition, Proceedings of the National Academy of Sciences of the United States of America, Vol. 100, No. 14, pp. 8062-8067.

Kanagawa, M. and Nakata, T. (2007) Analysis of the energy access improvement and its socio-economic impacts in rural areas of developing countries, Ecological Economics Vol. 62, pp. 319-329

Kemp, R., Schot, J. and Hoogma, R. (1998) Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management; Technology Analysis and Strategic Management, Vol. 10, No. 2, pp. 175-195

Kemp, R.; Parto, S., and Gibson, R. (2005) Governance for Sustainable Development: Moving from Theory to Practice. International Journal Sustainable Development, Vol. 8, Nos. 1/2, pp. 12-30.

Kemp, R.; Rotmans, J.and Loorbach, D. (2007) Assessing the Dutch Energy Transition Policy: How Does it Deal with Dilemmas of Managing Transitions? Journal of Environmental Policy & Planning, Vol. 9, Nos. 3-4, pp. 315– 33.

Kemp, R. and Martens, P. (2007) Sustainable development: how to manage something that is subjective and never can be achieved? Sustainability: Science, Practice, & Policy, Volume 3, Issue 2, pp. 5-14

Kinloch, T., Frances (2008) Historia de Nicaragua, Instituto de Historia de Nicaragua y Centroamérica, 3a. edición, Nicaragua, pp. 407.

La Prensa, (3/06/2005a), "Generadoras Negociarán Con Sisep", Diario La Prensa, Managua, Nicaragua.

La Prensa, (03/06/2005b), "Confundidos Por Decreto De Bolaños, Ejecutivo Ordena No Entregar Cargos A Sisep", Diario La Prensa, Managua, Nicaragua.

La Prensa, 06/05/2010, "Denuncias de corrupción rebasan embalse Las Canoas", Diario La Prensa, Managua, Nicaragua.

Loorbach, D., (2007) Transition Management: New mode of governance for sustainable development. The Netherlands, Intenational Books, pp. 327.

Loorbach, D. (2010) Transition Management for Sustainable Development: A Prescriptive, Complexity-Based Governance Framework. Governance, Vol. 23, No.1, pp. 161-183.

Martinot, E., Chaurey, A., Lew, D., Roberto Moreira, J. and Wamukonya, N. (2002) Renewable Energy Markets in Developing Countries, Annual Review Energy Environment, Vol 27, pp. 309–48

Meadowcroft, J., (2007) Who is in Charge here? Governance for Sustainable Development in a Complex World, Journal of Environmental Policy & Planning, Vol. 9 (3-4), pp. 299-314.

Meadowcroft, J. (2009) What about the politics? Sustainable development, transition management and long term energy transitions. Policy Science, Vol. 42, pp. 323–340.

Ministerio de Fomento, Industria y Comercio (MIFIC) (2008) Política de Desarrollo Industrial de Nicaragua, Dirección General de Industria y Tecnología, MIFIC, Nicaragua.

Ministerio de Energía Minas y Minas (MEM) (2010) Plan de Expansión de Generación Periodo 2011-2025, Dirección General de Política y Planificación Eléctrica y ENATREL, Nicaragua.

Ministerio de Energía y Minas (MEM) (2011a) Plan Estratégico del Sector Energético de Nicaragua: 2007-2025. Dirección General de Política y Planificación Eléctrica. Nicaragua.

Ministerio de Energía y Minas (MEM) (2011b) Programa Nacional de Electrificación Sostenible y Energía Renovable para Nicaragua (PNESER), Dirección General de Política y Planificación Eléctrica. Nicaragua.

Ministerio de Energía y Minas (MEM) (2011c), Data on Concession and Licenses, Consulted at: http://www.mem.gob.ni/index.php?s=2&idp=375&idt=1; April 10th 2011.

Ministerio de Energía y Minas (MEM) (2011d), Desarrollo de la Electricidad a Pequeña Escala para Usos Productivos en Zonas Fuera de Red, Presentation February 2011.

Moe, E. (2010) Energy, industry and politics: Energy, vested interests, and long-term economic growth and development, Energy Vol. 35, pp. 1730–1740

Mostert, W, (2007) Unlocking Potential, Reducing Risk Renewable Energy Policies For Nicaragua, The International Bank for Reconstruction and Development, Washington D.C.

