Regional Renewable Energy Planning:

International Case Studies, Lessons Learned

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1. Introduction

1.1 Study Objectives

This study was commissioned by the GEF / World Bank Assisted China Renewable Energy Scale-up Program (CRESP), and by the Energy Foundation's China Sustainable Energy Program (CSEP). Its purpose is to assist China's Center for Renewable Energy Development (CRED) to complete a study on provincial renewable energy planning, including the development of specific planning methodologies that China's provinces might follow.

According to the requirements of China's *Renewable Energy Law*, approved in 2005, the Government of China has established national renewable energy targets. These targets are not yet specifically allocated to provinces but, for the national targets to be implemented effectively, provincial renewable energy objectives must also be established. In fact, the *Renewable Energy Law* requires that China's national government, cooperating with provincial, autonomous region, and municipal governments, establish mid- and long-term targets for renewable energy development and utilization within each of these smaller administrative regions.[1] These local targets are to be consistent with the national targets, but are also to consider the economic context and resource potential at the local/regional level. Importantly, to ensure that the subsequent renewable energy targets are achieved, each relevant provincial, autonomous region, and municipal government[2] is required to establish and implement a renewable energy development and utilization plan.

In executing these responsibilities, it must be acknowledged that data availability, resource limitations, and staffing capabilities may hamper the development of sophisticated renewable energy planning efforts at the provincial level. Comprehensive and up-to-date renewable energy resource and cost data for China are still not available in many instances, though it should be noted that the *Renewable Energy Law* does require the preparation of national renewable energy resource surveys. Additionally, provincial planning departments in China have varying capabilities; not all of these departments have the ability to employ complicated energy-sector models. As such, relatively few examples of comprehensive provincial-level renewable energy planning exist in China. Moreover, China's *Renewable Energy Law* does not clearly specify what is to be included in these provincial plans and, to the authors knowledge, the national government has not yet established the provincial-level renewable energy targets that might guide the provincial-level renewable energy plans.

The CRESP and CSEP programs are interested in assisting China's provinces in executing their renewable energy planning responsibilities. To do so, CSEP has worked with several provinces, over the course of a number of years, on renewable energy issues. CRESP, meanwhile, is

[1] In addition to these targets, local governments at the above-county level are required to establish rural renewable energy targets and implementation plans.
[2] From here on, we refer simply to provincial planning, but we recognize that these plans are also required from autonomous regions and certain municipalities.

working with CRED to formulate planning methods that are practical for provincial application, including the development of appropriate datasets and planning tools. To assist CRED, CRESP has contracted with Tsinghua University to assist with China-specific datasets, planning methods, and formats. CRESP has also contracted with a team from the Center for Resource Solutions (CRS) to highlight international regional renewable energy planning practices and experiences.

This report is the culmination of that latter effort, and highlights a number of specific examples of regional renewable energy plans from the United States, the European Union, and emerging economies. The report emphasizes ten specific planning case studies, which were selected based on a number of criteria: (1) relevance to China's circumstances; (2) diversity of planning objectives, methods, approaches, and covered sectors; and (3) diversity of geographies and contexts. In focusing on international case studies and lessons learned, it is hoped that this work will assist CRED in evaluating various approaches that might be used by China's provinces.

1.2 Report Structure

This report is structured as follows:

In **Section 2** we provide a brief overview of the various objectives, tools, and processes used in renewable energy planning, and how the cases included in this report fit within that context.

In **Section 3** we summarize four renewable energy planning case studies from the United States, including cases from New Jersey, Pennsylvania, the Western United States, and California.

In **Section 4** we summarize three renewable energy planning case studies from the European Union, including cases from the United Kingdom, Germany, and the EU at large.

In **Section 5** we summarize three renewable energy planning case studies from emerging economies, including cases from Morocco, South Africa, and India.

Based on these 10 case studies, in **Section 6** we summarize some key findings and recommendations that may be relevant to China's circumstances.

2. Background

In the broadest sense, planning is an iterative process that involves articulating objectives, establishing measurable targets, assigning resources and responsibilities to achieve those targets, evaluating progress, and adjusting targets and actions over time as circumstances change. Energy planning is a broad term, however, and such planning can vary in scope and come in many forms. The role of data, analysis, modeling, and stakeholder processes within a plan can also vary. Focusing on renewable energy planning, some of the variations are as follows.

First, the basic <u>objectives</u> of a renewable energy planning process can vary substantially:

- **Overall Energy Mix:** In some instances, renewable energy planning may be part of an overall energy plan that contains many other elements as well. In this case, the use of analysis may be to evaluate the costs and benefits of different energy supply and demand scenarios, with renewable energy being only one of several options.
- **Setting Renewable Energy Targets:** In other instances, a renewable energy plan may have a goal of setting specific renewable energy targets. In this instance, analysis may seek to understand the costs and benefits of achieving different target levels, the implications of allocating those targets among different renewable technologies, and the policy efforts needed to achieve the agreed-upon targets.
- **Target Implementation:** In some cases, the renewable energy targets will have already been established, by law or regulation, in which case renewable energy planning is likely to focus on the allocation of those targets among renewable energy sources, and the policy efforts needed to achieve the pre-specified targets.
- **Spatial and Land-Use Planning:** In still other instances, the goals of renewable energy planning are more limited. For example, some plans may focus on identifying specific geographic areas that are suitable for renewable energy development, while minimizing land use conflicts or constraints.
- **Transmission and Grid Integration:** Finally, some planning exercises focus very explicitly on the implications of renewable energy on the need for new transmission infrastructure, and/or grid operations. In other instances, such considerations are embedded within a broader energy planning process.

Second, the <u>scope</u> of renewable energy plans may vary. In particular, most plans address the electricity sector, while a more limited set of plans also address the use of renewable energy in the transportation sector and in the heating and cooling sector. In some planning processes, rural energy needs are also addressed.

Third, the <u>role of data, analysis, and modeling</u> can vary substantially. In some instances, modeling is limited, and planning efforts primarily build on past analysis and stakeholder processes. On the other end of the spectrum, some renewable energy plans rely on complex data sets and sophisticated tools. In should be noted, however, that such modeling is rarely the final word: instead, modeling is used to inform the planning process.

Fourth, the entity responsible for the planning can vary. Renewable energy plans are frequently, but not always, overseen by relevant government bodies. In many instances, multiple government agencies are jointly responsible for the planning process, with responsibilities allocated based on government function. The use of contractors, however, varies, with some plans relying heavily on outside consultants to manage the analysis functions, while others rely primarily on government planning staff.

Finally, the process by which planning occurs often varies. The value of planning often derives from both the outcomes of the plan and the stakeholder process in which the plan is developed and evaluated. As such, most international cases include robust stakeholder processes, though the scope and nature of those processes often vary significantly.

These details are all discussed further with respect to the 10 specific case studies that follow. To provide some sense for the breadth of the case studies in our sample, however, Table 1 identifies the basic objectives and sectoral scope of each case.

Table 1. Scope of International Renewable Energy Planning Case Studies

Case Study	Primary Objective	Covered Sectors
United States		
New Jersey Energy Master Plan	Overall energy mix	Electricity; Heating
Pennsylvania Renewables Portfolio Standard	Setting renewable energy targets; Target implementation	Electricity
Western Clean and Diversified Energy Advisory Committee	Setting renewable energy targets; Target implementation	Electricity
California Renewable Energy Transmission Initiative	Transmission planning	Electricity
European Union		
United Kingdom Renewable Energy Strategy	Setting renewable energy targets; Target implementation	Electricity; Heating; Transportation
EU Proposed Renewables Directive: Target Allocation	Setting renewable energy targets	Electricity; Heating; Transportation
Baden-Wuerttemberg, Germany, Energy Concept 2020	Overall energy mix; Setting renewable energy targets; Target implementation	Electricity; Heating; Transportation
Emerging Economies		
Morocco Renewable Energy and Energy Efficiency Study	Setting renewable energy targets; Target implementation	Electricity; Heating; Transportation
West Cape, South Africa, Sustainable Energy Strategy	Setting renewable energy targets; Target implementation	Electricity; Heating; Transportation
Tamil Nadu, India, State (and National) Renewable Planning	Setting renewable energy targets; Target implementation	Electricity (focus of this report), including rural

3. Case Studies: United States

3.1 New Jersey Energy Master Plan

Introduction: Context and Purpose

Since the 1970s, the state of New Jersey has periodically published Energy Master Plans. State law requires that these plans be updated or revised at least once every three years, and that they are produced collaboratively by the state's various governmental departments and agencies. For the current plan, data, analysis, and modeling support was provided by Rutgers University, under contract to the state. The current version of the Energy Master Plan was first announced in late 2006, was worked on throughout 2007, and was released in draft form in April 2008 for public comment. The final version was completed in late 2008; this case however, reviews the draft plan, and has not been updated to reflect the final version.

The Energy Master Plan has three broad objectives:

- Identify key energy issues and problems facing the state;
- Develop solutions to those problems in the near- and long-term; and
- Highlight tangible actions to make those solutions a reality.

The Energy Action Plan includes, but is not particularly focused on, renewable energy. Instead, it covers many aspects of the state's energy system, including electricity and heating; transport will be covered in a separate report, not yet published. New Jersey's Energy Master Plan is included as a case here because it provides a good example of an energy planning process that is: (1) led by a regional government; (2) is reasonably comprehensive in scope, and includes renewable energy in the electricity and heating sectors; (3) involves extensive public engagement; and (4) includes modeling to estimate the impacts for the state of both a business-as-usual and alternative energy scenarios.

As context, New Jersey is located in the Northeastern United States, is densely populated, has 17,000 MW of electric generating capacity, and consumed 82,000 GWh of electricity in 2006. New Jersey is not particularly strongly endowed with renewable resources: it has some biomass potential, some wind potential (most located offshore), and a moderate solar resource. Energy policy responsibilities in the United States are split between state and federal government agencies, with states having primary responsibility for supply planning and retail rates. As a result, state energy planning processes are not uncommon, though those plans are often constrained by federal law that limits state authority over some energy issues.

Stakeholders were heavily involved in the drafting of the Energy Master Plan. The process involved stakeholder comments and feedback in the beginning stages, a series of committees and work groups that have provided input to the process (e.g., steering committee consisting of 11 state agencies, expert advisory panel, education and outreach working group, conventional electric supply working group), and a broad circulation of the draft in April 2008, including a number of stakeholder and public meetings to review the draft. Written and oral comments can also be offered during formal, public hearings, and though a website. Throughout the drafting, the goal was to maintain an open and transparent process.

Methods and Data

Rutgers University was contracted to provide data, analysis, and modeling support for the Energy Master Plan. As with the plan itself, the modeling was guided by stakeholder involvement and technical working groups. It should also be clearly stated that the modeling informed but did not solely determine the actions proposed in the plan. Consideration of stakeholder comments and expert consultation played significant roles.

The modeling specifically analyzed the state's energy situation through 2020 in a business-as-usual scenario as well an alternative scenario reflecting the policy changes outlined in the plan. The modeling sought to assess the implications of these two futures on energy use, energy prices, economic growth, air quality, and greenhouse gas emission. In so doing, it recognized the critical linkages among energy, environmental, and economic policies, and the need to address all three in a comprehensive fashion. Emphasis is placed on the difference between the two scenarios, more so than on the absolute value of modeling results in any one of the scenarios. The modeling also incorporated some sensitivity analysis to assess the impacts of changes in assumptions on the results, including different CO_2 prices, high fuel price cases, as well as cases that varied the amount of energy efficiency and demand response.

Two major models were used for the analysis behind the Energy Master Plan. The first is R/ECON, a detailed econometric time series model of the New Jersey economy. This model consists of over 300 equations, based on a large amount of historical data for New Jersey and the U.S. The heart of the model is a set of equations that model employment, wages, and prices, by industry. The model was extended for the purpose of the Energy Master Plan to include a variety of energy-sector specific inputs and equations. The purpose of the model is to generate projections for the macroeconomic impacts of alternative development pathways, focusing on employment and economic development indicators.

The second modeling tool is DAYZER, a sophisticated model of the wholesale electric power market that incorporates the unit commitment and dispatch of the electric power system that serves New Jersey. The tool simulates the operation of the electric power market, considering electrical demand, supply, and transmission. The model requires that transmission and generation additions, retirements, and costs are input exogenously into the model. The outputs of DAYZER, along with numerous other assumptions, are input into R/ECON, which then estimates the aggregate economy-wide impact of the two alternative energy futures.

Results and Policy Implications

The Energy Action Plan actually consists of three main reports: (1) the master plan itself; (2) a companion document that clearly identifies implementation strategies; and (3) a supporting document that describes the modeling assumptions and results.

The Energy Master Plan starts by providing background to the state's energy situation, and laying out the challenges associated with the business-as-usual scenario: growth in energy demand and concerns about electricity reliability, energy price increases, increasing greenhouse gas emissions, and reduced state government authority over energy matters. It then describes an alternative scenario that involves achieving certain goals: aggressive energy efficiency, reduced peak electricity demand, growing use of renewable energy, developing low-emission and efficient power plans, and investment in innovative clean energy technologies and businesses. Specific actions that are targeted to address each of the goals are listed and described in the Energy Action Plan. Some of these actions will require new legislation at the state level, while others can be implemented by government entities without new legislative authority. The various reports also describe the limits of state jurisdiction, and the need for federal policy action.

The Implementation Strategies report contains more-detailed information on each of the actions laid out in the Energy Master Plan itself, including a brief description, an estimate of anticipated energy savings or energy production, a detailed program design, estimates of the costs and savings to electricity consumers, identification of affected sectors, discussion of administrative costs, identification of the entity responsible for moving the strategy forward, a timeline for action, sources of funding, and the performance metrics that will be used to judge whether the strategy produces desired results. Though each of these areas does not contain an extensive discussion, the Implementation Strategies report clearly identifies implementation steps and evaluation metrics.

