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Multi-Level Governance of Low-Carbon Energy Systems in Thailand

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Abstract: Low-carbon future has in recent years recurred as a strategic element in energy and climate planning. The transition towards a low-carbon society requires fundamental changes in both the energy systems and in the ways that society adapts to large transformations. These changes cannot happen by themselves, but require purposeful mechanisms and measures steered by government and other actors in society. Actions are required at all levels of government from international to local. Thailand needs to transform its energy system to effectively address concerns about a range of environmental problems. This paper provides an analysis of Thailand's carbon governance structure as applied to the energy systems. The study applies a multi-level governance framework to understand the policy environment. It presents the elements of existing energy and climate governance and an examination of modeling exercises of the existing literature. It is concluded that multi-level governance enables integration of divergent perspectives and helps steer the course of responsible development. The paper also provides some recommendations on issues related to the governance challenges.

Keywords: energy and climate policy; multi-level governance; energy systems; Thailand

1. Introduction

The utilization of fossil fuels is the main source of greenhouse gas (GHG) emissions. Impacts of climate change can be reduced by mitigation and adaptation. This paper largely deals with the mitigation of climate change through reducing emissions of carbon dioxide (CO₂) in the energy system. Restructuring current energy systems in order to incorporate with low-carbon energy technologies is essential for the realization of the low-carbon society (LCS) vision. The transition towards low-carbon energy is underway, although fossil fuels still play a leading role in our energy systems and the mix of energy sources in the global primary energy consumption has remained almost unchanged. This suggests that greater efforts are needed to realize the LCS to minimize the impacts of climate change. These efforts must include policies and measures across multiple sectors and activities of the economy.

During the last decade a growing number of studies have been developed aiming at understanding and analyzing the conditions for transition governance for low-carbon futures. To date, most analysis has focused on the role of nation states in the design, promotion and implementation of various policy architectures and instruments towards LCS. Energy and scenario studies demonstrate that it is possible from a resource, technological and economic perspectives to achieve LCS that is consistent with the 2 °C target [1]. The central problem for the governance of LCS is that while potential problems can be identified with engineering techniques, these can only be resolved through effective policy instruments at all levels of the society. A comprehensive review of both quantitative and qualitative low-carbon scenario studies can be found in [2]. It is, however, carrying out such a transition towards low-carbon futures particularly the energy systems involves unprecedented challenges for political institutions and processes. It also requires new and innovative approaches to governance.

The term governance has become popular over the last two decades. The concept has principally been utilized to highlight that processes of preparing, deciding on an implementing measures to coordinate increasingly involve stakeholders other than the nation state, such as the private sector and local and international organizations. Governance is also used to denote the rules that shape the interactions between actors [3]. Multi-level governance (MLG) is concerned with the way policy has moved from centralized governmental forms and become distributed across levels and actors. Since its inception in European policy studies, MLG has been applied in a variety of policy domains (e.g., energy and environment) and at a variety of empirical levels [4]. Attempting to understand the governance of energy systems using a MLG approach helps to better characterize the relationships between different actors horizontally across and vertically between different levels of government.

A key motivation for the application of MLG is the nature of many environmental problems, e.g., carbon emissions, flooding, air pollution, *etc.* The adverse impacts at varying scales and interactions between levels reflect the increasing connectivity and complexity of human nature interactions. Bache and Flinders [5] discuss the classical problem of provision of public goods. This indicates that there are close linkages between the MLG and public goods. The energy can be viewed as commodity which comprises of a network of actors at different levels: within the country and between countries, international, and subnational actors, interactions between institutions form. How energy systems develop matters to the delivery of climate problem and sustainable economic growth in the country.

Thus, energy systems present important opportunities for reducing human impact on the global climate. However, there is a limited amount of literature on the links between modes of governance, types of governance arrangements, and energy and climate change, with most literature focusing on developed nations. This study contributes to the field by using the energy system as an example of MLG.

This paper applies MLG theory to explore linkages between national and local policies to the low-carbon energy systems in Thailand. A key hypothesis of this paper is that encouraging different levels of government to work together could be a main ingredient for successful transition to low-carbon energy systems. This paper aims to identify trends and recent developments of MLG in Thailand's energy system. In particular, the analysis is examined the main research questions of what different forms of national-local policy linkages exist to implement energy and climate policies, and what recommendations can be made regarding MLG of low-carbon energy systems. The ultimate goal of this work is seeking to understand and facilitate potential transition pathways for the future evolution of Thailand's energy systems towards a low-carbon regime.

The remainder of this paper is organized into five sections. The paper begins in Section 1 with an introduction to the problem and background of the paper. Section 2 focuses on the MLG as an analysis framework. Section 3 presents characteristic of the existing energy and climate governance. Section 4 analyzes the governance of energy system with multi-level dimensions. The paper concludes in Section 5.