Newell, Peter (2011) Transitioning to a low carbon economy: What role for global environmental governance?; Presentation Proceeding, Earth System Governance Inauguration Lung University, April 14th 2011.

Newig, J., Vob, J.P. and Monstadts, J. (2007) Governance for Sustainable Development in the Face of Ambivalence, Uncertainty and Distributed Power: An Introduction (Editorial), Journal of Environmental Policy & Planning, Vol. 9 (3-4), pp. 185-192.

Observatorio de la Deuda en la Globalización (2009): *Ayudando a Union Fenosa a hacer negocios,* [Online], Available at http://www.odg.cat/documents/enprofunditat/Estat_espanyol/FichasE.pdf , [Accessed on 04 Apr, 2011]

Owenn, N., Inderwildi, O. and King, D. (2010) The status of conventional world oil reserves—Hype or cause for concern?, Energy Policy Vol. 38, pp. 4743–4749

RENOVABLES, (2011) Available at: http://renovables.org.ni/www/index.php?option=com_content&view=article&id=50&Itemid=69, Consulted: April 10th 2011

Robins, L. (2008) Perspectives on capacity building to guide policy and program development and delivery, Environmental Science & Policy, pp. 687-701.

Rotmans, J.; Kemp, R. and van Asselt, M. (2001). More Evolution than Revolution: Transition Management in Public Policy. Foresight, Vol.03, Vo.01, pp. 15-31.

Rotmans, J. (2005) Societal Innovation: between dream and reality lies complexity. In Inaugural Addresses Research in Management Series. Erasmus University Rotterdam, pp. 1-77.

Rotmans, J. and Loorbach, D. (2009) Complexity and Transition Management. Journal of Industrial Ecology Volume 13, Number 2, pp. 184-196.

Sanden, B. and Azarb, C. (2005) Near-term technology policies for long-term climate targets— economy wide versus technology specific approaches, Energy Policy 33, pp. 1557–1576

Secretaría General Sistema de Integración Centroamericano (SICA), (2007) Estrategia Energética Sustentable Centroamericana 2020, Honduras.

Sen, Amartya (1999) Development as Freedom, Anchor Books Editions, New York, pp.366

Shafiee, S. and Topal, E. (2009) When will fossil fuel reserves be diminished? Energy Policy Vol 37, pp. 181–189.

Schot, J. and Geels, F. (2007) Niches in evolutionary theories of technical change: A critical survey of the literature Journal of Evolutionary Economics Vol 17, pp. 605–622.

Smith, A.; Stirling, A. and Berkhout, F. (2005) The governance of sustainable socio-technical transitions Research Policy 34, pp. 1491–1510.

United Nations Development Program (UNDP) (2009): Human Development Report 2009, [Online] Available at http://hdr.undp.org/en/reports/global/hdr2009/chapters/ , [Accessed on Apr 10, 2011]

United Nations Development Program (UNDP) (2010): *Human Development Report 2010*, [Online], Available at http://hdrstats.undp.org/en/countries/profiles/NIC.html , [Accessed on Jan 5, 2011]

Verbong, G. and Geels, F. (2007) The ongoing energy transition: Lessons from a socio-technical, multi-level analysis of the Dutch electricity system (1960–2004). Energy Policy Vol. 35, Issue 2, pp. 1025-1037

Vob, J.P., Newig, J., Kastens, B., Monstadt, J. And Nolting, B., (2007) Steering for Sustainable Development: a Typology of Problems and Strategies with Respect to Ambivalence, Uncertainty and Distributed Power, Journal of Environmental Policy & Planning, Vol. 9 (3-4), pp. 193-212.

Wall Street Journal, published by Saint Louis Federal Reserve Consulted: April 5th 2011, Available at: http://research.stlouisfed.org/fred2/series/OILPRICE/downloaddata

Walker, G. and Shove, E. (2007) Ambivalence, Sustainability and the Governance of Socio-Technical Transitions, Journal of Environmental Policy & Planning, Vol. 9 (3-4), pp. 213-225

World Bank (WB) (2010): *World Development Indicators 2010,* [Online], Available at http://data.worldbank.org/ , [Accessed on Feb 10, 2011]

Yin, R. (2002) Case Study Research: Design and Methods. Sage Publications, Inc., 3rd ed. Applied Social Research Methods Series, Vol. 5.