For renewable energy, the underlying goal specified in the Energy Action Plan is to meet 22.5% of the state's electricity needs from renewable sources by 2020, compared to a target of 5.5% in 2007. To achieve this goal, New Jersey has established a renewables portfolio standard (RPS), including a specific target for solar energy (also called a solar set-aside) as a part of that standard, which totals 22.5% by 2020. Specific actions identified in the Energy Action Plan to support the achievement of this goal include:

- Completing the implementation of the solar purchase requirement within the RPS;
- Developing the state's wind resources, including at least 1,000 MW of offshore wind and 200 MW of onshore wind, through a variety of specified actions;
- Increasing the amount of biofuels and biomass for use in electricity production and heating, including the creation of a biofuels standard for heating oil, and developing at least 900 MW of biomass electric capacity; and
- Increasing the percentage of renewable energy required by the RPS between 2021 and 2025, based on future analysis of the technical and economic viability of doing so.

More generally, the plan also calls for an expansion of investments in clean energy technologies, including supporting technology development and manufacturing businesses, and supporting "green" jobs through workforce training and other mechanisms.

Modeling shows that, if the goals and actions identified in the plan are achieved, the state's energy consumption may be reduced by 20%, greenhouse gas emissions will be significant reduced, energy expenditures will decline by $4.5 billion in 2020, and energy reliability will be maintained. Macroeconomic effects, such as employment, wages, and gross state product, are found to be marginally positive. The analysis also estimated the additional costs and benefits imposed by the renewable energy deployment called for under the Energy Master Plan, including overall impacts and impacts that are specific to offshore wind, onshore wind, and solar.

Importantly, the plan will have a strict implementation schedule, and results will be reviewed annually to ensure that interim goals are met and action items successfully executed. That assessment will compare the actions anticipated to be taken each year with what actually occurred. Where an action was not completed, the assessment will explain why, and what is being done to rectify the situation.

Advantages and Disadvantages

The modeling used for the Energy Master Plan includes both electricity-sector specific and macroeconomic tools, allowing for an analysis of energy consumption and production, prices and expenditures, environmental outcomes, and macroeconomic impacts. These tools are specific to the New Jersey context, however, and could not be readily applied in China. These tools are also quite complicated and require a considerable amount of data, making them unsuitable for provincial government implementation in the Chinese situation.

Key aspects of this case study that may be relevant to China include the following:

- Extensive use of stakeholder processes to develop modeling assumptions, guide the creation of the plan, and develop general consensus around the plan and its implementation strategies.

- Clear identification of challenges, goals, and specific implementation actions, including a specific plan for evaluating progress towards those actions on a yearly basis.

- Clear recognition of the limits of jurisdiction at the state level, and the need for federal policy support to fully implement the state's energy goals.

- Incorporation of broad, high-level renewable energy planning within the context of an overall plan that contains strategies and analyses that cover the entire electricity and hearting sectors.

- Addressing not just deployment incentives for renewable energy, but also the broader policy needs related to siting and permitting rules, development of a local manufacturing sector, and training and jobs development needs.

References

New Jersey's Energy Master Plan, Modeling Report for the Energy Master Plan, Implementation Strategies report, and other related documents can all be found at: http://www.state.nj.us/emp/

3.2 Pennsylvania Renewables Portfolio Standard

Introduction: Context and Purpose

In 2003, the U.S. state of Pennsylvania was considering the establishment of a renewables portfolio standard (RPS) in response to public interest in clean energy sources, energy security concerns, and the environmental impacts of fossil fuels. Political leaders had noticed that other states had implemented RPS laws to increase the percentage of electricity generated from renewable energy sources. Renewable electricity generation in Pennsylvania, meanwhile, was limited, at 1.4%. As part of the deliberations surrounding the consideration of an RPS, the non-profit Community Foundation for the Alleghenies (CFA) hired a consultant (Black & Veatch) in 2003 to produce a report on the potential economic impacts of an RPS in Pennsylvania.

The report was specifically to address the following issues:

- The current state of renewable technologies in the United States;
- The technical potential of the renewable resources available in Pennsylvania;
- The renewable resources most likely to be developed to meet a 10% RPS, based on a comparison of the costs of various renewable options;
- The likely change in state electric rates due to an RPS;
- The economic impact to the state due to the reduced fossil fuel use from an RPS; and
- The economic development impacts to the state due to an RPS.

The report was to be a document that would be publicly available, not owned or used by any single interest group. The report was not sanctioned by the Pennsylvania state government, but was expected to be widely distributed and discussed by state legislative and community leaders. It was specifically targeted to the state governor's office and related energy leadership, and the goal was to influence the legislative process in the establishment and design of a state RPS.

CFA's role in the project was to engage the consultant, Black & Veatch, and to approve the scope of work, in consultation with other stakeholders. The stakeholders for the project included CFA, the state Department of Environmental Protection, and the state authority responsible for regulatory oversight in the electricity sector, the Public Service Commission. Stakeholder interaction was mainly limited to reviewing draft results and providing comments on the report.

The process by which the report was created was not strictly a government-driven renewable energy planning exercise. Nonetheless, we include it as a case study primarily because the methods used, though rigorous, are not overly complex, but instead rely upon an Excel-based supply-curve model. Though that model is not publicly available, the basic approach is straightforward and transparent, and could potentially be implemented in China's provinces. The key limiting factor would likely be input data, not model complexity.

As context, Pennsylvania is a state on the eastern seaboard of the United States. The eastern side of the state is home to Philadelphia and is closely aligned with the New York metropolitan area.

The western half of the state, home to Pittsburgh, is more industrial and rural agrarian. The state has a long history of coal mining, as well as oil and gas drilling.

Methods and Data

The study first reviewed the status of renewable energy in Pennsylvania, including existing generation sources and businesses in the field. Next, renewable power generation technologies were characterized, based on technical and economic considerations, leading to assumptions about the cost and performance of various renewable technologies under different conditions and in varying locations. Then, an assessment of Pennsylvania's renewable energy resource potential was made, considering a full range of possible renewable technology options. Finally, the study evaluated the potential economic impacts of implementing a 10% RPS.

To characterize the various renewable technologies and assess their potential in Pennsylvania, a wide range of publicly-available reports and studies were reviewed. No single source was available for such data, but the significant existing literature did provide a starting point. Black & Veatch also used its own engineering judgment and project development knowledge to supplement the large number of pre-existing studies. The ultimate data sources were generally of high quality, but in some cases were not as detailed as was desired. For instance, biomass fuel potential was identified on a county level, but the study was not able to perform a more-detailed survey around potential plant sites. Modeled, GIS-based wind resource data were used for wind resource analysis.

The results of this technology characterization and resource potential effort were then used as inputs into the Excel "supply curve" model that Black & Veatch created for the project. "Supply curves" were developed based largely on best-available public information, and did not assume significant future technological advances. The model did not include any quantification of the expected benefits to Pennsylvania citizens in the areas of improved environment, health, and safety. Instead, the model's primary purpose was to evaluate which renewable resources might be most cost-effectively deployed to achieve the 10% RPS target (based on the "supply curve") and, based on a comparison of those costs to the costs of fossil generation, to estimate the net cost of meeting the RPS target.

This "supply-curve" approach was the primary tool for gauging what renewable projects were likely to be most cost-effectively developed, at what size and by what date. A visual of such a supply curve is provided below as Figure 1. As shown, the resulting costs of hypothetical renewable projects are arranged on the x-axis in order of levelized cost ($/MWh), which is provided on the y-axis. The type of generation (wind, solar, biomass, hydro) is color-coded. A renewable energy supply curve was generated for every other year from 2006 through 2016, to assess the most cost-effective renewable energy options over time. Key inputs to the supply curve were the renewable resource information, described earlier, and assumptions about the capital and operating costs and financing assumptions of various renewable resource options.

The 10% RPS was compared to a "business as usual" case that was created using Black & Veatch assumptions about the cost and performance of conventional technologies, as well as future costs of fossil fuel. The BAU case assumed that the current generation mix in

Pennsylvania would remain unchanged (roughly 50% coal and 50% natural gas). The renewable generation selected by the supply curve approach under the 10% RPS scenario was compared to the BAU system on a net present value basis. Rate impacts were derived from this NPV analysis. Finally, the United States Bureau of Economic Analysis Regional Input-Output Modeling System (RIMS II model) was used to estimate the direct and indirect economic effect of the RPS compared to the BAU case. This included impacts to employment and gross state product.

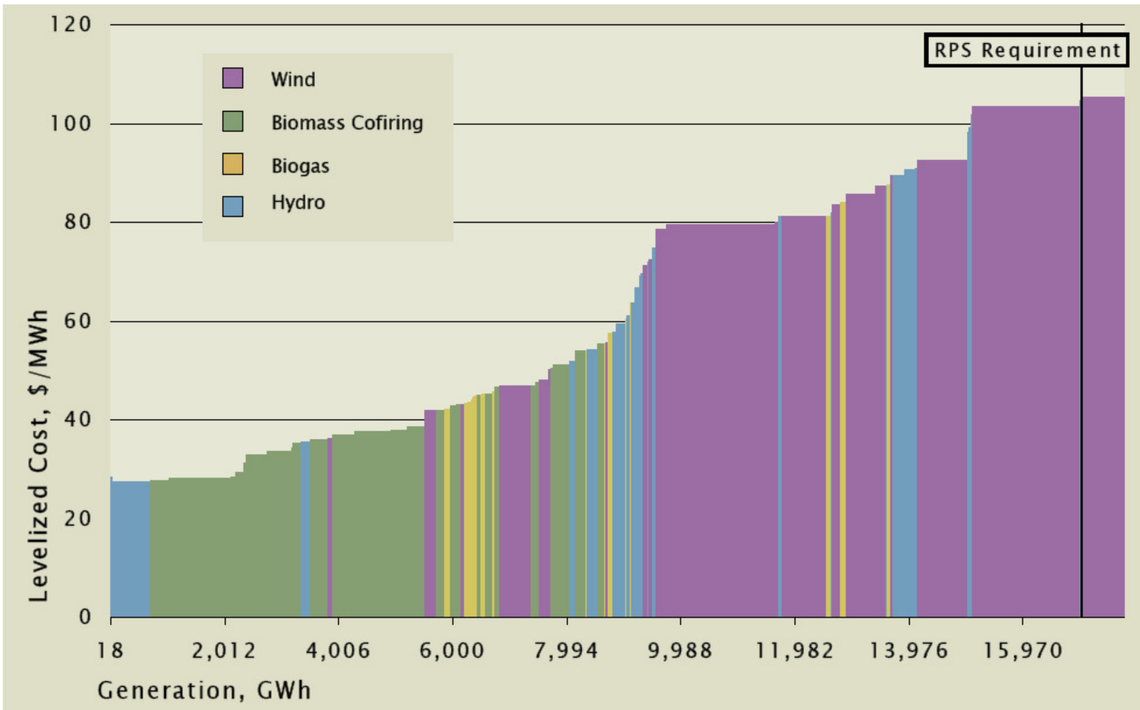

Figure 1. Example Pennsylvania Supply Curve

The supply curve approach selected an RPS portfolio with a capacity mix consisting of approximately 65% wind, 21% biomass co-firing, 11% hydro, 2 percent landfill gas, 1 percent digester gas, and a minimal amount of solar photovoltaics (0.1%). Energy efficiency was included in later versions of the supply curves, and was included by calculating the levelized cost of saved energy, which allowed efficiency projects to be compared to renewable projects.

The report quantified three key economic impacts of the 10% RPS case compared to the "business as usual" (fossil fuel) case:

1. The cost of electricity, both wholesale and retail.
2. The socioeconomic impacts (jobs, income and gross state product).
3. The impact on fossil fuel prices.

The report did not attempt to quantify environmental benefits.

Results and Policy Implications

The report showed that Pennsylvania has enough renewable energy resource potential, at least in theory, to meet its entire electric power needs with renewable energy. More realistically, the report found that it appears feasible and economically viable to develop over 5,200 MW of renewable energy capacity and 17,600 GWh of electricity from renewables in the near term. Most of these additions were forecast to come from wind and biomass co-firing. In aggregate, these total additions represent 12.6% of the 2002 energy consumption in the state, and were projected to be enough to satisfy the 10% RPS for 2015 without importing renewable energy from outside the state.

The report also estimated that there was an annual economic cost of $1.23 billion of the "10% renewables" case over the "business-as-usual" case. This amounts to only a 0.5% increase in average electricity costs. The report also estimated that meeting the 10% renewable energy standard would create more than $10 billion of additional energy investment over the business-as-usual case and create an additional 85,167 job-years.

The report was widely distributed and used by policy makers in Pennsylvania. Ultimately, the Pennsylvania legislature enacted an Alternative Energy Portfolio Standard in 2004 that requires electric utilities to increase the percentage of renewable energy generation to 10% over the next 15 years. It also enacted a separate and additional standard for energy efficiency and "advanced" energy generation options. The report was likely a factor in the legislation. Subsequent legislation has increased the renewable energy purchase requirement even further.

Advantages and Disadvantages

The Pennsylvania analysis was not a state-sponsored renewable energy planning process, but the analysis techniques used and questions addresses were similar to those covered by more-traditional governmental planning efforts. The analysis conducted for this case was underpinned by a solid assessment of the cost and potential of various renewable energy sources. The economic modeling was exclusively focused on the electricity sector, and allowed for an analysis of the most cost-effective deployment of renewable energy to meet a specified target, and the ultimate cost of achieving that target. Assuming that input data are available, the modeling approach used in this report could – with some modification – be used in China. Such a "supply curve" approach is relatively simple in its implementation and transparent in its interpretation. This approach is unable to capture all of the complexities associated with the operation and planning of the electricity sector, but for screening-level assessments the basic method is robust and in common use.

The report also did not comprehensively evaluate the environmental or other benefits of renewable generation, or conduct extensive sensitivity analysis (although some sensitivities were carried on the cost of wind). Macroeconomic impacts were analyzed separately, however, based on a comparison of total capital investment in the renewable case vs. a "business as usual case." Indirect economic effects of this capital investment were modeled using the United States Bureau of Economic Analysis Regional Input-Output Modeling System (RIMS II model).