2. Multi-Level Governance: A Theoretical Framework

Governance is a concept that is used to describe how societies, organizations and networks are collectively steered and governed. It emphasizes steering enacted in cooperation and deliberation between public authorizes and private actors. According to the Earth System Governance [6] definition, the governance refers to forms of steering that are less hierarchical than traditional governmental policy-making, rather decentralized, open to self-organization, and including non-state actors. The governance is also defined as the concept encourages the understanding of the role of different actors and how these actors interact [7]. Governance considers the system of governing rather than a traditional hierarchical, linear form of control from national to local levels [8]. The analysis in this paper was built up by a desk research on MLG and energy systems theories, underlying the energy transition plans for the low-carbon energy systems. The material studied in this paper is mainly major policy documents of relevance for energy and climate change, such as white papers, action plans and strategies. It also uses secondary sources, such as reports, journal articles and books.

Typically, governance has a top-down approach with little interaction across scales. MLG has emerged as a conceptual approach to studying public policy. It provides an understanding of how central governments and other public and private actors interface to design and implement policies from international to national and local levels of action [9]. MLG also provides an analysis framework to understand the relationships between local, national, regional, and international across energy and climate policy. The key elements of MLG include increased participation of non-state actors in government functions. MLG has been used as a framework for studying climate change mitigation and adaptation policy interactions between cities, regions and national governments as well as non-state and non-governmental actors, see e.g., [10–14].

MLG has been widely used by the Organization for Economic Cooperation and Development (OECD). The approach used in this study follows that of the OECD framework [7,14,15]. Accordingly, MLG has proved as a useful framework to analyze energy policy and implementation processes. Hooghe and Marks [15] depict a view to establishing types of MLG (see Table 1). Type I MLG consists of well-ordered, nested responsibilities, distributed neatly between multi-functional institutions and networks, and at a limited number of clearly demarcated levels. Type II MLG is task-specific jurisdictions, with memberships intersecting across levels through more flexible institutional designs [16]. Using this framework, the analysis focuses on whether MLG is primarily concerned with Type I or Type II influence.

Table 1. Types of MLG.

Type I	Type II
General-purpose jurisdictions	Task-specific jurisdictions
Mutually exclusive jurisdictions at any particular level	Overlapping jurisdictions at all levels
Limited number of jurisdictions	Unlimited number of jurisdictions
Jurisdictions organized in a limited number of levels	No limit to the number of jurisdictional level
Jurisdictions are intended to be permanent	Jurisdictions are intended to be flexible

Source: adapted from [15,17].

Another framework used in this analysis is to consider modes of governance for studying MLG arrangements. Following the past studies [7,18], they propose four modes of governance, including governing by authority, governing by provision, governing through enabling, and self-governing (see Table 2).

Table 2. Modes of governance.

Modes of governance	Description
Governing by authority	National governments intervene directly through mandatory means.
Governing by provision	Additional services and incentives are offered by national governments.
Governing through enabling	National governments stimulate the action by providing enabling conditions such as regulations, guidelines and best practices.
Self-governing	This mode is characterized by self-motivated action.

Source: adapted from [7,19].

3. Architecture of Existing Energy System and Energy and Carbon Governance

Studies on LCS and energy transition pathways have in recent years recurred as a strategic element in energy and climate planning. Energy systems are a representation of the relationships between production and consumption of energy services in a society. Generally, energy systems are comprised of three main components, including the energy resources in the form of primary energy, the conversion technologies, and the demand sectors. The architecture of energy systems determines the configuration of the energy system or the combination of resources and technologies. This can be described by means of what is known as a reference energy system (RES).

Adapting current energy systems to LCS involves a transition to low-carbon energy systems at multiple levels. Thus, to establish potential transition pathways in the energy system, it is imperative to

characterize key elements of the existing regime. The realization of the low-carbon energy systems involves shifting from conventional to low-carbon energy technologies. These changes can be guaranteed with the policies and measures in MLG. Previously energy governance was mainly defined at the national level, now it is characterized by the involvement of a variety of non-state actors from different levels. Figure 1 characterizes the socio-technical regime that meets energy services by household, building, transportation and industry sectors, as presented in a simplified RES. The demands are met through delivery networks of energy and power from energy sources embedded in energy infrastructures. The paper also looks out to energy-related emissions trajectory based on existing literature (Table 3). This can enable to explore alternative plausible governance patterns for Thai energy systems in the future.

Figure 1. Simplified Thailand RES in 2010 (Source: [20]).