Zeijl-Rozema1, A.; Cörvers, R.; Kemp, R. and Martens, P. (2008) Governance for Sustainable Development: A Framework Sustainable Development; Sustainable Development Vol. 16, pp. 410–421

IX. APPENDICES

APPENDIX 1 LIST OF INTERVIEWS

#	DATE	DESCRIPTION
1	Jan 14, 2011	FODIEN / MEM
2	Jan 18, 2011	MEM - Unit of Wind, Solar and Biomass Energy
3	Jan 19, 2011	Wind Energy Developer (63 MW) and Hydroelectricity Developers (25 MW)
4	Jan 27, 2011	Blueenergy / Small Scale RE Promoter and Developer in the Atlantic Coast
5	Jan 27, 2011	Asociación Nicaraguense para Energías Renovables y el Ambiente RENOVABLES
6	Jan 21, 2011	Municipality of Rivas
7	Jan 25, 2011	Municipality of San Juan del Sur
8	Jan 31, 2011	MEM - General Direction of Electricity and Renewable Resources
9	Jan 31, 2011	MEM – General Direction
10	Feb 02, 2011	Small Hydroelectric Plants Program (PCH)/FODIEN - MEM
11	Feb 02, 2011	Small Hydroelectric Plants Program (PCH)/FODIEN - MEM
12	Feb 08, 2011	National System of Public Investments (SNIP) - Pre-investment Unit / Ministry of Finance
13	Feb 15, 2011	Small Hydro-Electric Plant (900 KW) El bote / Municipality of El Cua / Jinotega (ATDR-BL NGO)
14	Feb 15-17, 2011	Small Hydroelectric Plants Program (PCH)/FODIEN - MEM
15	Feb 16, 2011	Small Hydro-Electric Plant (240 KW) El Naranjo / Municipality of Waslala / North Atlantic Region
16	Feb 17, 2011	Small Hydro-Electric Plant (900 KW) El bote / Municipality of El Cua / Jinotega (ATDR-BL NGO)
17	Feb 17, 2011	Municipality of Matagalpa
18	Feb 23, 2011	Hydroelectric Energy Developer (250 MW)
19	Feb 23, 2011	Inter-American Development Bank, Energy Specialist
20	Feb 24, 2011	MEM - General Direction of Energy Policies
21	Mar 15, 2011	Programa Bolivar NGO Wind Power

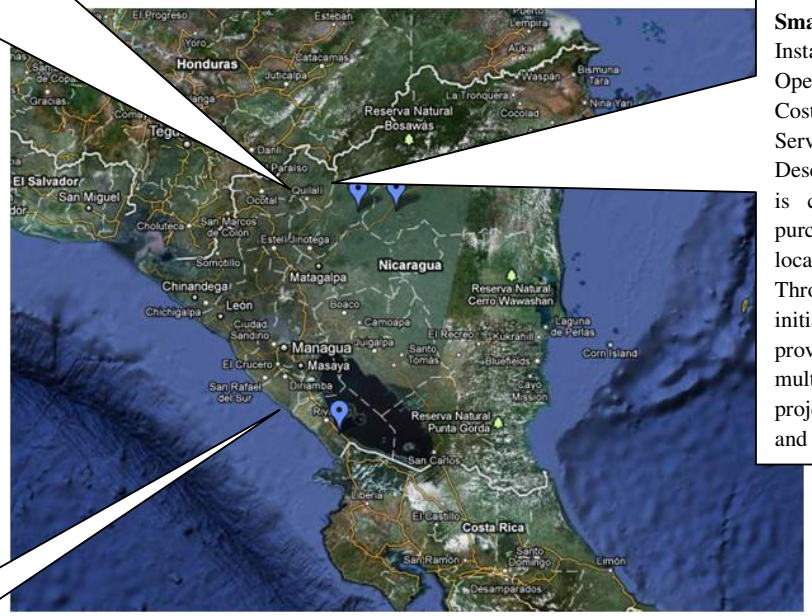
Appendix 2 Field Visits

Small-Hydropower Plant El Bote
Installed Capacity: 930 KW
Operational since 2005
Served Population: 2,325 households, ≈8,070 people
Cost: U$ 2.8 million incl. 65 km transmission lines
Description: Developed by ATDR-BL, an NGO focused on sustainable rural development, it´s the largest concession after the national distributor and the only SHP that has connected to the national grid. The project was financed with loans and donations from bi- and multilateral sources. Watershed management is carried out by the NGO through land purchases, promotion of alternative crops, educational campaigns on consequences of deforestation.