Separate analysis also sought to estimate the impact of renewable energy in reducing natural gas prices, by virtue of reducing natural gas demand.

Key aspects of this case study that may be relevant to China include the following:

- Assessment of the cost and potential for various renewable energy sources, based in large part on available, pre-existing studies.

- Creation of a relatively simple "supply curve" model that could, with modifications, be adapted to the Chinese situation, were adequate data inputs available, to evaluate the lowest-cost renewable energy options and the cost of renewable energy deployment.

- Use of RIMS-II model (or some similar model) to estimate the employment implications of increased renewable energy development.

References

The final report can be found at:
http://www.bv.com/Downloads/Resources/Reports/PA_RPS_Final_Report.pdf

3.3 Western States Clean and Diversified Energy Advisory Committee

Introduction: Context and Purpose

The Western Governor's Association (WGA) serves the Governors of the 19 Western U.S. states and 3 U.S.-flag Pacific Islands. In a 2004 resolution, the WGA set out the objective of "identifying ways to increase the contribution of renewable energy, energy efficiency and clean energy technologies within the overall energy needs for the West." There were four goals established at that time:

- The additional development of 30,000 MW of clean energy by 2015 from resources such as energy efficiency, solar, wind, geothermal, biomass, clean coal technologies, and advanced natural gas technologies;
- A 20% increase in energy efficiency by 2020;
- An ability to meet the transmission needs of the West for the next 25 years; and
- Improve the position of the Western energy system to respond to new environmental challenges, including potential limitations on greenhouse gas emissions.

The WGA subsequently appointed a 31 member Clean and Diversified Energy Advisory Committee (CDEAC) and charged it with identifying recommendations to facilitate 30,000 MW of new, clean and diverse energy by 2015, a 20% increase in energy efficiency, and adequate transmission for the region.

The CDEAC used task forces, white papers, and public comment to produce information on the effort, ultimately producing a large number of individual subject-matter reports as well as a synthesis report that offered key policy and institutional recommendations. At the 2006 WGA Annual Meeting, the Governors adopted a policy resolution that incorporated many of the recommendations from the ultimate CDEAC report.

The CDEAC effort is included as a case because it covered multiple renewable electricity technologies, and addressed policy and institutional needs including, most prominently, the need for expanded transmission infrastructure. Moreover, by using a large number of task forces, some to cover individual technologies and another to cover transmission needs, the CDEAC process engaged a large number and wide breadth of stakeholders to inform its efforts. Finally, as a multi-state effort, the CDEAC process recognized the value of regional transmission solutions, and was not restricted to assessing in-state resource supply.

Methods and Data

Task forces were created for each of the major renewable technologies (biomass, geothermal, wind, and solar), energy efficiency, and transmission. Each task force was made up of a diverse group of participants, including industry, utilities, research organizations, state policymakers, environmental groups, and policy advocates. The focus of each task force was on collaboration and consensus to achieve the stated WGA goals. All of the task forces relied on a quantitative working group to supply consistent economic data, and ensure some level of consistency across the final task force reports. The task forces that produced reports were: Advanced Coal, Biomass, Energy Efficiency, Geothermal, Solar, Wind, and Transmission. These reports not only provided information on resource potential and cost, but also on policy needs and solutions.

Each renewable technology task force report produced a “cost curve” (also known as a supply curve) to show how much renewable resource was available at a specific levelized cost (in dollars per MWh). The solar and wind task forces used GIS mapping to produce these supply curves, while the geothermal task force used cost information for specific, identified sites throughout the study area. Biomass used information on the location and cost of various fuel types to create its cost curves. There was a central quantitative group that assisted in creating the cost curves, which ensured that all the task forces were using consistent economic assumptions. The project used these supply curves to choose the quantity of each renewable resource to meet the overall 30,000 MW goal established by the WGA.

The transmission task force analyzed several existing transmission plans and performed additional modeling to determine the amount of new transmission that would be needed to support the level of renewables identified by the other reports. In particular, it identified several specific transmission upgrades needed to support a “high renewables” case that was similar to the overall CDEAC recommendation.

Several additional white papers were also produced. One of the more technical papers was titled “Importance of Fossil and Renewable Energy Technology Integration to Western Energy Development.” This paper presented opportunities for renewable energy to be used to enhance fossil fuel development, such as biomass co-firing with coal. Another white paper on combined heat and power (CHP) was focused on the barriers to CHP development and policy changes that could bring the “extensive benefits” of CHP to the West. This paper presented real world examples of barriers to CHP, suggested specific policy changes, and offered examples of regional and state activities encouraging CHP.

Individual reports and a summary report were presented by the CDEAC to the WGA at their annual meeting in 2006, nearly two years after the policy direction that launched the process.

Though the cost curves and modeling were an important part of the project, the focus was on identifying and promoting policies to meet the WGA’s goals. The process relied heavily on a consensus of experts from a wide range of energy industry positions for these policy recommendations. The diverse collection of participants was designed to ensure that the consensus was broad-based and that the report was not viewed as an advocacy document.

Results and Policy Implications

The overall message of the CDEAC effort was that the ambitious renewable, efficiency, and transmission goals of the WGA were feasible and economical. Though there were detailed and specific policy recommendations made by the CDEAC, it does not appear at this time that the group has kept a detailed “scorecard” showing the status of its many recommendations in the 19 U.S. Western states. That said, more-general progress reports have subsequently been published.

Though the CDEAC process was beneficial in finding common ground for agreement on energy policy issues, it is hard to point to specific results from the effort. This may be a natural and even desirable outcome considering the large number of states involved in the effort, and the lack of a strong regional governance structure. State governments all have the ability to pick and choose which recommendations they consider appropriate for their state and may not want CDEAC to "watch over" their actions and grade them on the level of implementation reached.

Since the CDEAC report was published, however, several western states have passed RPS legislation or significantly increased their RPS goals. While the CDEAC may not have had a direct effect, most state policymakers are aware of the report and its positive conclusions.

Much of the GIS modeling work conducted under the auspices of the CDEAC has helped lead to more-recent and more-ambitious efforts, such as the nationwide 20% wind analysis and the current Western Renewable Energy Zones effort, which is also a WGA effort. The WGA has emerged as a leader in western energy policy, partly due to the CDEAC effort.

Advantages and Disadvantages

The CDEAC was able to engage a wide range of stakeholders in a deliberative process to develop broadly supported policy recommendations. CDEAC encouraged communication between industry, utilities, regulators, environmentalists, and policy advocates. Many task forces created informal networks that have since been used in other arenas. The CDEAC also created a successful method for collaboration between different renewable energy industries, which had previously rarely worked so closely together. It also allowed a larger, West-wide focus that is critical for regional transmission planning purposes.

Because there is no West-wide regional governance structure, however, it is hard to identify a clear path between CDEAC policy recommendations and new state and federal policies. Additionally, though using separate task forces for each renewable technology allowed for a distribution of the workload, it produced seven separate reports making integrated policy recommendations somewhat more complicated.

Key aspects of this case study that may be relevant to China include the following:

- <u>A model for regional collaboration</u> - the Western U.S. is a very large geographical area with a diverse group of states, and given the locational dependence of certain renewable sources, a larger regional approach to renewable energy and transmission planning is often warranted.

- <u>A model for stakeholder involvement and consensus in policy development</u> - the WGA engaged a wide rage of stakeholders to work together.

- <u>A supply curve approach to renewable resource potential and cost</u> that lends itself to multiple resources (solar, wind, geothermal), is transparent, and is relatively simple to implement if adequate data on renewable energy resources and costs are available at a reasonably high degree of geographic specificity.

- A model for incorporating transmission planning in the development and implementation of renewable goals.

References

Western Governor's Association web site and related reports and articles, http://www.westgov.org/wga/initiatives/cdeac/.

3.4 California Renewable Energy Transmission Initiative

Introduction: Context and Purpose

The state of California has an aggressive renewables portfolio standard (RPS). Utilities are required to obtain 20% of their power from renewable sources by 2010, and the state has a non-binding goal of achieving 33% by 2020; these goals compare to renewable energy deliveries of roughly 12% in the early 2000s. To meet those goals, significant new transmission development will be required to ensure that remotely located renewable resources can be delivered to load centers. The state's electric utilities are currently behind in meeting their 2010 goals, and all cite lack of transmission as the most significant barrier. The California Renewable Energy Transmission Initiative (RETI) is an ongoing effort to identify the major transmission upgrades that are needed to most cost-effectively meet the state's renewable energy objectives. The project began in 2008, and is expected to continue through 2010.

The RETI process is intended to inform and support policy-making, regulatory activities, and planning processes. It is focused on transmission issues, so is not intended to be a comprehensive effort that addresses all aspects of renewable energy planning. Additionally, it supports, rather than supplants, existing processes, including:

- California Independent System Operator (CAISO) interconnection reform and planning processes;
- California Energy Commission (CEC) transmission corridor designation and plant siting;
- California Public Utilities Commission (CPUC) proceedings on renewables and transmission; and
- Publicly owned utility resource and transmission planning processes.

RETI's relevance to China comes from the fact that its focus is on a barrier to renewable energy development that already exists and will continue to grow in China: transmission investment to remote renewable resource areas. Additionally, the methods used in RETI, including technology and cost characterization, resource assessment, and land-use planning, are all relevant to renewable energy planning efforts that have a broader scope than does RETI.

RETI is a multi-stakeholder collaborative process involving a broad range of participants, including utilities, generators, regulatory agencies, and public interest and environmental groups. The RETI organization includes two permanent committees, and creates ad hoc committees or working groups as necessary. RETI is directed by the Coordinating Committee comprised of the states major energy agencies: the California Public Utilities Commission (CPUC), the California Energy Commission (CEC), and the California Independent System Operator (CAISO). The main governing body is the Stakeholder Steering Committee (SSC), which is comprised of renewable generators, environmental stakeholders, public and private utilities, along with the members of the coordinating committee. Several other key working groups have been formed, such as the Environmental Working Group (EWG), to address specific issues as they arise. Black & Veatch, a large engineering and consulting firm, was retained by the SSC as the primary consultant for the first phase of the RETI work. Stakeholders have been engaged throughout the process to provide input on assumptions, methodologies, and results. Monthly meetings of the full SSC have been held, along with weekly teleconference calls of the various working groups.

As context, California is a large state on the west coast of the United States. It is the most populous state in the U.S., with 36 million inhabitants, and is the third largest state in the U.S. geographically. It was a leader in renewable energy development in the 1980s, developing the first commercial wind farms and solar thermal plants in the world. The RETI effort emphasizes meeting California loads with renewable energy from both within and outside the state.

Methods and Data

The RETI process has been divided into three distinct phases.

- **Phase 1** will identify defined areas of excellent renewable resources (called renewable resource zones, or REZs) and develop supply curves for these resources in each zone. The supply curves will represent the cost and quantity of the renewable resources in each zone. Phase 1 will also include conceptual transmission plans from load centers to each zone. Zones will be ranked economically and environmentally, and the highest ranking zones will be passed forward to Phase 2. Phase 1 began in the fall of 2008 and will be completed in the fall of 2009. Phase 1 was divided into two parts. Phase 1A was a report that defined the methodology and assumptions, and was released in the spring of 2008. Phase 1B includes the results of the REZ ranking, and was released in late 2008.

- **Phase 2** will develop more-detailed transmission plans for the zones ranked highest in Phase 1. This detailed study will include assessments of the environmental impacts of specific transmission routes and system impact costs. The utilities and the CAISO will perform the bulk of the analysis, which began in late 2008 and will continue through 2009.

- **Phase 3** will involve utility proposals for the detailed transmission plans developed in Phase 2 and submission of those proposals to the CPUC and CEC for approval.

The following are the five key steps in Phase 1:

- **Resource Assessment and Project Identification:** The RETI study region spans several U.S. states and three countries, and includes California, Arizona, Nevada, Oregon, Washington, as well as British Columbia, Canada, and the northern part of Baja California, Mexico. California's efforts to look at renewable resources outside the state reflects a desire to source the least-cost renewable resource supply, and a willingness to consider multi-state transmission investments in order to access those resources. In Phase 1, the renewable resources were assessed and costs to develop and deliver the energy estimated. Renewable energy project potential information came from public sources. A request for additional information was issued to stakeholders to identify planned projects. To the extent possible, actual planned projects were identified. Where planned projects were not sufficient to exploit an identified resource potential, hypothetical, but realistic projects were modeled using generic information.

- **Resource Valuation:** Cost and performance assumptions were used to estimate levelized cost ranges for the various renewable technologies. To fairly judge the relative merit of different resources in different resource zones, other factors were also included in the resource valuation process, including estimated transmission costs, energy value under different temporal production patterns, and capacity value based on the ability of resources to deliver during peak electric load. This methodology is more detailed than most renewable studies as it includes more than simply the levelized "busbar" cost of energy.

- **Renewable Energy Zones Identification and Characterization:** Renewable energy projects that share a common area and are likely to be connected at a common interconnection point to the transmission system were organized into renewable energy zones (REZs). REZs are to be ranked by their cost-effectiveness based on developable potential, taking into account environmental concerns, the quality of the resources, the cost to develop those resources, and the cost of transmission needed to deliver those resources to load centers.

- **Environmental Assessment and Ranking:** The Environmental Working Group (EWG) developed a set of exclusion criteria for lands that were considered off-limits or restricted to renewable development due to environmental or other land use concerns. The EWG then constructed a criterion for ranking REZs based on remaining environmental factors, such as land use, habitat impact, and visual impact. This criterion was used to score each REZ on environmental impact, which was combined with each REZs economic score to provide a final REZ ranking.

- **Conceptual Transmission Development:** Black & Veatch developed conceptual transmission plans, including a rough cost estimate, for each REZ. Existing transmission rights of way were used as much as possible. Conceptual transmission plans developed by other agencies, such as CAISO, were also used, if available.