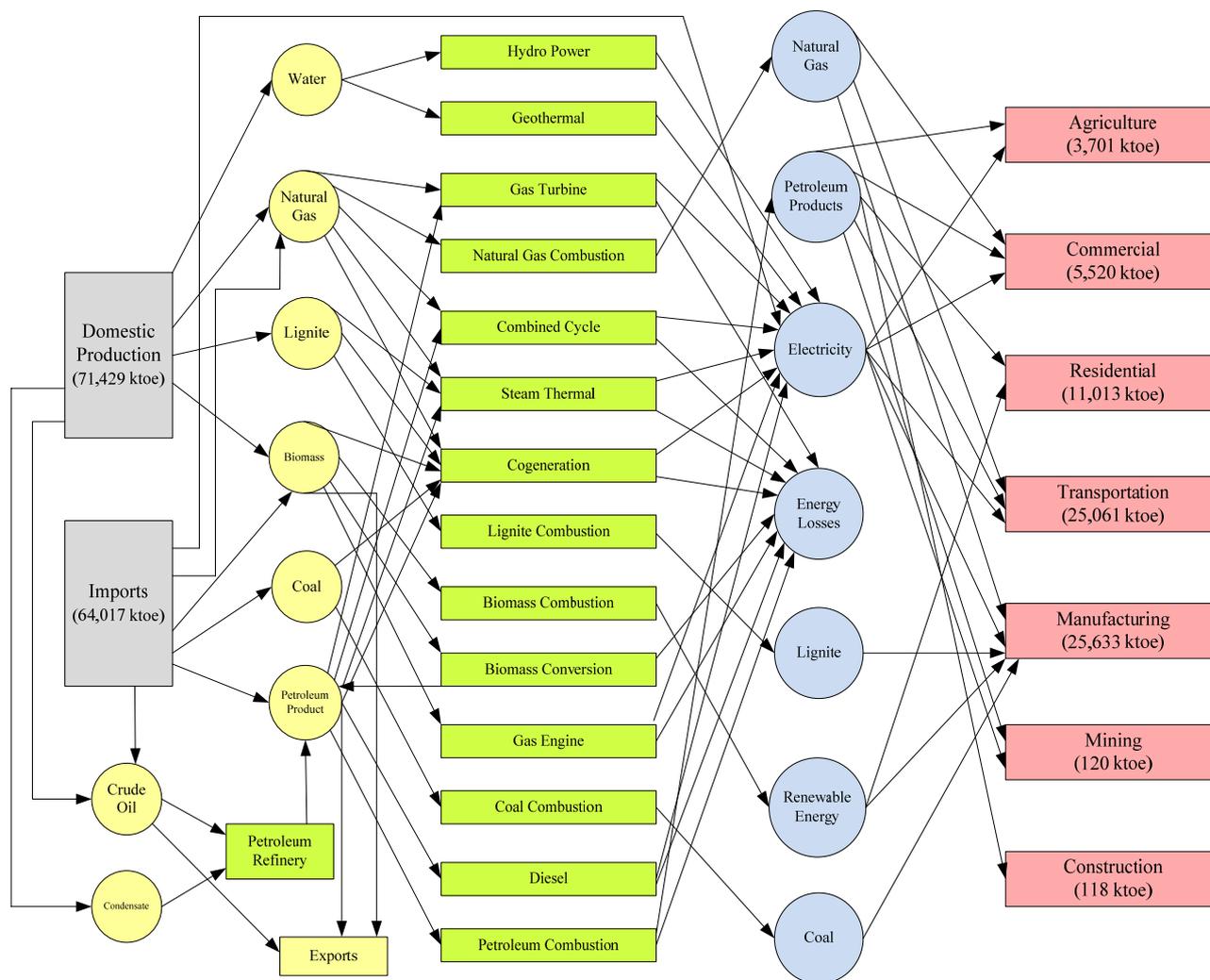


Table 3. Estimation of energy-related CO₂ emissions from Thailand in different scenarios (MtCO₂).

	Model	2010	2020	2030	2050
ADB [21]	DNE21+ model				
Reference		-	350	-	510
S550		-	275	-	420
S450		-	250	-	360
Shrestha and Pradhan [22]	MARKAL model				
Base case		300	475	750	2000
Shrestha <i>et al.</i> [23]	AIM/Enduse model				
TA1		250	480	700	1312
TA2		220	400	580	1180
TB1		210	350	500	1150
TB2		200	280	380	647
Shrestha <i>et al.</i> [24]	AIM/Enduse model	2015	2025	2035	
Base case		486	670	1224	
TRF [25]	LEAP model	2011	2016		
BAU		264	332		
APEC [26]	n/a	306.7	516.7	733.6	-
Tanatvanit <i>et al.</i> [27] *	LEAP model				
BAU		150	225		
UNEP/GEF and World Bank [28]	n/a	490	810		