Picture 1 Turbines El Bote

Picture 2 Reservoir El Bote

Picture 3 Watershed Las Nubes-El Naranjo



Small-Hydropower Plant Las Nubes-El Naranjo
Installed Capacity: 220 KW
Operational since: 2007
Cost: U$ 1.3 million
Served Population: 594 households, 3,564 people
Description: Financed by the MEM (FODIEN) the SHP is constituted as a private enterprise with stocks purchased by the community and administered by a local board of directors elected by the stockholders. Through the SHP, the board has developed parallel initiatives such as the first cyber cafe in town and provides IT classes to the community. It has received multiple awards as an exemplary rural development project but still struggles with upstream deforestation and expansive cattle farming.

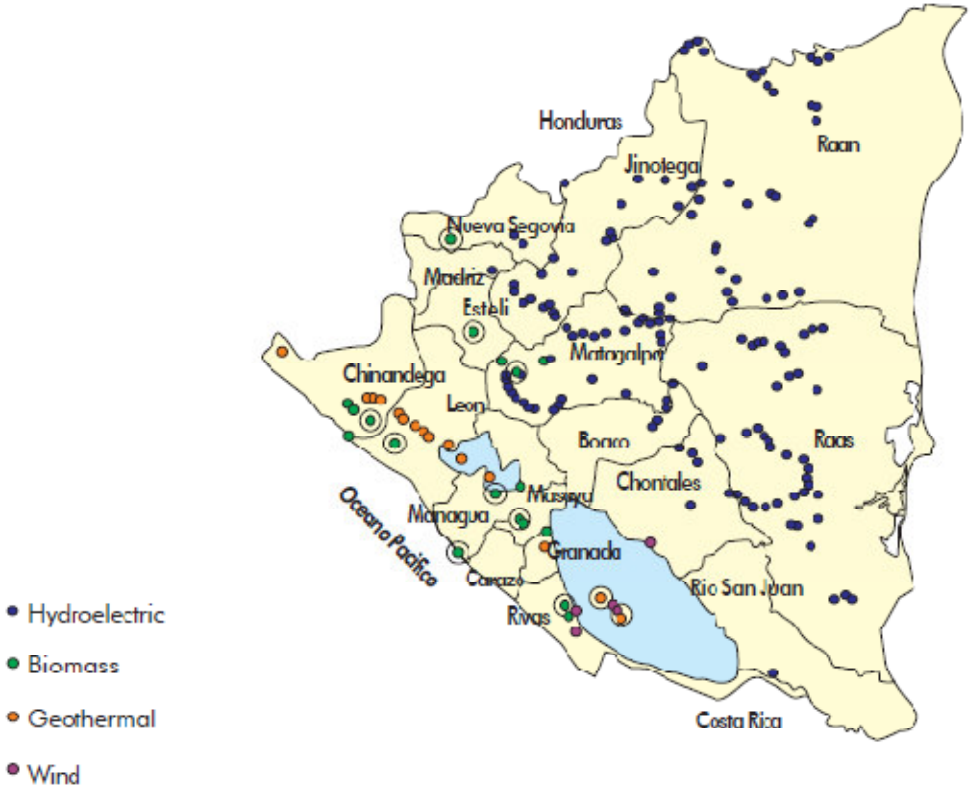
Picture 4 Turbines Las Nubes-El Naranjo

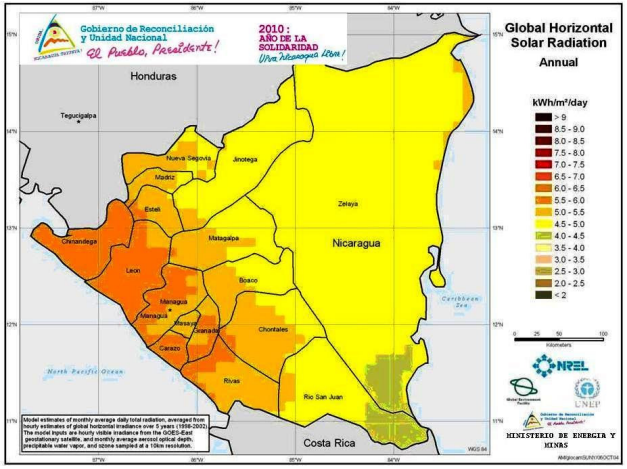
Amayo Wind Power Farm
Installed Capacity: 63 MW
Operational since 2009
Description: First wind power on grid developed by a consortium of national and international investors.

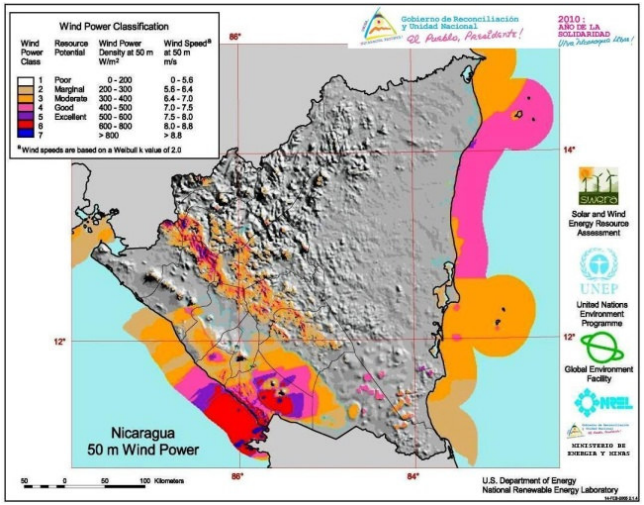
Picture 5 Amayo Wind Farm

Source: Map Google Earth, Pictures by author.

APPENDIX 3 MAPPED RENEWABLE GENERATION POTENTIAL IN NICARAGUA







Source: MEM (2011[a]); Mostart (2009)

APPENDIX 4 SUMMARY OF STRATEGIC ENERGY PLAN 2011-2025

PLAN DE EXPANSIÓN DE GENERACIÓN 2011-2025
ESCENARIO INDICATIVO A (DEMANDA MEDIA)
(POTENCIA EXPRESADA EN MW)

PROYECTOS	Tipo	Inversionista	AÑOS																					
			2011		2012		2013		2014		2015		2016		2017		2018	2019	2020	2021	2022	2023	2024	2025