Black & Veatch made extensive use of Geographic Information Systems (GIS) tools throughout the process. GIS layers for wind and solar resources were used, GIS exclusions were applied based on environmental factors developed by the Environmental Working Group, and GIS was the primary database for all project and REZ identification.

Figure 2 shows an example GIS snapshot of three REZs – Tehachapi, Kramer, and Inyokern. The purple areas represent potential wind projects, the yellow squares potential solar projects, the green dot a potential biomass plant, and the red dot a potential geothermal plant. The black squares are substations, and the tie lines from each project are shown. The grey shading depicts the boundary of the REZ.

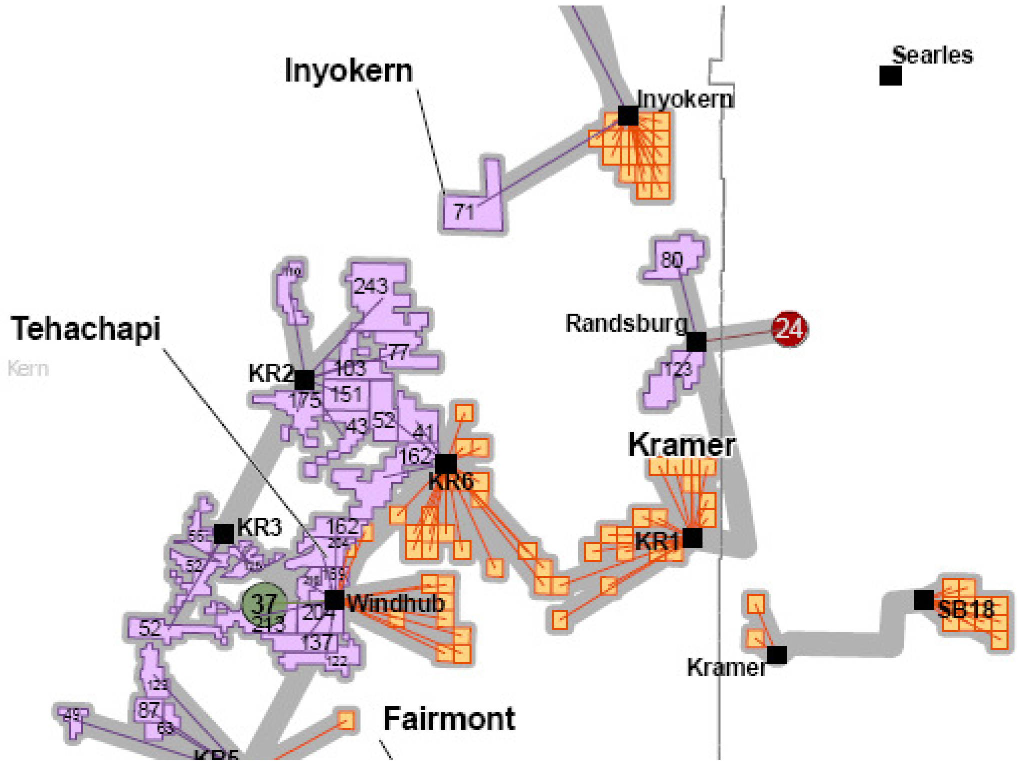

Figure 2. Example REZ GIS Output

Results and Policy Implications

The RETI process is an ongoing one and has not released final reports. Phase 1 identified over 500 GW of potential renewable projects in the study area, which is an order of magnitude greater than the total generating capacity in California.

The RETI process is not comprehensive in a number of ways. For example, it does not model the potential impacts of non-renewable power, such as a large increase in nuclear generation or extremely effective energy efficiency measures. The process also does not model significant changes in electricity demand brought about by new technology, such a large increase in electric vehicle use and their possible impacts on the transmission system. The process is instead specifically targeted to assist in the transmission planning process for renewable energy.

The large number of stakeholders involved in RETI does create a situation in which conflicting opinions are prevalent. The RETI process is designed to take into account as many opinions as possible so that differences can be addressed early in the process while there is still some flexibility on the part of many participants as to the location, size, and design of projects and transmission. Stakeholders have been active participants in the process, and this type of public planning effort requires consultants who have the ability to work in a public setting with opinionated advocacy groups.

Advantages and Disadvantages

RETI's relevance to China stems from the fact that its focus is on a barrier to renewable energy development that already exists and will continue to grow in China: transmission investment to remote renewable resource areas. Though it is not a comprehensive planning process per se, there are some general elements of RETI that may be relevant to the renewable energy planning process in China, including:

- Assessment of the cost and potential for various renewable energy sources, based in large part on available, pre-existing studies, using sophisticated GIS analysis to assess the location-specific nature of various renewable resource options.

- In identifying possible renewable project potential, by location, accommodating alternative land uses and environmental concerns to both restrict expected development in some areas, and to assess the relative merits of development in others.

- Evaluating the relative cost and value of renewable resource options and locations based not just on generator costs, but also transmission expenditure, as well as energy and capacity valuation.

- Consideration of both in-state and out-of-state generation options, rather than simply restricting renewable energy planning to in-state resources.

- Applying GIS tools, detailed analysis, and extensive stakeholder involvement to plan for the transmission investments needed to cost-effectively meet aggressive renewable energy targets.

References

The Phase 1 reports and other related documents can be found at: http://www.energy.ca.gov/reti/

4. Case Studies: European Union

4.1 United Kingdom Renewable Energy Strategy

Introduction: Context and Purpose

The UK has not historically been among the world's leading countries in terms of renewable energy development. To meet the EU's renewable energy target of 20% by 2020, the EU and UK climate goals, and to ensure a secure energy supply, it is clear that renewable energy deployment will need to increase at a rapid pace. The proposed UK renewable energy share is 15% by 2020 (including 10% in transport), an almost 10-fold increase from current levels. This is an aggressive target, given historical rates of growth. As such, the UK's Department of Business Enterprise & Regulatory Reform (BERR) released its consultation report in June 2008, responses to which will help shape the UK Renewable Energy Strategy.

The UK's Renewable Energy Strategy consultation report focuses almost entirely on renewable energy applications, covering the electricity, heating, and transportation sectors. Some emphasis is also placed on energy efficiency, because reduced energy demands will lower the demands of meeting a 15% target. Though it is a national (not local) plan and uses sophisticated analysis techniques that may not all be appropriate for provincial application in China, this case study nonetheless demonstrates what is possible in terms of comprehensive treatment and analysis if funding and capabilities are not limiting factors. Some of the analysis is complex, sectoral coverage is broad, and the report addresses a broad array of policy and institutional needs, including financial needs, planning requirements, grid infrastructure, and more.

Stakeholders have been involved in informing the UK's Renewable Energy Strategy. The consultation document, discussed here, contains very specific questions for consideration and comments on that report were due in September 2008. The report also contains a "code of practice for consultation" that lays out several key principles and practices that are to be followed during the consultation process. Based on comments received, the final Renewable Energy Strategy is to set a clear framework to provide policy certainty and is to detail the specific policies that will be used to reach the 2020 renewable energy target. Legislation is then to be introduced accordingly.

Methods and Data

Detailed analysis was conducted for the BERR consultation report, much of it embedded in a large number of background documents that have been made available as part of the consultation process. That analysis included the following elements:

- Estimating the relative shares of renewable energy in electricity, heating, and transport in order to meet the overall 15% renewable energy target.
- Estimating the relative shares of specific renewable energy technologies that may be developed to meet the 15% renewable energy target.

- Evaluating the impact of achieving the 15% renewable energy target on energy costs and bills, including the development of supply curves for different technology options.
- Quantitatively and qualitatively analyzing the merits of feed-in tariffs relative to a continuation and expansion of the Renewables Obligation quota system.
- Quantifying the constraints to growth of the various renewable energy sources, and plausible growth rates over time.
- Analyzing the potential impact of renewable electricity supply on reliability and grid operations, estimating the investments needed in new grid infrastructure, and conducting a dedicated review of transmission policy as it relates to renewable energy.
- Evaluating the possible influence of supply constraints on achieving the 15% renewable energy target, and needed supply-chain investments and employee skill sets, including a discussion of policy options to build the supply chain.
- Assessing the UK's competitive advantage in the green energy sectors.
- Assessing the opportunities, constraints, and costs of the use of renewable energy in the heating market, as well as possible policy measures to support this market segment.
- Evaluating the constraints and opportunities for distributed energy including research into consumer behavior.
- Evaluating the sustainability issues associated with different biofuels.
- Assessing the impact of achieving the 15% on employment, GDP, carbon emissions, and carbon emission prices.

It is important to note that no single analysis covered this diversity of topics. Instead, BERR contracted and collaborated with a large number of analysts to produce the necessary background assessments, each of which used its own analysis techniques. As with the other plans in our sample, the modeling informed but did not determine the nature of the consultation document.

Because of the number of documents in question, and diversity of analytic techniques, we do not summarize all of those details here. It should be noted, however, that some of the modeling techniques that were used are sophisticated, including the methods used to assess the potential implications of achieving high levels of renewable penetration in the electricity sector, and how those change when different policy measures are used. That analysis explored three different renewable energy targets under several different policy tools, conducted a large number of sensitivity analyses, and did so with a detailed electricity-sector capacity expansion and operations model. Data input for each technology option on renewable resource and capital costs, maximum build limits, and other variables came from a variety of sources; details are provided in the linked report at the end of this case study.

Tools used in some of the other background reports are somewhat less sophisticated. One report, for example, estimates overall compliance costs for meeting the 20% EU renewable energy target, including those costs that may fall on the UK. That analysis relied heavily on existing renewable resource data compiled for the EU-wide Green-X project, used a different and relatively simple learning curve model to estimate future renewable energy costs, and compared renewables costs with those of conventional fossil generation, ultimately creating a renewable energy "supply curve." A variety of sensitivity analyses were performed to assess the robustness of the results, including an assessment of the benefits on inter-regional trading in renewable energy relative to a scenario in which countries must meet their targets only with domestic resources. A separate background report estimates the employment implications of achieving the UK's renewable energy targets, using simple technology-specific jobs estimates, and ignoring the negative employment implications for the nation's fossil generation sector.

Results and Policy Implications

The UK Renewable Energy Strategy consultation report contains information on: the status of renewable energy in the UK and the climate challenge; the impacts, costs, and benefits associated with achieving the 15% target; the importance of energy savings; renewable energy resource potential; sectoral chapters on centralized electricity, heating, distributed energy, transport, and bioenergy; and policy measures needed to help achieve specified targets and goals, in each sector; innovation policy; and wider impacts and benefits. The report is backed-up by a large number of supporting analyses and documents, as highlighted previously.

The reports note that the UK already has a large number of renewable energy support mechanisms, including the Renewables Obligation (RO); the Renewable Transport Fuel Obligation (RTO); aggressive support for offshore wind energy; and R&D funding. The report calls for further revisions to these policies to strengthen their effect. Importantly, because existing policies will not be sufficient to reach the 15% renewable energy target, a bold set of new measures is proposed for consideration. These include:

- Extending and raising the level of the Renewables Obligation to encourage up to 30-35% of electricity to come from renewable sources by 2020;
- Introducing a new financial incentive mechanism to encourage a very large increase in renewable heat;
- Delivering more effective financial support for small-scale heat and electricity technologies in homes and buildings;
- Helping the planning system to deliver, by agreeing to a clear deployment strategy at the regional level that is similar to the approach established for housing;
- Ensuring appropriate incentives for new electricity grid infrastructure and removing grid access as a barrier to renewable deployment;
- Exploiting the full potential of energy from waste, by discouraging the landfilling of biomass as far as is practical;
- Requiring all biofuels to meet strict sustainability criteria, to limit adverse impacts on food prices, or other social and environmental concerns;
- Promoting the development of new renewable technologies, through effective support particularly where the UK has the potential to be a market leader;
- Maximizing the benefits for UK business and jobs, by providing a clear long-term policy framework, working with Regional Development Agencies to tackle key blockages, considering support for specific technologies and addressing skills shortages.

As noted in this list, the consultation document places great emphasis on the need for supporting programs and policies to reduce the institutional barriers to renewable energy development. Particular emphasis is placed on reforms to transmission grid planning and siting and permitting procedures, with a number of specific possible measures identified in the report on these issues.

The report also addresses all level of government, and covers not just electricity but targets and policy needs in the heating and transportation sectors.

Based on analysis performed for the consultation report, BERR concludes that if all of the policy options and strategies described in the report were successfully implemented and if no cost constraints existed, then 15% by 2020 would be possible. Based on the BERR analysis, the 15% target will clearly be very challenging to achieve. The modeling conducted for the report shows that the electricity sector is likely to require the greatest level of renewable energy penetration (30-35%, up from 5% today); the report expresses some concern about the ability of the UK to meet its target of 10% renewable energy in transport in a sustainable manner. Further analysis based on the cost and constraints of different renewable technologies suggests that key growth areas will be on- and off-shore wind in the electricity sector and biomass for heating and transport. The cost of achieving the target is estimated, both as a central estimate, and with several sensitivity scenarios.

The strategy document further estimates many of the benefits of achieving the 15% target. Specifically, the analysis finds that achieving 15% renewable energy 2020 will reduce gas imports by 12-16%, increasing energy security and decreasing dependence on foreign energy sources. Analysis further estimates the impacts of the strategy on carbon emissions and prices, and employment opportunities (160,000 new jobs in the "green" sector are estimated by 2020).

Advantages and Disadvantages

Though it is a national plan and uses analysis techniques that may not all be appropriate for provincial application in China, this case study nonetheless demonstrates what is possible in terms of comprehensive treatment and analysis if funding and capabilities are not limiting factors. The modeling used for the UK Renewable Energy Strategy consultation paper is diverse, and is contained in a large number of background documents prepared for the main strategy report. A number of the tools used in this process are quite complicated and require a considerable amount of data, making them unsuitable for provincial government implementation in the Chinese situation. Other tools used in the UK analysis may be suitable for application in China. Even these tools, however, often rely on the availability of solid, existing datasets on renewable energy resource availability and costs. Though the UK Renewable Energy Strategy consultation paper, and its development, provides a good example of a comprehensive national plan, it would be difficult to replicate on a regional basis.