* This study considers only three economic sectors: residential, industrial and transport sectors. The commercial sector is excluded in the model. Note: DNE21+ is Dynamic New Earth 21+ model and its two scenarios: stabilization at 550 ppm (S550) and stabilization at 450 ppm (S450). MARKAL is acronym for MARKET Allocation. AIM/Enduse is Asia-Pacific Integrated Assessment model and four scenarios are global market integration (TA1), dual track (TA2), sufficiency economy (TB1), and local stewardship (TB2). LEAP is Long-range Energy Alternative Planning System model and BAU is business-as-usual scenario.

As shown in Figure 1, Thailand's commercial energy sector is heavily dependent on energy imports. Fossil fuels dominate the energy supply. The average growth rate of energy demand has been about 7% per year for the past two decades. The total energy demand in 1980 was 9056 ktoe and has increased almost eight-fold to 71,166 ktoe in 2010. Overall, the industrial and transport sectors account for the largest shares of final energy consumption, followed by the residential and commercial sectors. In the past twenty years, the transportation sector accounted for the largest share about 38% of total energy consumption. However, during a past few years the industrial sector became the largest consumer sector. While the transport sector has continued at a high level since 1986, its contribution to the economy has been comparatively small and remained stable at about 9% of the real gross domestic product (GDP). The industrial and residential and commercial sectors contribute significantly to overall real GDP by about 42% and 38% to the total real GDP, respectively [29]. Agriculture sector consumes a small share of energy demand only about 5.2% in 2010. Also, its contribution to the economy is smaller than other sectors.

The energy systems in Thailand can be categorized into two major sources: electricity and petroleum products. The main physical infrastructures dominate Thai energy service delivery, including the electricity generation, transmission and distribution networks and the petroleum authority. Overall

management of the energy sector has been under the National Energy Policy Council (NEPC) since 1992, with the Energy Policy and Planning Office (EPPO) acting as the secretariat. The NEPC is chaired by the Prime Minister, and members from Deputy Prime Minister and the Ministers of Agriculture, Commerce, Energy, Finance, Industry, Science and Technology, and Transport. It is responsible for setting national policies and strategies on energy, promotion of energy conservation and management of the Energy Conservation Promotion Fund (ENCON Fund). The Ministry of Energy (MOEN) is responsible for managing the energy sector and developing national strategic energy plans and targets. Two key agencies under the MOEN are EPPO and the Department of Alternative Energy Development and Efficiency (DEDE). The EPPO acts as policy-maker to recommend and set overall energy policies, measures and plans. It also implements voluntary and complementary energy conservation programs. The DEDE is responsible for energy efficiency promotion, energy conservation regulation, development of alternative energy, and dissemination of energy technologies. It sets and implements renewable energy and energy efficiency policies and promotion program.

Regarding climate change, the Office of the Prime Minister is responsible for overall regulation of climate change management. The secretariat has been set up at the Office of Natural Resources and Environmental Policy (ONEP) within the Ministry of Natural Resources and Environment (MONRE). The ONEP is the national focal point for the UNFCCC and acts as the secretariat to the National Committee on Climate Change Policy. Thailand Greenhouse Gas Management Organization (TGO) is newly autonomous governmental organization under the MONRE. TGO performs its role as the Designated National Authority for Clean Development Mechanism (DNA-CDM) office.

The electricity regime has a diverse range of actors and networks. The regime is also influenced by wider landscape factors (e.g., public awareness) and alternatives and options. The current electricity regime for meeting service demands can be characterized as a centralized system. Electricity is centrally generated, largely from natural gas, coal (bituminous and lignite), oil, hydropower and renewable energy. Electricity Generating Authority of Thailand (EGAT) is responsible for generation and transmission. Electricity is delivered to households, buildings and businesses through the distribution networks, which the Metropolitan Electricity Authority (MEA) is responsible for Greater Bangkok and the Provincial Electricity Authority (PEA) is responsible for the rest of the country. There has been attempt for privatization EGAT, MEA and PEA but they were opposed by the labor unions and other non-government organizations. As a result, the privatization was postponed and no significant changes in the electricity sector since 1998.

Thailand's main energy efficiency and conservation policy is the Energy Conservation Promotion Act, B.E. 2535 (1992). This Act empowers various efforts to improve the use of energy, including renewable energy. Under this Act, the ENCON Fund was established to provide financial support to government agencies, state enterprises, non-government organizations and businesses that implement measures to improve energy efficiency and utilization of renewable sources. In this regard, most efforts on energy efficiency improvements taken by different agencies are serving the needs of reducing energy demand and securing energy supply. However, Thailand is having difficulty in promoting energy efficiency in the transportation sector.