			I S	II S	I S	II S	I S	II S	I S	II S	I S	II S	I S	II S	I S	II S								
San Jacinto *	Geo	POLARIS	36		36																			
Boboké *	Hidro	MIXTO (BOT)											70											
Hidro Pantasma (filo de agua)	Hidro	FCC - SARET						12																
Larreynaga (filo de agua) *	Hidro	ENEL					17.2																	
Tumarín *	Hidro	MIXTO(BOT)										250												
EOLO [1]	Eólico	EOLO			37																			
Geo 2 X 35 MW *	Geo	No definido									35		35											
Blue Power [2]	Eólico	Blue Power			40																			
Geo 2 X 35 MW *	Geo	No definido													35		35							
Eolico	Eólico	No definido																			40			
El Carmen *	Hidro	No definido																				100		
Copalar Bajo *	Hidro	No definido																150						
TOTAL	928		36	0	113	0	17	12	0	0	35	250	105	0	35	0	35	150	0	0	40	100	0	0

* Estos proyectos representan potencias firmes
* La Entrada de los proyectos está en dependencia del avance de los mismos.
* La capacidad de los proyectos geotérmicos pueden disminuirse o aumentarse dependediendo de los resultados de la exploración.
* Las capacidades de los proyectos garantizan un respaldo de potencia suficiente para suplir la demanda máxima.
* La generación que resulta de este escenario asegura factores de plantas mayores a 40% para las plantas hidroeléctricas y de 85% para las geotérmicas.
Notas:
[1] Cuenta con Liciencia Generación.
[2] Pendiente la aprobacion de su contrato de comprar-venta de energia con la distribuidora, por parte del ENTE regulador(INE)