Key aspects of this case study that may still be relevant to China include the following:

- <u>Comprehensive treatment of renewable energy in electricity, heating, and transportation</u>.

- <u>Detailed analysis that considers resource availability, deployment constraints, cost implications, impacts and benefits, and policy needs</u>, including targeted analysis to address specific areas of great concern.

- <u>Policy options and recommendations that address a broad array of policy and institutional needs</u>, covering financial needs, planning requirements, grid infrastructure, and more.

- Outsourcing of much of the analysis, with independent consultants tasked with much of the analysis that ultimately was used by BERR to produce the consultation report.

- Specific "supply curve" analysis techniques and jobs impact analyses methods that may be suitable for application in China, presuming that data are available to support them.

References

The UK Renewable Energy Strategy consultation paper can be found at:
http://renewableconsultation.berr.gov.uk/

The many background documents supporting the consultation paper can be found at:
http://renewableconsultation.berr.gov.uk/related_documents

Of particular interest may be:

- Simple estimates of EU-wide compliance costs: http://renewableconsultation.berr.gov.uk/download?filename=compliance-costs-for-meeting-the-20-renewable
- Supply chain constraints and possible impacts on jobs: http://renewableconsultation.berr.gov.uk/download?filename=supply-chain-constraints-on-the-deployment-of
- Possible impacts of transmission and grid operations: http://renewableconsultation.berr.gov.uk/download?filename=growth-scenarios-for-uk-renewables-generation-and
- Detailed analysis of impacts of renewable energy in the electricity sector: http://renewableconsultation.berr.gov.uk/download?filename=implementation-of-the-eu-2020-renewable-target-in
- Assessment of growth constraints, and maximum build limits: http://renewableconsultation.berr.gov.uk/download?filename=quantification-of-constraints-on-the-growth-of-uk

4.2 EU Proposed Directive on the Promotion of Use of Energy from Renewable Sources: Member State Target Allocation

Introduction: Context and Purpose

In March 2007, the 27 European Union (EU) Member Countries agreed to adopt a 20% binding target for renewable energy. The proposed EU Renewable Energy Directive ("RE Directive") was released in January 2008, and includes mandatory targets for the Member States. The RE Directive would cover electricity, heat, and transport, and would replace two current Directives, one for electricity and one for biofuels, addressing renewable energy; those earlier targets for renewable energy were voluntary in nature. The RE Directive is part of a legislative package to cut greenhouse gasses across Europe by 20%. In addition to the mandatory overall target of 20% renewable energy by 2020, the proposed Directive also includes a 10% binding minimum target to be achieved by all Member States for the share of biofuels in transport consumption by 2020.[3] Additionally, the RE Directive addresses institutional barriers to renewable energy.

The ongoing engagement of stakeholders has critically shaped EU renewables policy. The planning leading up to the RE Directive proposal included an impact assessment process with numerous consultations with stakeholders. Four public consultations, via the Internet, were held between 2006 and 2007 on a variety of specific topics. The impact assessment and other supporting documents were important milestones in the planning process, providing estimates of costs and benefits and outlining approaches to target allocation. The impact assessment was based on a number of key principles: cost-effectiveness, flexibility, internal market and fair competition, subsidiarity, fairness, competitiveness, and innovation.

The European Union cites the need for strengthening and expanding the current EU regulatory framework in order to provide the business community with the long term stability it needs to make rational investment decisions in the renewable energy sector. This need is highlighted by the fact that, despite the gains made, the EU is not on-schedule to meet previously set, voluntary targets laid out in the current Directives—specifically, a 21% share of electricity produced from renewable energy sources in total Community electricity consumption by 2010 (the Community will fall short, at around 19%) and a target of 5.75% of biofuels of all transport fuels placed on the market by 31 December 2010 (the share is expected to reach only 4.2%).

The Renewable Energy Directive is expected to be approved by national governments and by the European Parliament in early 2009. Under the proposed Directive, Member States would be required to submit National Allocation Plans outlining policies and measures to meet their individual targets. These National Allocation Plans would have to be submitted by each Member State in March 2010. Member States that do not meet their final targets will be penalized, though the details of these penalties are not included in the current draft of the RE Directive.

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[3] The binding character of this target is subject to production being sustainable, second-generation biofuels becoming commercially available, and the Fuel Quality Directive being amended to allow for adequate levels of blending.

The Renewable Energy Directive is included as a case study because it represents an attempt equitably allocate top-down mandatory renewable energy targets to subsidiary governmental bodies, and may therefore be useful in the context of China's national and provincial renewable energy plans. Also of possible interest are that all three sectors, electricity, heating, and transport, are included; the modeling tools used in the impact assessment; and the process by which Member State progress towards their targets might be tracked.

As context, the European Union is comprised of 27 Member States that vary widely in size, population, and level of development. The EU-25 had a total electric generating capacity of 720 GW in 2006. Renewable electricity, excluding large hydropower, contributed 75 GW in 2006. Renewable energy development varies among the Member States, however, as does available resource potential. The EU attempted to address this unequal distribution of population, resources, and development in the allocation of Member State targets.

Methods and Data

The planning process that resulted in the proposed RE Directive included a number of steps: country reporting under the current voluntary EU Directives; assessment of voluntary targets and progress in EU Member States; strategies and proposals for a comprehensive climate change and renewables package; impact assessment of mandatory targets; and stakeholder processes. This case study cannot hope to cover all of these developments. Instead, it focuses on the modeling tools used in the impact assessment, the methodologies evaluated for Member State target allocation, and the data available for checking Member State progress towards their targets.

Modeling Tools

The impact assessment used a number of sophisticated modeling tools to analyze the climate and renewables package in the proposed Directive:

- PRIMES: This is a detailed partial equilibrium energy model dealing with all sectors and fuel types including their transformation in a technology rich way. It is detailed at the Member State level, which allows for meaningful comparisons of impacts across Member States. It was used to assess changes in the energy system in detail, e.g. investment costs, changes in fuel mix and consumption.
- GAINS: This is a model that allows an assessment of the impact of reducing non-CO2 greenhouse gases (GHGs) taking into account developments in the energy system. It was also used to assess the resulting impact on air pollution emissions other than GHGs.
- GEM-E3: This is a general equilibrium model that represents all economic sectors and their interactions, but has less detail on different mitigation technologies. It was used to assess the macroeconomic impacts at the Member State level of reducing GHG emissions in the energy sector (e.g. GDP effects, effects on private consumption, and employment).
- PACE: This is a global general equilibrium model similar to GEM-E3 but with more detail on electricity generation technologies. It was used to examine the sector-specific impacts on energy-intensive industries.
- POLES: This is a global partial equilibrium energy model that was used to assess the impacts of a future international climate agreement on the EU energy system. It does not include macroeconomic impacts.

Member State Target Allocation

Two primary methods were assessed to allocate the 20% target among the Member States: (1) targets that are related to the renewable resource potential in each Member State, and (2) a flat-rate increase in renewable energy for all Member States. In the latter case, however, several adjustments were made to a simple flat-rate increase. First, it was concluded that a flat-rate approach modulated by GDP would be most appropriate; when weighted by GDP, the result reflects the wealth of the different Member States. Second, the targets should take account of early progress in renewables development to recognize the role that "early starters" have played in leading Europe in the development of renewable energy. Finally, an overall cap on the targeted share of renewable energy in 2020 in individual Member States was also included. The resulting proposed targets are relatively complicated, and seek to address a variety of factors.

In the first method, a team led by the Fraunhofer Institute for Solar Energy Systems used the PRIMES model to develop the potential-based scenario based on least-cost implementation of both the greenhouse gas and renewables targets. The model simulates the European energy system and markets on a country-by-country basis, and provides detailed results about energy balances, CO_2 emissions, investment, energy technology penetration, prices, and costs at 5-year intervals from 2000 to 2030. The PRIMES energy baseline, developed with Member States, reflects current trends and policies and their impacts. Scenarios to achieve greenhouse gas and renewable energy targets were applied on the basis of this baseline. The results of the modeling runs on the least-cost achievement of the EU-wide targets and can then be used to judge the potential-based target allocation approach, under which targets are allocated to countries in such a way as to minimize EU-wide costs (and therefore, countries with more low-cost renewable resource potential are also subject to higher targets).

The second method, the flat-rate increase plus GDP, is a formula developed by the European Commission itself and consists of several steps.

<u>First, EU Wide Calculation:</u>

[20% * (EU gross final energy consumption in 2020)] - (2005 base year share$_{\text{adjusted}}$)= additional effort.

<u>Then, the Member State Calculation:</u>

2005 base year (adjusted for early action) + additional effort/2 + (0.16 toe/person$_{\text{weighted by GDP/capita index}}$ x population) = full renewable energy share of total final energy consumption in 2020$_{\text{cap applied}}$

Table 2 illustrates each of the steps. In the first step, a forecast of EU gross final energy consumption in 2020 is established, at 1270.6 Mtoe. The renewable energy target for the EU as a whole is 20% of this figure, or 254.1 Mtoe.

The second step is taken to reflect different national starting points for renewable energy development. In principle, it is likely that the renewable energy opportunities exploited by "early starters" are the cheapest. Thus, remaining potential will tend to have higher unit costs for the early starter than for those countries that have not yet begun to exploit these less expensive opportunities. The "potential" approach takes this factor into account implicitly; the flat rate/GDP option (taking 2005 as the starting point for the calculation of flat-rate increases) is explicitly adjusted to take it into account. This is done by examining the growth in renewable energy shares between 2001 (when the first European renewable energy legislation was adopted) and 2005 and, for those Member States with growth of more than 2%, a deduction of one third of the difference is granted (of the countries listed in Table 2, those marked with an asterisk were adjusted to reflect their early actions).

By subtracting from the overall target of 254.1 Mtoe the renewable energy produced in 2005, adjusted as described above for one third of the early action in those Member States that have increased their renewables share by at least 2% between 2001 and 2005 (101.9 Mtoe), the required additional effort is determined: 254.1 – 101.9 = 152.2 Mtoe.

Target Allocation Formula Based on Modulated Flat-Rate Increase of GDP

	Column 1 2005 RES share (*adjusted for early action)	Column 2 Forecast 2020 gross final energy consumption (Reference Case)	Column 3 RES share after flat-rate increase of %5.5	Column 4 Residual effort per citizen adjusted by GDP/ Head Index	Column 5 Residual effort per Member State	Column 6 Total RES needed in 2020	Column 7 Targets: Total RES
Member State	%	MTOE	%	TOE	MTOE	MTOE	%
Austria	23.3	29.5	28.8	0.21	1.69	10.18	34.5
Belgium	2.2	37.4	7.7	0.20	2.08	4.95	13.2
Bulgaria	9.4	12.3	14.9	0.02	0.15	1.98	16.1
Cyprus	2.9	1.9	8.4	0.12	0.09	0.26	13.2
Czech Republic*	5.0	30.2	10.4	0.07	0.69	3.84	12.7
Denmark*	15.4	15.6	20.9	0.27	1.44	4.70	30.1
Estonia*	17.1	3.7	22.6	0.06	0.08	0.91	24.7
Finland	28.5	25.7	34.0	0.21	1.09	9.82	38.2
France	10.3	164.6	15.8	0.19	11.84	37.79	23.0
Germany	5.8	220	11.3	0.19	15.53	40.33	18.3
EU 27	8.4	1270.6	13.9	.16	76.1	254.1	20.0

Table 2: Target Allocation Table Featuring 10 EU Countries and Totals for EU 27

This additional effort is then shared as follows.

Half of this effort is apportioned to Member States so that a fixed percentage (5.5%) – common to all – is added to their (adjusted) renewable energy share in 2005.

The remaining half of the effort is divided by the EU population to determine an 'effort per citizen.' This 'effort per citizen' is then multiplied by a GDP-per-person index. As a result, a citizen of the richest country in terms of GDP-per-person (Luxembourg) has to contribute a larger amount towards the renewable energy target than that of a citizen of the poorest Member

State (Bulgaria). The effort per citizen, adjusted by the GDP-per-person index, is then multiplied by the population of the country to determine the aggregate residual effort per Member State.

The per-country residual effort is then added to the amount of production already established for the Member States to determine the final required amount of renewable energy production and as a percentage of final energy consumption in 2020.

Finally, the targets were capped to ensure that no Member State has a renewable energy share of 50% or more, and rounded down from half a percentage point.

Checking Member State Progress

The EU has a dedicated project to collect official, consolidated statistics—Eurostat. As part of its mandate, Eurostat collects yearly renewable energy statistics that are then freely available. These statistics are published nearly two years after being received. To provide more up-to-date data, the EU has also mandated that the EurObserv'ER project provide quicker "barometers" of renewable energy and Member State progress in meeting the EU goals. The renewable energy production statistics, as well as information on renewable energy policies, are collected from a number of sources. In some countries, renewable energy statistics come from a specific government-designated body that has devoted resources to maintaining reliable data. In other countries, where renewables are less developed and/or the government has fewer resources to devote, the data are pieced together from personal contacts, industry sources, and popular journals. The result is a best estimate that shows the latest trends in the sector. These data sets are published and made available online and, in combination with country reporting, the data sets are critical tools to evaluate Member State progress in meeting EU goals.

Member States are to work towards an "indicative trajectory" tracing a path towards the achievement of their 2020 targets, and to this end are responsible for national allocation plans including sectoral targets in transportation, heating and cooling, and power generation. The indicative trajectory starts with the renewable energy share for each Member State in 2005 (S_{2005}) and steadily increases as a percentage of each Member State's target in 2020 (S_{2020}):

$S_{2005} + 0.25 (S_{2020} - S_{2005})$, as an average of the two-year period 2011 to 2012;
$S_{2005} + 0.35 (S_{2020} - S_{2005})$, as an average of the two-year period 2013 to 2014;
$S_{2005} + 0.45 (S_{2020} - S_{2005})$, as an average of the two-year period 2015 to 2016; and
$S_{2005} + 0.65 (S_{2020} - S_{2005})$, as an average of the two-year period 2017 to 2018.

where S_{2005} = the share for that Member State in 2005 as indicated in Table 2 above,
and, S_{2020} = the share for that Member State in 2020 as indicated in Table 2 above.