In September 2010, the government has set a policy by encouraging energy conservation and energy efficiency in all sectors through campaigns fostering energy-savings discipline and conscience

and promoting rational use of energy, providing incentives to private sector for high efficient appliances, setting incentive measure for household sector to reduce electricity peak demand, supporting research and development and standard setting, and supporting the development of mass public transportation. Furthermore, the government works with the Local Administration Organizations to act as focal points in creating and disseminating energy-saving measures under the Community Energy Volunteers mechanism.

Energy is the sector from which it has high potential to cut emissions. To make substantial progress in the future, action will be required at all levels of government, from international to local. Energy is also a complex policy problem which spans all levels of territorial governments. Thailand's national energy strategy focuses on improvement in energy intensity, development of alternative energy sources, and expanding the use of renewable energy. At the city level, local governments are beginning to play increasingly important roles in addressing energy and climate issues. Individual cities are also taking action. Best known is certainly the case of Bangkok. Many other cities are taking their own initiatives as well. They are establishing renewable energy and energy efficiency strategies, transportation planning, and climate change mitigation and adaptation strategies.

Analyzing the possibility of the transition to low-carbon energy systems is a complex issue. The analysis is typically based on the systems approach through the application of energy models. For more detail, see [30,31]. Currently, there are few studies on energy demand and CO₂ emissions in Thailand. Understanding the energy and emission paths is fundamental to the transition towards low-carbon energy systems. Table 3 compiled the results of energy-related CO₂ emission scenarios from past studies focusing on Thailand. It should be noted that different studies used different models and assumptions, and the relevant results may vary significantly. The energy-related CO₂ emissions are expected to increase over the next 40 years, as shown in Table 3. For deep cuts in CO₂ emissions, a new set of policy measures and governance system must be introduced.

4. Analysis of Policy Issues and the Governance of Energy System

Towards low-carbon energy system is the emerging national policy issue in Thailand. However, the country does not yet set out a particular policy framework. It should be noted that an analysis in this paper is to identify trends and recent developments within MLG framework. It is not to assess the effectiveness of policy instruments. Currently, energy and carbon is regulated through a range of policies. Both energy and climate policies are matters for which the government is responsible. In Thailand, the policy responses for these issues are set out at macro level. Whilst supported both financial and by steering group representation by departments under different ministries. Following the MLG framework, it is a Type II institution. However, voluntary climate actions are also taken at the city level, such as Bangkok. The role of local policy-makers is increasing with regard to climate change mitigation actions. It is reflecting a transfer from Type II institution to Type I institution. According to TERI [32], which mentions that the fluid nature of Type II governance can make coordination amongst actors difficult and hence necessitate a central actor for the coordination, thereby underlying the need for Type I institution. In fact, dispersion of authority in Type I governance has taken place in many countries, particularly in the European Union. There have seen widespread

decentralization of authority from central states to regions and localities [15]. Table 4 presents the current modes of governance related to energy and climate policies in Thailand.

In Thailand, national government plays a central role in developing energy and climate policies. Local and regional governments also play a critical role in the implementations. However, local and regional governments cannot act alone, thus encouraging different levels of government to work together could be a key successful policy implementation.

Overall, the policy instruments tend to rely on voluntary participation and are likely to be initiated by national governmental bodies. Some involve grant, for example the ENCON Fund. Others include voluntary agreements or public recognition. According to modes of governance, the most common found are governing by provision and governing by enabling. Governance by provision is most common in grants-oriented programs. The government offers funding for energy efficiency actions. Governing through enabling focuses on information dissemination.

Table 4. Modes of governance and energy policies in Thailand.

Self-governing	Governing by Authority	Governing by Provision	Governing through Enabling
-Procurement of energy-efficient appliances	-Guidance on energy efficiency design	-Energy efficiency measures	-Campaigns for energy efficiency
-Energy-saving house demonstration project	-Guidance on renewable energy technology installation	-Community energy projects	-Grant for energy efficiency measures
-High energy efficiency standards in new and existing buildings	-Enhancing energy conservation in buildings and industries	-Soft loan for energy efficiency investment	-Promote the use of renewable energy
-Retrofits of governmental buildings	-Commercial building energy efficiency program	-Provision of grants for small and medium enterprises	-developing building energy codes for commercial building
	-Minimum Energy Performance Standards	-Energy auditing in large buildings and factories	-Energy auditing for designated buildings and factories
	-Demand-side Management program		

Energy efficiency has played a central role for years in Thailand's energy system and, later, climate strategy. Different energy efficiency programs have had both targets and different types of instruments such as fiscal, legislative and promotional measures. Accelerating energy efficiency through widespread deployment of energy efficiency technologies is a key strategy to making the transition to low-carbon energy system in Thailand. Governance of energy efficiency requires attention to barriers and challenges in all energy use sub-sectors.