RETIRO DE PLANTAS DE GENERACIÓN Y/O TERMINO DE CONTRATOS PPA (MW)
ESCENARIO INDICATIVO A (DEMANDA MEDIA)

PLANTAS	Tipo	AÑOS																				
		2011		2012		2013		2014		2015		2016		2017		2018	2019	2020	2021	2022	2023	2024	2025
		I S	II S	I S	II S	I S	II S	I S	II S	IS	II S	I S	II S	I S	II S								
Managua 3	Térmico							-40															
Nicaragua 1	Térmico								-50														
Nicaragua 2	Térmico							-50															
Managua 4	Térmico								-5														
Managua 5	Térmico								-5														
Momotombo	Geotermico										-31												
Tipitapa PPA (1)	Térmico														-50.9								
Corinto PPA (1)	Térmico														-68.5								
CENSA PPA (1)	Térmico														-57								
TOTAL	-357	0	0	0	0	0	0	-90	-60	0	-31	0	0	0	-176	0	0	0	0	0	0	0	0

Notas:
(1) Término de contrato PPA en año 2014.

ADICIONES Y RETIROS
ESCENARIO INDICATIVO A (DEMANDA MEDIA)

AÑO		2011		2012		2013		2014		2015		2016		2017		2018	2019	2020	2021	2022	2023	2024	2025
SEMESTRE		I S	II S	I S	II S	I S	II S	I S	II S	IS	II S	I S	II S	I S	II S								
ADICIÓN	MW	36	0	113	0	17	12	0	0	35	250	105	0	35	0	35	150	0	0	40	100	0	0
RETIRO	MW	0	0	0	0	0	0	-90	-60	0	-31	0	0	0	-176	0	0	0	0	0	0	0	0
ADICIÓN NETA	MW	36	0	113	0	17	12	-90	-60	35	219	105	0	35	-176	35	150	0	0	40	100	0	0

Source: MEM (2011a:63-64).