Member States are to report on their progress every two years, starting in 2011. The reports are to include overall and sectoral shares of renewables as well as the measures implemented on the national level to promote growth (taking into account the indicative trajectory as calculated above). The reports are to detail the introduction and function of renewables support schemes, and a number of other details, including progress made in improving administrative procedures, frameworks aimed at improving cost-sharing for transmission and distribution, and the estimated net greenhouse gas savings achieved due to the use of renewable energy. It is important to note that while an indicative trajectory was provided to measure Member States' interim progress, penalties have yet to be included for States that are not on track to meet their targets.

Results and Policy Implications

The EU's 20% renewable energy commitment was proposed by the Commission in the Renewable Energy Roadmap and endorsed by the Spring 2007 European Council. The impact assessment of the renewable energy roadmap analyzed the 20% target for renewable energy. It found that annual CO_2 emissions would fall, that annual fossil fuel demand would fall, and that there would be a slightly positive effect on GDP growth resulting from employment and technological/industrial development. Analysis by the Institute for Prospective Technology Studies for the biofuels target suggested that GDP would be 0.23% higher and 144,000 jobs would be generated (these results depend on oil price and import assumptions).

Member State Target Allocation
The resource potential method to assigning renewable energy targets came up with national targets that differ substantially between Member States, as do the percentage point renewable production increases required (between 6 and 17%). This is because resource potential differs among Member States. The differences between the additional efforts required from Member States (the percentage point increases) are not as large as might be expected, however, because weaker potential in one technology is often compensated by stronger potential in another. The second, flat-rate method modulated by GDP, was included in the proposed Directive. The individual country targets are yet to be finalized, but despite heated debate and political negotiations, few are likely to change significantly from the proposed flat-rate method.

Checking Member State Progress
It was on the basis of country reports mandated under the current electricity and biofuels Directives that it became clear that Member States would fail to meet the current voluntary targets. The European Commission also relied on data collected from ongoing projects such as Eurostat and EurObserv'ER in their assessment of Member State progress. The up-to-date trend data provided by EurObserv'ER, rather than the official consolidated data provided by Eurostat, allows Member States to evaluate their relative position and progress in reaching the EU renewables targets. The trend data has proved itself reliable enough for the task it is given.

Advantages and Disadvantages

Many of the models used to conduct the impact assessment under the proposed EU Directive are not appropriate for provincial application in China. Nonetheless, this case does offer several implications for China on target allocation and on progress reporting.

With respect to target allocation to Member States, the EU considered a number of factors: renewable resource potential, equal additions, GDP variations, and early actions. Resource potential alone was considered insufficient, as it does not take into consideration other important factors, especially differences in relative GDP. Ultimately, the targets that have been proposed take all of these factors into consideration. In allocating targets to provinces in China, whether this is accomplished at the provincial or central level, similar factors might be considered, and the central government may wish to compile relevant datasets to allow stakeholders to consider different target allocation approaches.

The EU and China also face similar challenges in collecting reliable data on renewable energy resources and technologies across their territories. The EurObserv'ER project provides reactive, trend data and is evolving to include more countries and more technologies. EurObserv'ER has developed data collection networks and methods that are responsive to the changing realities of the various Member States. This kind of project—relying on a small, dedicated group of people rather than sophisticated collection tools—could benefit China as the Provinces begin to implement the National Renewable Energy Law.

Finally, renewable energy policies require a clear process of reporting and review—Member State reporting on the current Directive clearly showed that voluntary targets were not enough to meet EU goals and the European Parliament and Commission reviewed the country reports and reacted with a package of proposals including mandatory targets. This process of reporting and review, followed by appropriate policy reactions, is critical to successful market development.

References

The "Proposal for a Directive of the European Parliament and of the Council on the Promotion of the Use of Energy from Renewable Sources," as well as other background and related documents can be found at http://ec.europa.eu/energy/climate_actions/

4.3 Baden-Wuerttemberg, Germany, Energy Concept 2020

Introduction: Context and Purpose

As previously introduced, the EU is in the process of establishing a number of Directives aimed at ensuring a sustainable energy future for the 27 Member States. Among these are mandatory targets for 2020, including: 20% reduction in greenhouse gas emissions levels, 20% energy efficiency savings, and 20% renewable energy. EU Member States must submit plans explaining how they are to meet these targets. Germany, one of the largest economies in the EU, has developed an energy strategy to meet its own national targets as well as those at the EU-level. Accordingly, German provinces must contribute to the national, and thereby, international aims. The German government has not mandated how the provinces must contribute; it is therefore up to each province to come up with its own strategy.

In 2007, the Economics Ministry of Baden-Wuerttemberg contracted with the Centre for Solar Energy and Hydrogen Research to develop an energy plan through 2020 for the German province. The intent was to explicitly examine German and EU targets to see if they could be adopted one-to-one for the province. The researchers developing the plan built on previous work, including previous analysis of provincial-level resource potential, energy sector modeling, and policy scenario building. Specifically, the researchers relied heavily on a study completed in 2002 "Structure and Development of the Future Energy Supply of Baden-Wuerttemberg."

The Energy Concept for Baden-Wuerttemberg 2020 is an integrated approach to energy planning and includes supply-side renewable options and demand-side energy efficiency. It is included here because it represents a provincial response to demands placed at the national and international level. It is also an example of the realities of planning—though the necessary resource potential, scenario, and modeling work for renewables had already been thoroughly analyzed in 2002, they were not followed by a comprehensive plan of action. Instead, several years later, top-down targets were applied and the province needed a response. The 2002 study, rather than providing the basis for the creation of targets, became the proof that the province could fulfill its commitments to Germany and the European Union.

As context, Baden-Wuerttemberg is the third largest province—in terms of both area and population—of 16 provinces in Germany. Renewable energy accounted for 6.5% of primary energy and 11.8% of total electricity supply in 2006 in Baden-Wuerttemberg. In the heating sector, renewables contributed 7% in 2006. This can be compared to the national numbers where renewables contributed 5.8% to primary energy, 12% to electricity generation and 6% to heat. Total electricity demand in Germany increases, on average, by roughly 1% per year. Primary energy, at both the national and provincial levels, has remained about the same in recent years.

Methods and Data

Here, after briefly introducing critical methods and data used at the national level to develop sustainable energy targets and policies in Germany as a whole, the methods and data that went into the development of the "Energy Concept for Baden-Wuerttemberg" are discussed. In this case, similar tools were used at the provincial, national, and international levels—resource potential information was compiled and analyzed and scenarios were developed, incorporating supply and demand-side modeling to create reference and alternative cases for energy system development pathways and policy options.

National Level

The Lead Scenario 2006 is a targeted scenario outlining how Germany's target of cutting greenhouse gas emissions to 20% of 1990 levels by 2050 can be achieved. The target is to be met without the use of nuclear power, and includes: increased efficiency in all sectors, increased cogeneration, and widespread use of renewable energy. The Lead Study 2007, "Update and Reassessment of the Strategy to Increase the Use of Renewable Energies up until the Years 2020 and 2030, plus an Outlook to 2050," was the summation of the background documentation, including the Lead Scenario 2006, for the German government's Integrated Energy and Climate Program. The Lead Scenario from 2006 and the Lead Study from 2007 do not present new resource potential data sets or create new models. Instead, these works synthesize a number of studies, building on previously developed models and updating values and assumptions. Importantly, the structure of an energy system that meets the climate goals is considered—including the necessary requirements for renewables- and fossil fuel-sourced facilities. Electricity costs and differential costs of increasing the use of renewables are estimated.

Provincial Level

The "Energy Concept for Baden-Wuerttemberg" also relied heavily on previous work, in this case the study from 2002. Though some assumptions, oil and carbon prices for example, had changed between 2002 and 2007/2008, many other factors had not. The researchers could, for the most part, rely on simple spreadsheet analyses to determine whether or not the province was in line to reach a given target. The main work of the 2002 study was to develop scenarios and model different development pathways for the province. On the basis of a reference scenario, two alternative scenarios were developed for the 2002 Baden-Wuerttemberg study. The TREND reference scenario is the "business-as-usual" scenario. EFFICIENCY is the second scenario and includes targets aimed at increasing efficiency and utilizing combined-heat-and-power, all of which can be characterized as relatively small, little-or-no-cost measures. SUSTAINABILITY is the final scenario and includes measures that lead to the development of a more sustainable energy system; in this scenario, greenhouse gas reductions are the lead indicator. These scenarios were presented with all their background information and inputs in a 300+ page document.

Results and Policy Implications

National Level

The Lead Study 2007 concluded that the conversion of the German energy supply will happen in several stages. The period between now and 2010 is the first stage and is a window of opportunity in the transition to a sustainable energy system. The second phase, from 2010 to around 2020, involves the build-up of renewables through energy and environmental policy, and after 2020, the expansion and development of the system. Under the scenario, by 2020 renewables will contribute 27.3% to gross electricity generation, and 15.7% to total primary energy consumption. By 2030, renewables will contribute 25% of primary energy consumption, and by 2050 this share will rise to 50%. The scenario outlines the minimum expansion of renewables needed in the medium term in order to sustain the current expansion momentum. Energy productivity will increase by an average of 2.9% per year between 2005 and 2020, and equal weight is given to energy efficiency and renewable energy. 2020 is estimated to be the date around which additional public support of renewable energy will no longer be necessary.

Based on this and other studies, the German government began implementing its Integrated Energy and Climate Program. The triple objective of supply security, economic efficiency, and environmental acceptability is to be met through targets, acts, and ordinances. Reports to Cabinet, starting in 2010 and every two years thereafter, will determine if progress is being made and if the program needs to be supplemented. Over 20 key elements of the program, including legislative action, were identified, some of which include the following actions:

- Doubling of combined heat and power—this required an amendment to the Combined Heat and Power Act and is complemented by voluntary commitments with industry;
- Amending the Renewable Energy Sources Act, the German feed-in tariff, to increase the level of renewables from the current 13% to 25-30% in 2020; and
- Creating the Renewable Energies Heat Act to mandate renewable heat shares in all new buildings to help achieve a 14% share of renewable heat by 2020.

Provincial Level
The "Energy Concept Baden-Wuerttemberg 2020" is divided into several sections that correspond with its goals: Energy Efficiency and Energy Savings; Build-up of Renewable Energies; Securing Energy Supply, Economic Aspects, Structure and Competition; and Research, Development and Demonstration. In each section, a target is given along with information pertaining to the sectors in which policy implementation will help to achieve the target.

The 2020 targets are summarized below:

- A 2% increase in energy productivity and a 10% decrease in primary energy demand—and, more specifically, combined heat and power should be at least doubled, contributing 20% to the power supply; and
- A minimum of 20% of the electricity supply, 16% of heat, and 12% of primary energy will come from renewable energy sources.

The overall goal is to achieve a secure, economic, and environmentally acceptable energy system. The energy mix is to be balanced and the structure is to be as decentralized as possible and as centralized as necessary. Important emphasis is placed on the maintenance and build-up of transmission and distribution networks. The energy plan through 2020 includes a mix of fossil fuels, nuclear power, and renewables on the supply-side, and energy efficiency on the demand-side. The Energy Concept should result in a 27% reduction of CO_2 emissions.

Advantages and Disadvantages

The mirroring of energy planning methods at the provincial and national levels is not always an option. In the case of Baden-Wuerttemberg, they were not under a strict mandate to develop or submit an energy plan. Instead, encouragement came from the establishment of national and international targets and from within the Baden-Wuerttemberg government itself. In both the national and provincial planning exercises described here, little new modeling was conducted; instead, both studies drew and extrapolated from previous work.

Key aspects of this case study that may still be relevant to China include the following:

- Comprehensive scenario-based energy planning efforts that include both supply- and demand-side energy options and that cover the electricity, heating, and transport sectors.

- Reliance on synthesis of existing data and modeling studies, to the extent feasible, while minimizing the need for truly new analysis.

- Interactions between international, national, and provincial planning efforts in ways that can be mutually reinforcing.

References

The German Integrated Energy and Climate Program is summarized online at:
http://www.bmu.de/english/climate/downloads/doc/40589.php

The Lead Study 2007 is available through the German Ministry for Environment, Conservation and Nuclear Safety (BMU) at:
http://www.bmu.de/erneuerbare_energien/downloads/doc/38787.php
And a summary is available in English at:
http://www.bmu.de/english/renewable_energy/downloads/doc/39499.php

The Energy Concept Baden-Wuerttemberg 2020 is available in German at:
http://fraktion.cdu-bw.de/showMedia.php?ID=2265&rand=1217613171

5. Case Studies: Emerging Economies

5.1 Morocco Renewable Energy and Energy Efficiency Study

Introduction

Energy demand in Morocco, and in particular electricity demand, has increased significantly in recent years. On average, an increase in primary energy demand of 3.5%/year and an increase in electricity consumption of 6.9%/year can be observed. Domestic energy resources currently supply only 5% of energy demand. To achieve more independence from energy imports and the rising prices for fossil fuels, the country needs a comprehensive strategy for the use of its renewable energy sources. It is also recognized that renewable energy sources may be accompanied by a multitude of additional positive effects, including: reduced pollutants and greenhouse-gases; creation of new employment opportunities; and improvement of technological standards and thereby enhancement of the competitiveness of the Moroccan economy.