Thailand has the Renewable Energy Development Program to increase the use of renewable energy and other alternative energy. The promotion of renewable energy has been high in the political agenda. The implementations are focused in five areas: biofuels (gasohol and biodiesel); renewable energy utilization in power generation; renewable energy for heat production; policy study and technology research; and public relations work. Governance for renewable energy is very complex because it deals with number of jurisdictions, for example land-use and urban planning. In some cities, local authorities are beginning to play important roles in implementation of renewable energy technologies.

Carbon capture and storage (CCS) has received increasing attention in the climate change mitigation debate. In Thailand, the potential for CCS is discussing in the power sector. A challenge for CCS has to do with the initial costs of technology and making cost reductions. Currently, CCS is only in the government concern. A key challenge is to get the necessary public support and acceptance for developing this new infrastructure. Government agency should look on what type of legal and administrative frameworks are needed to govern CCS.

The recent developments in carbon governance have given rise to new approaches of the most innovative and experimental. Carbon governance is not limited confined to nation states but is characterized by increasing participation of actors at the subnational level. This multi-actor governance includes private actors such as networks of experts, multinational corporations, and new agencies set up by governments [33]. The key point is that the ability of these non-state actors to take part in steering the energy systems and the strength of coordination among them. Thus, the governance of energy systems is important to determine the outcomes of their influences at different levels. This suggests that policies should go beyond government and public administration to deliver effective results. The governance structure should also connect to different levels. Good interactions with higher levels of government determine the capacity of local governments to act. In addition, the connections among non-governmental groups at the different levels strengthen their capacity to influence policy-making and act.

MLG is used to describe situations in which governance and policy-making is best understood as a process not only dominated by actors centrally located in nation states. This implies that policy formation and political authority significantly influenced or transferred to other levels [34]. Previous studies [11,14] have suggested that cities become at center stage in developing innovative strategies with regard to MLG. There are several good examples worldwide regarding MLG linking in cities. For example, China's central government is aware of the need for regional governance in energy and climate change. It has signed contracts on energy efficiency and pollution reduction targets with provincial level. It also seeks for a new approach in the energy sector [35]. In Japan, several case studies exist where regional and local governments take the lead in climate change regulations and policies. Some prefectures and cities are acting as regulators in climate change mitigation [14]. Brazil sees the mechanisms under Kyoto Protocol as the most appropriate instrument. Even the country has no emission gaps, but a growing number of initiatives to mitigate emissions are being taken on the use of CDM at subnational levels [36]. Many cities around the world have their own low-carbon goals and plans targeting after 2020. Some of them are aiming at emission reductions of 50% or more comparing to their base year emissions, for example see [30,31,37]. Additionally, there is an emerging concept of city carbon budgets [38,39] that works in line with MLG of energy and climate change. Although this concept is actively working in developed countries, however, it is also showing promise in developing countries as a mechanism for allowing cities access to the climate-related funds being created by affluent countries under the auspices of the United Nations.

5. Conclusions

This article analyzes the current Thai energy and climate regime and tries to understand current policy instruments in terms of MLG perspective. Energy and climate change are complex issues which span all levels of territorial governments. In Thailand, the responsibility for energy and climate change policies is shared across the most relevant government ministries. Overall, the governance mix in Thailand's energy and climate governance is currently still under development. Regardless of the difficulties with policy and strategy implementation, government plays a central role. Central government is a crucial role to plan in transition governance. Government action is important on its own but more effectively in concert through local agreements and institutions.

Thailand's approach to energy governance is established around thinking about Type II institutions. A particular problem in energy and climate governance is the dilemma between the need for long-term change and the political realities that favor short-term concerns. The governance challenges associated with energy efficiency are included types of organizations and institutions, jurisdiction and resources to govern energy efficiency. Key governance for renewable energy is the appropriate governance approach to handle land-use management, food security, and removal of economic and non-economic barriers. With regard to CCS type of legal and administrative frameworks are needed.