APPENDIX 5 PRESENTATION OF SMALL HYDROPOWER PLANTS COMMUNITY PROJECTS

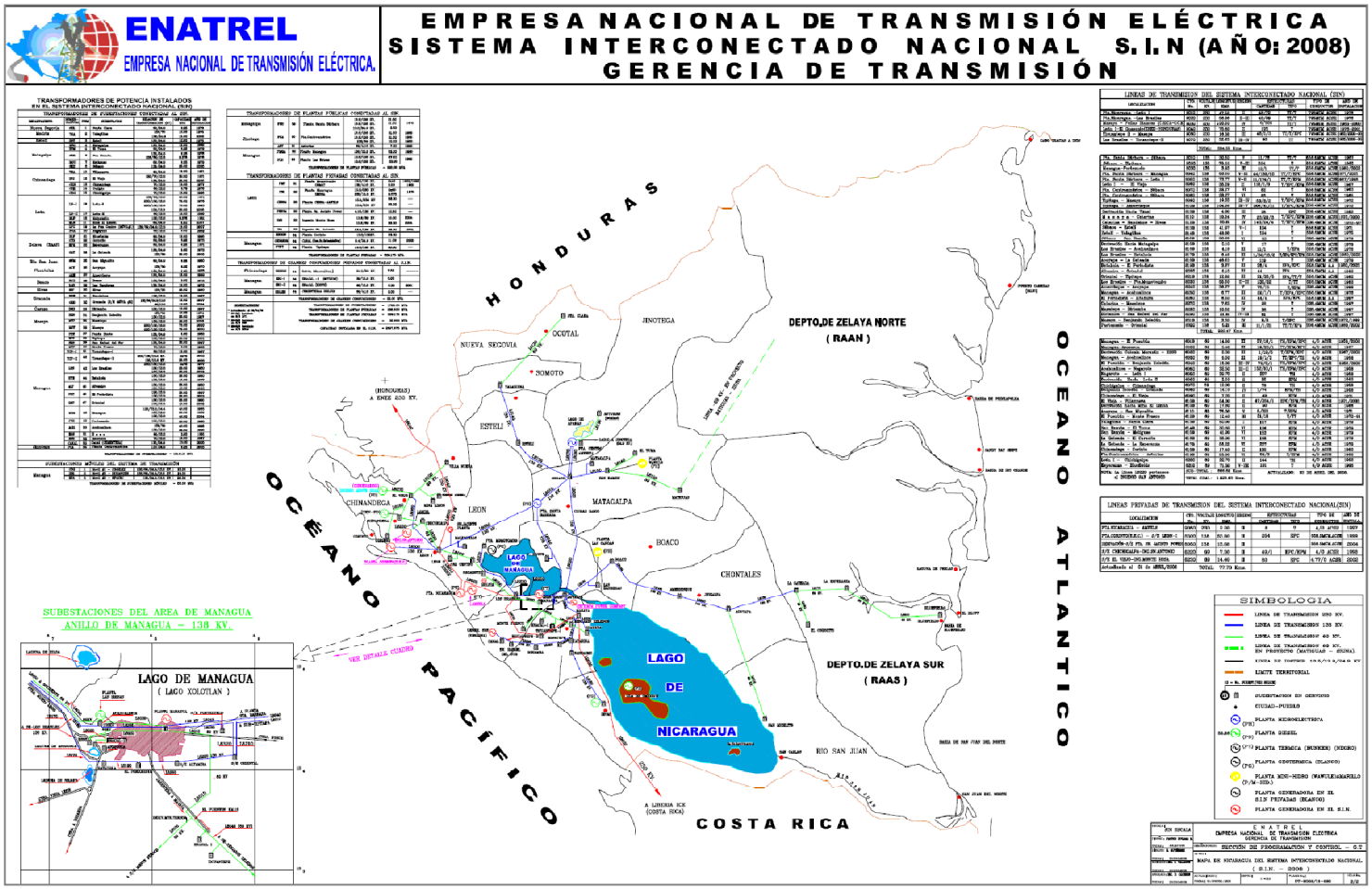
Rural electrification is one of the bigger challenges facing rural development in Nicaragua. Expansion of the transmission lines to remote rural areas represents an elevated investment cost and the dispersed population in rural areas makes extension of distribution lines costly and complicated. To address the electricity needs in rural areas not covered by the grid, ROR small scale hydropower plants are being promoted as a technically and financially viable and environmentally sustainable alternative. Developed initially by NGOs and small technology developers, the Government has adopted the SHPs scheme at the core of its national rural electrification plan (MEM, 2011b).

The administrative model developed for these SHPs is based on an arrangement where the state finances the investment cost, through external loans and grants, and a private enterprise is constituted for the ownership and administration of the isolated concession area. The private enterprise works as a stock company where project beneficiaries in the community buy stocks to become co-owners of the project. The legal charter of the companies establishes that from their income they have to create a mandatory U$50,000 fund to capitalize the company and cover eventualities in the future. The stockholders elect a board of director to administer the company through shareholder voting procedures. The idea behind this modality is that as a private enterprise the company will not be subject to political manipulation, as co-owners the community will safeguard the success of the project and the decisions will be legitimate within the community. To date, 4.67 MW have been installed with an estimated cost of U$25 million and another 2.3 MW are planned for the next 4 year with an investment of U$23.3 million.