Given these circumstances, the Moroccan government aims at augmenting the contribution of renewable energy to 20% of the country's electricity demand and 10% of the country's total energy consumption by 2012. To attain this goal, it will be necessary to produce 5,880 – 6,270 GWh of electricity from renewable energy and to replace approximately 1470 - 1560 ktoe of primary energy demand with renewable energy. Moreover, it should be noted that concerns exist about the long-term production of existing hydroelectric power plants in the country, given changes wrought by global climate change; this concern further complicates the achievement of the government's renewable energy targets.

To better understand the potential and cost for renewable energy development in Morocco, the Moroccan Ministry for Energy and Mining and the Development Center for Renewable Energies (CDER) commissioned a study that was conducted between January and July, 2007. The study was supported by the German Society for Technical Co-Operation (GTZ) and by a team of international and local advisors (Expertise Environment Dévelopment in France; DIESE Consulting in Morocco; University of Bingen, Fraunhofer and TSB Energie in Germany).

The study evaluates the energy demand of Morocco and estimates the potential for renewable energy in the country and implied costs through 2020. The study further analyzes the incentives for and obstacles to the promotion and development of renewable energy in Morocco, and compares possible finance mechanisms. Finally, the study develops a specific possible plan for the promotion of renewable energy in Morocco. The study itself involved several workshops and bilateral interviews with the major stakeholders in Morocco, in particular with the national utility and grid operator, renewable investors, the scientific community, policy makers, and regulators.

The study was intended to serve as an input to the energy planning and policy processes of the Moroccan government. It is included as a case here because of its analytic techniques, which rely heavily on a compilation of existing data sources and an adaptation of existing analytic tools developed in Europe, and because it illustrates the possible use of consultants to conduct the analytic work that underpins regional planning and policy efforts. The case covers the electricity, heating, and transportation sectors, and includes quantitative analysis and qualitative policy and barriers assessments. Though the analysis is somewhat complicated, with the requisite data inputs, the modeling tools could potentially be adapted for China's circumstances.

Methods and Data

The study is subdivided into five parts:

1. Evaluation of energy demand in Morocco
   Energy demand estimates are based on figures from the Department of Statistics and the Ministry for Energy and Mining. Estimates assume that further electrification of the country, which has already reached 86%, will not strongly influence energy demand in the near future. The share of electricity in total energy consumption is projected to increase. The impact of energy efficiency in reducing energy and electricity demand is accounted for by a rough evaluation of the relationship between the development of the primary energy sector and gross domestic product (GDP), and the resulting demand estimates are contrasted with a "business as usual"-scenario (extrapolated from data from 2000-2005).

2. Estimation of the potential of renewable energy and associated costs
   A variety of studies on the potential of different renewable energy sources in Morocco have been published in recent years. The results of several of these publications are analyzed in this study to estimate Morocco's overall potential. Main data sources on the potential for wind and solar energy are CDER, the World Bank, the Institute for Solar Energy Technique (ISET) in Kassel/Germany, and the German Aerospace Center (DLR). To supplement these pre-existing assessments, the study team also conducted its own assessments of the cost and potential of renewable energy sources. To do so, GIS-data were combined with climatic data as well as agricultural production figures and technical information from wind energy producers to estimate potential annual renewable energy generation at different sites.

3. Analysis of incentives and obstacles for the promotion of renewable energy
   Current obstacles and incentives for the development of renewable energy are analyzed, given existing environmental, institutional, and legal frameworks. Moreover, the status and jurisdiction of the most important governmental institutions, the CDER and the ONE ("Office National de l'Electricité"), is investigated. Legal background on taxes, tariffs, access to the electric network, approval procedures, pollution control, subsidies, and promotion and safety of private investments are all analyzed. The social structure and acceptance among the population is considered because increased use of renewable energy can create competition for certain resources with other potential uses (e.g. water, land use, biomass). The negative and positive impacts of renewable energy sources are described and assessed, focusing in part on the environment (in particular, abatement of CO_2-emissions) and the development of the economy (in particular, expected changes to employment).

4. Comparison of possible policy options and technology portfolios
   Different scenarios for the future development of renewable energy sources in Morocco are designed mainly based on the application of the computer model *Green-X* in which varying assumptions concerning national energy policy and accompanying basic conditions (e.g.

energy prices) can be assessed. Though initially created for the European Union, the *Green-X* model was adapted for the Moroccan context; *Green-X* is a professional modeling tool that covers the electricity, heating, and transport sectors. Four possible ways of promoting the future development of renewable energy are emphasized:

- **No incentives/promotion**: A scenario that outlines the economic potential for renewable energy without further support, and shows the marginal extent of development in a case where existing incentives are not continued and additional incentives are not created.
- **Least cost scenario**: A scenario that only aims at the development of the most promising and lowest cost renewable technology options, primarily wind energy, biogas, and solar thermal systems in the building sector.
- **Balanced development**: A scenario that primarily relies upon the most favorable renewable technology options (e.g., wind energy, biogas), but that also demands the limited promotion of other promising options for the future (e.g., concentrating solar power and biofuels for transport).
- **Solar strategy**: A scenario that requires the wider development of all renewable technology options, including photovoltaics.

Much of the input data for the analysis of these scenarios – including data on energy demand and renewable resource potential and costs – came from sections 1 and 2 of the study, described above. Assumptions about other energy prices are adapted from scenarios that came from the European Union (DG TREN); based on these primary energy prices, the prices for electricity, heating, and transport fuels can be calculated. On a sectoral level, reference prices are determined by referring to selected transformation technologies and the present Moroccan proportion of different energy sources. Finally, different political instruments for the promotion of renewable energy sources are evaluated.

The modeling includes detailed sensitivity analysis based on variations in several parameters: interest rate (risk evaluation), energy demand (reference vs. energy efficiency scenario), technology learning (technology development uncertainty), and market diffusion (non-economic barriers). The risk evaluation is based on variations to the "Weighted Average Cost of Capital": 6.5% (base value) and 8.6% (higher risk). To assess the future effects of technological learning, two scenarios for the global development of renewable energy are considered: a business as usual scenario and an alternative accelerated development scenario. To evaluate the future extent of market diffusion, the historical development of renewable energy is analyzed and two alternative variants are considered: existing non-economic barriers (e.g. complex licensing procedures, lack of information, technological and sociological obstacles) persist and account for a retarded market diffusion, or those barriers are overcome allowing an accelerated penetration of renewable energy. Assumptions about renewable energy policy instruments are also considered, including: application of technology specific tariffs, security of the financial support, time limit of the payments, and dynamic adjustment of tariffs specific for each technology for new installations. Macroeconomic impacts are analyzed outside of the *Green-X* model, based on simplified post-calculations and comparisons with other countries.

5. <u>Suggestions for a specific plan to promote renewable energy in Morocco</u>
   The fifth part of the study relies on the results from the previous work to suggest a detailed plan for the promotion and development of renewable energy sources in Morocco.

Results and Policy Implications

The resulting analysis of the four deployment scenarios clearly point out the advantages of further development of renewable energy in Morocco. The analysis finds positive effects on the environment (e.g., reduction of CO_2-emissions and the amount of released pollutants) and also beneficial impacts to the economy. In particular, increased use of renewable energy is found to reduce dependence on fossil-fuels and energy imports, and to create new employment opportunities and enhance Morocco's competitiveness.

More specifically, the modeling results show that, from 2007 to 2020, the implied average annual costs of the renewable energy support scheme reach 8.3 million Euros for the "least cost scenario," 132 million Euros for the "balanced development scenario," and 451 million Euros for the "solar strategy scenario." These costs are compared to the environmental impacts of each scenario as well as the employment implications, summarized in the table below.

Scenarios	**Production**		**Avoided external costs**		**Avoided costs CO2**	**Transfer costs 2007/2020**		**Employees**	**Employees**
	[TWh/an]		**million €/year**		**million €/year** [1)]	**million €/year**		**thousand**	**thousand**
	2010	**2020**	**2010**	**2020**	**2020**	**maximum**	**average**	**2010**	**2020**
No support	2,2	5,5	39	98	30	0	0	577	4.168
Least costs	3,9	13,9	69	247	105	19,5	8,3	3.678	10.944
Balanced portfolio	4,1	17,9	73	318	140	250	132	4.325	12.529
Solar strategy	4,4	22,4	78	399	180	917	451	4.465	16.818
Economic realizable potential	**4,6**	**24,7**	**82**	**439**	**198**	**-**	**-**	**7.633**	**63.061**
Alternative with wind repowering[2)]	5	33,7	89	600	264	250	132	7.633	121.089

The study ultimately recommends the initial implementation of the "least cost scenario," but to progressively add elements of the "balanced development scenario." As a result, the proposed scenario for Morocco for 2010 is dominated by wind energy and the use of comparatively low-cost biogas options. To foster the greater future use of solar energy (in particular CSP) and to reduce the costs of related technologies, it is recommended that Morocco finance pilot projects and intensify its efforts to support this sector. Thus, Morocco's feasible renewable energy potential for 2020 is more diversified, including a wider variety of renewable energy sources. In particular, this scenario integrates solar-thermal systems (CSP) as well as photovoltaic systems. Biogenic sources of energy (biogas, solid biomass, liquid biomass) and biofuels (e.g. biodiesel, bioethanol) are also found to be promising future options for transport and combined heat and power applications.

The assessment also finds that the existing legal and institutional framework in Morocco imposes a variety of barriers to the development of renewable energy. It is therefore essential to reform the relevant institutions. To reduce existing obstacles and to increase incentives for the development of renewable energy, the study therefore makes suggestions for policy development and institutional reorganization.

Advantages and Disadvantages

The analysis conducted for this case was underpinned by a comprehensive assessment of the cost and potential of various renewable energy sources, and by an analysis of the political, institutional, and economic conditions in Morocco. The economic modeling allowed for an analysis of energy consumption and production, prices and expenditures, and environmental outcomes. Macroeconomic impacts were analyzed based on simplified post-calculations. The modeling tools used for these analyses (especially Green-X) were originally developed for EU Member States, but were adapted to the Moroccan context. With effort and available data, these tools could similarly be adapted to and applied in China. Although the model is reasonably sophisticated, its application by consultants at the provincial level in China may be possible if comprehensive input data on the cost and potential of various renewable energy options were available and adequate modeling capabilities existed.

Key aspects of this case study that may be relevant to China include the following:

- <u>Detailed assessment of the cost and potential for various renewable energy sources</u>, based in large part on available, pre-existing studies, but with some new complementary analysis.

- <u>Elaboration of a limited number of renewable energy deployment scenarios</u> to assess the possible impacts of key deployment options, and completion of scenario analysis to test the sensitivity of model results to input parameters.

- <u>Adaptation of the Green-X model,</u> previously used in Europe, to analyze the economic consequences of different renewable energy deployment and policy options.

- <u>Clear identification of challenges, goals, costs, benefits</u>, and specific implementation actions to select most promising policy options.

- <u>Use of stakeholder processes</u> to develop modeling assumptions, guide the creation of the plan, and develop general consensus around the plan and its implementation strategies.

- <u>Addressing not just deployment incentives for renewable energy</u>, but also the broader policy needs related to institutional barriers and legal considerations.

References

Detailed information on the case study for Morocco is available in the final project report: "Etude sur le cadre organisationnel, institutionnel et législatif pour la promotion des Énergies Renouvelables," July-Dec. 2007. Available on request.

5.2 Western Cape, South Africa, Sustainable Energy Strategy

Introduction: Context and Purpose

The Western Cape province of South Africa experienced power outages in 2005 and 2006. Because of this recent energy crisis, the provincial government has fast-tracked the process of introducing a new, sustainable energy program. Although various national efforts are underway to increase the provision of energy to the Western Cape, the provincial government cites the need for additional efforts and is therefore implementing a program of energy efficiency and renewable energy. In November of 2007, the provincial government released its Sustainable Energy Strategy and Programme of Action (SES). The SES has four broad objectives:

- To support economic and social development, poverty alleviation, and infrastructure development;
- To address environmental issues such as air quality, energy conservation, and climate change[4];
- To foster the development of a clean energy sector; and
- To support and enhance provincial investment programs in an effective manner.

Traditionally, energy planning in the Western Cape has followed a least-cost approach, and therefore failed to take into account issues of sustainability, social development, and environmental protection. The SES instead utilizes a portfolio-based approach, and focuses on securing a range of energy generation and management options including demand- and supply-side options. The SES is particularly focused on renewable energy and energy efficiency.

The SES is included as a case here because it provides a good example of a state energy plan that is targeted at increasing renewables in the electricity, heat, and transportation sectors. Additionally, the ongoing planning process relies heavily on stakeholder participation. The Department of Environmental Affairs and Development Planning consulted with stakeholders from government, business, and civil society in 2006 and early 2007. Stakeholder comments were incorporated into the SES. Moreover, to help ensure that all stakeholders are actively involved in the sustainable energy program process, the provincial government is to create a Provincial Sustainable Energy Team (SEAT). SEAT will consist of representatives from all the relevant government entities and other stakeholder groups. SEAT will meet every four months and a non-governmental Chairperson will be designated. Finally, the SES was chosen as a case study because of its emphasis on supporting individual municipalities, and acknowledgement of the role of the national government. To support local governments, the provincial government will conduct energy audits at the local level, provide support for incorporating energy concerns into local economic development plans, offer capacity building support, and improve communication and planning between government spheres.

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[4] South Africa does not have an emissions reduction target under the UNFCCC's Kyoto Protocol; the commitment to reducing the West Cape's carbon footprint stems from the province's climate change review that found mitigation and adaptation strategies would be necessary to deal with the future consequences of climate change.

As context, the Western Cape's population in 2001 was over 4.5 million, more than 2.8 million of which live in Cape Town. 85% of the urban population lives in electrified households, but only 65% of rural households are electrified. The provincial share of total national energy demand is 10%. In 2004, approximately 250 million GJ of energy was consumed, a figure that the government estimates will grow to 375 million GJ in 2020, without a change in energy consumption patterns. The largest final energy demand is for liquid fuels due mainly to their use in transport. The second largest final energy carrier is electricity. Electricity production is responsible for the largest amount of carbon dioxide emissions in the Western Cape. Most of the electricity – much of it coal – is generated outside of the province and is bought from the national energy supplier Eskom. A small portion is generated locally and sold nationally, including energy from a nuclear plant, a gas turbine facility, a pumped storage hydro facility and a wind farm. There is an estimated 3,000 MW of wind potential and 6,501-7000 MJ/m2/pa of available solar radiation across the Western Cape. The long coastline also signals the potential for wave power development. Biomass, waste, and hydropower resource estimates are also provided.