It is clear that the central government plays an important role in the transition to a low-carbon energy system but the nature of that role is less clear. The lack of an independent planning agency responsible for policy analysis and planning is a significant governance problem. Government should set up long-term visions, provide directions, set targets and create opportunities and framework conditions for the transition. The successful transition to low-carbon futures requires a new notion of governance. Governance should also involve and actively engaging actors in society at both national and local levels. The study concludes that a MLG framework, which embraces all the vertical and horizontal levels involves in the development, application and regulation of low-carbon energy technologies, would enable integration of divergent perspectives and help steer the course towards responsible development of low-carbon energy system. It is recommended that new policy tools are developed that take a systems approach to reducing carbon emissions within the energy system, whilst concurrently using a target based framework that looks to achieve reductions within a set time period. Thailand is at a crossroad on its development path. Low-carbon energy system can simultaneously tackle local environment degradation, climate change and energy security challenge. To apply the analysis of this study to an existing situation, Thailand should command long-term commitment, determination and resources for the achievement. There should be a high level of integration of energy policies across scales of governance, supply and demand-sides of energy systems, and energy technologies. Establishing a national institutional champion with clear mandates, high level authorities, and adequate resources can lead the multi-sector efforts, with clear roles and responsibilities across the key sectors and between the central and local governments.

Future studies should look into the role of different actors at different levels in governance of energy systems, how they interact with each other, and how they influence the energy and climate landscape. It is also worth to examine pathways based on alternative plausible governance patterns for the energy systems and how these patterns will affect technological, institutional and social changes.

This will go beyond the work on energy and emission scenarios that have focused on examining technical aspects and their costs and benefits using modeling exercises.

References

1. Nilsson, L.J. Governing the transition to low-carbon energy and transport systems. *Carbon Manag.* **2011**, *2*, 105–107.
2. Söderholm, P.; Hildingsson, R.; Johansson, B.; Khan, J.; Wilhelmsson, F. Governing the transition to low-carbon futures: A critical survey of energy scenarios for 2050. *Futures* **2010**, *43*, 1105–1116.
3. Magnusson, T. *Governance of Innovation for Sustainable Transport: Hybrid-electric Vehicle Technology in Sweden 1990–2010*; Project Report; Stockholm Environment Institute: Stockholm, Sweden, 2011.
4. Smith, A. Emerging in between: The multi-level governance of renewable energy in the English regions. *Energy Policy* **2007**, *35*, 6266–6280.
5. Bache, I.; Flinders, M. Themes and Issues in Multi-Level Governance. In *Multi-Level Governance*; Bache, I., Flinders, M., Eds.; Oxford University Press: Oxford, UK, 2004; pp. 1–14.
6. Biermann, F.; Betsill, M.M.; Gupta, J.; Kanie, N.; Lebel, L.; Liverman, D.; Schroeder, H.; Siebenhüner, B.; Zondervan, R. Earth system governance: A research framework. *Int. Environ. Agreements* **2010**, *10*, 277–298.
7. Jollands, N.; Gasc, E.; Pasquier, S.B. *Innovation in Multi-Level Governance for Energy Efficiency: Sharing Experience with Multi-Level Governance to Enhance Energy Efficiency*; Information Paper; International Energy Agency: Paris, France, 2009.
8. Biermann, F. Earth system governance as a crosscutting theme of global change research. *Glob. Environ. Change* **2007**, *17*, 326–337.
9. Hooghe, L.; Marks, G. Unravelling the central state, but how? Types of multi-level governance. *Am. Polit. Sci. Rev.* **2003**, *97*, 233–243.
10. Marks, G. Structure Policy and Multilevel Governance in the EC. In *The State of the European Community Vol. 2: The Maastricht Debates and Beyond*; Cafruny, A., Rosenthal, G., Eds.; Lynne Rienner: Boulder, CO, USA, 1993.
11. Betsill, M.; Bulkeley, H. Cities and the multilevel governance of global climate change. *Glob. Gov.* **2006**, *12*, 141–159.
12. Bulkeley, H.; Schroeder, H. *Governing Climate Change Post-2012: The Role of Global Cities-London*; Tyndall Center for Climate Change Research: Norwich, UK, 2008.
13. Corfee-Morlot, J. California in the Greenhouse: Regional Climate Change Policies and the Global Environment. Ph.D. Thesis, Geography Department, University College London, London, UK, 2009.
14. Corfee-Morlot, J.; Kamal-Chaoui, L.; Donovan, M.G.; Cochran, I.; Robert, A.; Teasdale, P.J. *Cities, Climate Change and Multilevel Governance*; OECD Environmental Working Papers N° 14, 2009; OECD Publishing: Paris, France, 2009.
15. Hooghe, L.; Marks, G. Types of Multi-level Governance. Available online: <http://eiop.or.at/eiop/texte/2001-011a.htm> (accessed on 10 October 2010).