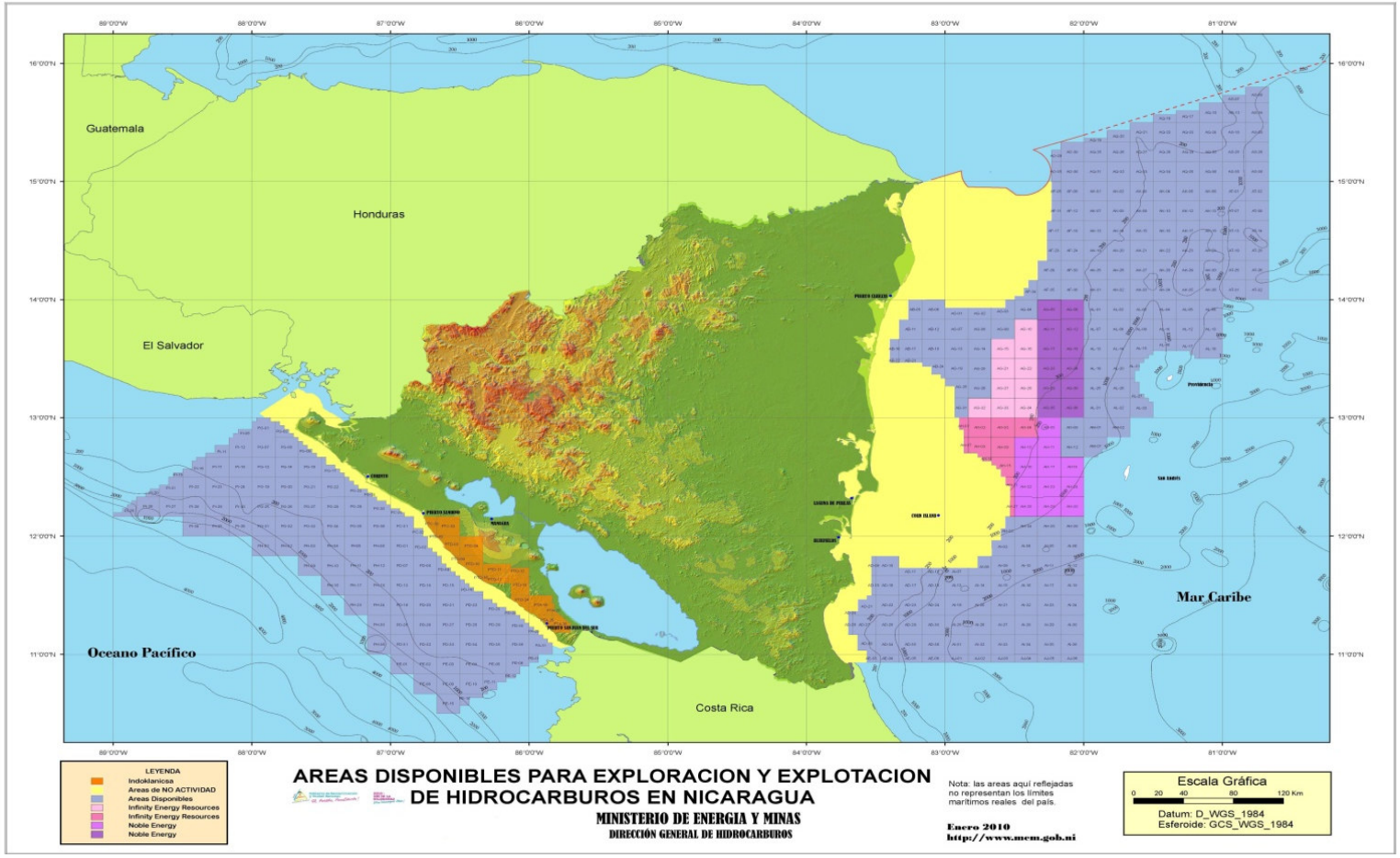
The socio-economic impact of these projects was measured in the period 2005-2008 and some illustrative figures are, for example, in participant communities the number of refrigerated dairy collection centers increased from 14 to 29, use of refrigeration for food preservation rose from 2 households to 737, commercial businesses increased from 21 to 68, the number of community service centers (health, education) increased from 84 to 137 and prices for milk and cheese doubled and real estate value rose 5 times. These significant impacts evidence the positive social and economic impact of electrification in rural areas. The biggest challenge for the long-term sustainability of these projects lies in the conservation of watershed areas and the MEM has not put forward a coherent and integral approach to address this issue. To date the project strategies have been to try to encourage producers to switch to coffee and cacao plantations, halt deforestation through community control efforts and upstream land purchases in projects with more resources. One of the biggest challenges expressed by projects is that upstream land owners are not beneficiaries of the electricity services developed by the project, thus they feels no immediate benefit in altering their land uses.

Figure 6 Map of Existing and Planned Small Hydropower Plants (Marked in Red) (MEM, 2011a)

APPENDIX 6 EXISTING AND PLANNED EXTENSION OF NATIONAL INTERCONNECTED GRID



APPENDIX 7 AREAS OF OIL EXPLORATION IN NICARAGUA



Source: MEM, 2011a.