16. Marks, G.; Hooghe, L. Contrasting Visions of Multi-Level Governance. In *Multi-Level Governance*; Bache, I., Flinders, M., Eds.; Oxford University Press: Oxford, UK, 2004.
17. Marsden, G.; Rye, T. The governance of transport and climate change. *J. Transp. Geogr.* **2010**, *18*, 669–678.
18. Bulkeley, H.; Kern, L. Local government and the governing of climate change in Germany and the UK. *Urban Stud.* **2006**, *43*, 2237–2259.
19. Schroeder, H.; Bulkeley, H. Global cities and the governance of climate change: what is the role of law in cities? *Fordham Urban Law J.* **2009**, *36*, 313–359.
20. Department of Alternative Energy Development and Efficiency (DEDE). *Energy Situation in Thailand 2010*; Department of Alternative Energy Development and Efficiency, Ministry of Energy: Bangkok, Thailand, 2010.
21. Asian Development Bank (ADB). *The Economic of Climate Change in Southeast Asia: A Regional Review*; ADB: Manila, Philippines, 2009.
22. Shrestha, R.M.; Pradhan, S. Analyzing Co-benefits of Greenhouse Gas Mitigation Targets and Measures in Thailand. Presented at Better Air Quality (BAQ) 2008 Workshop, Bangkok, Thailand, 12–14 November 2008.
23. Shrestha, R.M.; Malla, S.; Liyanage, M.H. Scenario-based analyses of energy system development and its environmental implications in Thailand. *Energy Policy* **2007**, *35*, 3179–3193.
24. Shrestha, R.M.; Mall, S.; Liyanage, M.; Marpaung, C.O.P. Some Results of Emission Modeling Studies on Thailand and Indonesia. Presented at the 12th International AIM Workshop, National Institute for Environmental Studies (NIES), Tsukuba, Japan, 19–21 February 2007.
25. Thailand Research Fund (TRF). *Policy Research for the Promotion of Renewable Energy and Energy Efficiency in Thailand*; Report 2; TRF: Thailand, 2007.
26. Asia-Pacific Economic Cooperation (APEC). *APEC Energy and Supply Outlook 2006*; APEC: Singapore, 2006.
27. Tanatvanit, S.; Limmeechokchai, B.; Chungpaibulpatana, S. Sustainable energy development strategies: Implications of energy demand management and renewable energy in Thailand. *Renew. Sustain. Energy Rev.* **2003**, *7*, 367–395.
28. UNEP/GEF and the World Bank. Climate Change Mitigation in Asia and Financing Mechanisms: Country Presentation. In *Proceedings of a Regional Conference*, Goa, India, 4–6 May 1998.
29. Leesombatpiboon, P.; Joutz, F.L. Sectoral demand for petroleum in Thailand. *Energy Econ.* **2010**, *32*, 15–25.
30. Shimada, K.; Tanaka, Y.; Gomi, K.; Matsuoka, Y. Developing a long-term local society design methodology towards a low-carbon economy: an application to Shiga Prefecture in Japan. *Energy Policy* **2007**, *35*, 4688–4703.
31. Nakata, T.; Silva, S.; Rodionov, M. Application of energy system models for designing a low-carbon society. *Prog. Energy Combust. Sci.* **2011**, *37*, 462–502.
32. The Energy and Resources Institute (TERI). *Multi Level Governance (MLG) Framework for Nanotechnology*; Project Report; The Energy and Resources Institute: New Delhi, India, 2010.
33. Biermann, F. Beyond the intergovernmental regime: Recent trends in global carbon governance. *Curr. Opin. Environ. Sustain.* **2010**, *2*, 284–288.

34. Nykvist, B. *Environmental Policy Integration in Multi-Level Governance—A Literature Review*; EPIGOV Paper No. 30; Ecologic–Institute for International and European Environmental Policy: Berlin, Germany, 2008.
35. Yuan, H. Implementation of voluntary agreements for energy efficiency in China. *Energy Policy* **2007**, *35*, 5541–5548.
36. Puppim de Oliveira, J.A. The implementation of climate change related policies at the subnational level: An analysis of three countries. *Habitat Int.* **2009**, *33*, 253–259.
37. Gomi, K.; Shimada, K.; Matsuoka, Y. A low-carbon scenario creation method for a local-scale economy and its application in Kyoto city. *Energy Policy* **2010**, *38*, 4783–4796.
38. Salon, D.; Sperling, D.; Meier, A.; Murphy, S.; Gorham, R.; Barrett, J. City carbon budgets: A proposal to align incentives for climate-friendly communities. *Energy Policy* **2010**, *38*, 2032–2041.
39. Phdungsilp, A. A Policy Framework of City Carbon Budgets: Science and Policy Mechanism Linkages. In *Proceedings of the 7th Conference on Energy Network of Thailand (E-NETT2011)*, Phuket, Thailand, 3–5 May 2011; Paper No. DEN02.

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