Methods and Data

Data analysis and modeling were used to explore some of the implications of the proposed energy targets, and to revise those targets based on the analytic results. Ultimately, however, the modeling was intended to inform – and not to dictate – the energy strategy of the province. Interestingly, much of the detailed analysis was done not by the provincial government itself, but by other stakeholders under the direction of provincial planners.

Demand Side

The Long-Range Energy Alternative Planning (LEAP) modeling software was used for the demand-side planning to simulate how energy might develop in the Western Cape over a 20 year period. LEAP is an accounting framework; rather than trying to optimize a system's behavior, it helps the user account for the implications of "what if" questions. Factors such as population growth, household size, and sectoral economic growth influence developments in the energy sector. A number of different scenarios were developed and entered into the model based on the provisional SES targets, in order to assess the implications of meeting those targets on energy demand, CO_2 emissions, costs and savings, etc. Scenarios were developed for transport, industry, commerce, government, and residential. The target scenarios were then compared with a "business as usual" reference case and, in some cases, this analysis led to a revision of targets. This scenario analysis work was undertaken by the non-profit Sustainable Energy Africa and Incite Sustainability, with input from the provincial government.

The only demand-side scenario that involved renewable energy was in the residential sector: a solar water heater scenario that assumed that 10% of electric water heaters were replaced by solar water heaters by 2015, and that percentage was set to increase to 50% by 2024; for low-income households, this percentage was assumed at 80%, due to these households requiring less hot water and therefore being able to meet most of their water heating needs with the solar water heaters. The LEAP analysis concluded that this scenario would likely have costs that exceed the financial benefits. Implementing a solar water heating program in low-income households, in particular, is not as financially attractive as implementing such a program in medium- to high-income households, but numerous other benefits, including health and welfare benefits, were cited. That being said, if cost reduction of solar water heaters is assumed, positive program savings were calculated by 2018. This program was also estimated to result in a cumulative savings of over 3 million tons of CO_2-equivalent emissions by 2020, and energy savings, SO2 reductions, and particulate emissions reductions were all also calculated.

Supply Side

The renewable energy component of the SES was based on the proposed Renewable Energy Plan of Action for the Western Cape: Resource Assessment, Scenarios, Proposed Objectives and Actions. Drawing on a number of sources, the renewable energy document was written by consultants working for Sustainable Energy Africa.[5] The Plan of Action outlines the viability of a 15% renewable energy target by 2014 based on a resource assessment and six scenarios; it also highlights the challenges to be faced in meeting the Sustainable Energy Strategy. The focus is on the period up to 2015, although much of the scenario development extends through 2035. While renewable resources are clearly available in the Western Cape, and the Plan summarizes the region's resource potential, the difficulty expressed in the Plan of Action will be in bringing the technologies to a level of viability within the appropriate time horizon.

The specific scenarios that were developed and analyzed were: 1) Business As Usual, Reference Demand scenario, 2) the Business as Usual, Energy Conscious Demand scenario, 3) Progressive Renewable, Reference Demand scenario, 4) Progressive Renewable, Energy Conscious Demand scenario, 5) High Renewable, Reference Demand scenario, and 6) High Renewable, Energy Conscious Demand scenario. The first scenario can be described as a "do nothing" or status quo, reference case and the second scenario makes no changes to supply, but employs energy efficiency and demand-side management. The third and fourth scenarios introduce some renewables on the supply-side—in the first case without comprehensive demand-side management and energy efficiency and in the second case with these measures. The fifth and sixth scenarios rely on a more aggressive introduction of renewables—the latter modeling aggressive measures to increase and diversify supply and to curb and manage demand. The SES targets are ultimately based on the "High Renewables Energy Conscious Demand" and "Progressive Renewable, Energy Conscious Demand" scenarios.

The Renewable Energy Plan of Action provides a detailed renewable resource assessment by technology, including a discussion of deployment barriers, challenges, and cost trends. This analysis is based primarily on existing literature, supplemented with resource assessments and analyses prepared specifically for the SES. Using simple learning curves, the levelized cost of energy for renewable and fossil generation options is then estimated. In combination with data on practical deployment potential, by technology, these data are then used to develop assumed resource mix combinations of the various renewable energy options for each of the six scenarios. Those resource mixes are developed based on expert judgment, not (optimized) modeled output. With those data, a spreadsheet model was developed to estimate the cost and retail rate implications of the 6 scenarios, which themselves include low, medium, and high levels of renewable energy.

[5] Sustainable Energy Africa can be found online at http://www.sustainable.org.za/

Because of the simplicity of this analysis, it is unable to address a number of key topics, including the ability of renewable energy to meet peak load requirements, grid expansion needs, storage requirements, and the interplay between renewable and fossil generation. It also excludes any monetization of environmental costs, though the analysis does calculate carbon emissions reductions. The SES and supporting documents did estimate the job creation potential associated with the Progressive Renewable, Energy Conscious Demand scenario, with an estimated net job gain of 75,000 by 2035 over the Business As Usual scenario. The analysis supporting this estimate is simple, and is based on jobs/GWh metrics developed elsewhere. This estimate helped support the government's aggressive ambitions in setting renewable energy targets.

Results and Policy Implications

The main SES report starts by describing the objectives and vision for the sustainable energy plan, and by highlighting the motivations for the strategy as well as the specific mandate of the provincial government in supporting sustainable energy development, relative to other levels of government. It provides a profile of energy demand and supply in the West Cape region. It then offers a detailed discussion of demand-side scenarios and options (with associated analysis), before turning to supply-side options and analyses, with a focus on renewable energy. It ends by discussing important stakeholder and governmental interactions, and by offering specific targets and actions plans that the provincial government is to execute.

The background Renewable Energy Plan of Action provides a detailed renewable energy resource assessment, describes the analysis of the 6 supply scenarios noted earlier, and proposes a renewable energy strategy and program, for consideration in the main SES report. The report covers renewable energy for use in electricity, heating, and transport.

Based in part on the analysis described earlier, the SES ultimately includes a number of energy targets for the Western Cape, including energy efficiency, renewable energy, and carbon targets. For renewable energy, the specified regional target is that renewable electricity generation in the Western Cape increase to 4,200 MW, or 15% of electricity consumption by 2014. Additionally, renewable energy is to be purchased by provincial government agencies at a 10% share by 2010.

Demand Side
In order to achieve the SES' energy efficiency targets (not summarized here), the province outlined an action plan for itself, including:

- Information dissemination on strategies, financial benefits, and program implementation;
- Capacity building of local governments to enable implementation;
- Facilitating the development of financing mechanisms for solar water heaters;
- Developing CDM or other province-wide projects to secure carbon revenue and lower transaction costs;
- Facilitating bulk supply of products where appropriate;
- Supporting local government with implementation via development of pro-forma by-laws, regulations, and guidelines; and

- Active promotion of public transport modes, implementation of public transport and modal shift plans, and support to municipalities on the implementation of smaller-scale public transport initiatives.

Specified measures under this program were evaluated for their viability based on financial feasibility, social and environmental benefits, as well as the challenges faced in implementation. Immediate implementation priority was given to solar water heaters—challenges facing implementation of this renewable energy technology include the fact that establishing suitable financing mechanisms may be institutionally demanding and that appropriate standards for equipment and operation need to be in place. A bio-diesel fuel switch in the transport sector was given medium-term implementation priority, with some immediate emphasis on a promotion strategy. Including bio-diesel in the supply network was listed as an institutional challenge that would require the cooperation of industry.

Many of the interventions explored in the demand-side scenario work were acknowledged to be best promoted and implemented directly by individual municipalities, including:

- Developing sustainable energy plans and strategies, and soliciting support from the province;
- Development and dissemination of information specific to the municipality;
- Implementation of efficient lighting in residential, commercial, and government sectors;
- Promotion of energy efficiency in industry; and
- Seeking support from the province in the implementation of a solar water heater program.

The provincial government, through various mechanisms, intends to support these local government actions.

Supply Side

The scenario work determined that there is significant potential in the medium- to long-term to generate a high proportion of the region's electricity from renewable resources and, based on the cost reduction assumptions used, the cost differential compared to the Business as Usual scenario is reasonable. Twelve percent of locally generated renewable electricity by 2015 is found to be achievable if a highly aggressive renewable energy plan is implemented and strong energy efficiency is practiced, with additional renewables coming from outside of the region.

It is recognized that revisions to the renewable energy targets may be necessary in the future. Nonetheless, the following renewable energy targets were included in the SES:

- 12% of the electricity consumed in the Western Cape will be from certified local renewable energy generation resources by 2014, 18% by 2020, and 30% by 2030.
- Western Cape provincial and local governments will ensure that 15% of the electricity they use is generated from renewable energy resources by 2014.
- Solar water heaters are to be installed at a rate compatible with the implementation scenario presented in the Demand Side and Energy Efficiency Strategy.
- Biofuel should be incorporated within the provincial diesel and petrol consumption, in line with the national strategy; the provincial government vehicle fleet will lead the conversion and uptake of biofuel with 50% of the fleet converted by 2010.

- Industry, electricity distributors, and other key purchasers of electricity commit to a voluntary target, sourcing 15% of their electricity from renewable resources.
- New buildings to include on-site generation for 10% of their energy needs.
- CO_2-equivalent emissions attributable to the consumption of electricity should be held within 5% of 2006 levels, and by 2020 there should be a downward trend.

The renewable energy component of the SES includes 14 areas where provincial action is expected to have a positive impact on increasing renewables in the Western Cape. The actions range from assisting in the development of a national renewable energy certificates scheme and establishing provincial-level feed-in tariffs or obligations for key consumer classes, to providing funding for feasibility studies and facilitating the introduction of biodiesel and ethanol production and consumption in the province.

The Programme of Action is a critical component of the SES and clearly states how the objectives are to be achieved, who is to achieve them, and when the process will be initiated. It is made clear that the Programme of Action will be continuously reviewed and structured to suit the overall objectives of the SES. It is to accommodate new developments and challenges. The SES will be presented as a Green Paper to the provincial cabinet and then developed into a White Paper. Some elements of the White Paper will be taken up in the legislative process. Nonetheless, the SES also recognizes that the provincial government itself may be unable to achieve the targets specified in the SES, absent aggressive action by local governments and new policies by the national government.

Importantly, the provincial government acknowledges the need to address energy concerns in an integrated manner and the SES is to be integrated into a broad range of existing and pending policies for the Western Cape's development.

Advantages and Disadvantages

The comprehensive approach to sustainable energy planning at the provincial level, used by the Western Cape, provides a useful model for other jurisdictions. Unlike many of the case studies reported in this paper, the West Cape's planning efforts cover all aspects of energy demand and supply, including electricity, heating, transport, and addresses renewable energy applications in each sector. As with many other plans described in these case studies, the actual analysis behind the SES was often prepared by parties outside of the provincial government. The analysis is diverse: while LEAP is used as a primary tool for the demand-side measures, a simple spreadsheet-based approach is used to evaluate various renewable energy scenarios, considering cost implications, investment needs, CO2 reductions, and job creation. Underpinning this latter analysis is the need for solid renewable resource and cost information.

Key aspects of this case study that may be relevant to China include the following:

- <u>Extensive use of stakeholder consultation</u> throughout the planning process to ensure that strategies and actions are broadly agreed upon.

- Clear engagement of municipalities and local governments, and provincial-level support for local governments in their own planning processes and energy policy development (e.g., sharing of resources, funding of feasibility studies, etc.).

- Development of a clear plan of action, with goals, implementation strategies, and timelines, while also acknowledging the role of the provincial government relative to national and municipal governments.

- Development of a sustainable energy strategy and plan of action that incorporates demand- and supply-side considerations, including the possible use of renewable energy in the electricity, heating, and transportation sectors, and considering a range of policy needs.

- Coordination of the plan with other relevant policies at the local government and national government levels.

- Simple scenario modeling techniques for renewable energy that require solid renewable resource and cost information, and that ignore some key issues, but that are otherwise simple to develop and implement, and that do not require great sophistication.

References

The "Sustainable Energy Strategy and Programme of Action for the Western Cape" is part of a suite of documents that also include: The Sustainable Energy Strategy and Programme of Action Compendium; The Renewable Energy Strategy and Action Plan; The Demand Side and Energy Efficiency Strategy and Plan of Action; and Consolidated Comments – Stakeholder Consultation Process. These documents are available online by following the Department Environmental Affairs and Development Planning link at http://www.capegateway.gov.za

The Renewable Energy Plan of Action is available at:
http://www.capegateway.gov.za/Text/2008/3/4._ses_re_banks_resources_scenarios_plan_drafoct20070523v5_print.pdf

Related information can be found on the Western Cape Sustainable Energy Policy Website http://www.wcapeenergy.net

"Energising South African Cities & Towns: A Local Government Guide to Sustainable Energy Planning" provides energy planning guidance to municipalities and can be found online, together with a number of municipal energy plans, at Sustainable Energy Africa's website http://www.sustainable.org.za/resources/reports-documents.html

5.3 Tamil Nadu, India, State (and National) Renewable Electricity Planning

Introduction: Context and Purpose

In India, the central government sets national targets and policies for renewable energy, including some specific incentive policies. However, the national government has left much of the implementation of these targets to be accomplished at the provincial level. In particular, provincial governments are obligated to set local renewable energy targets via provincial-level renewables portfolio standards (RPS). The provinces are also responsible for establishing electricity purchase prices for renewable energy, as well as for developing local incentive policies to encourage renewable energy deployment. This arrangement of central and provincial target setting and incentive program design is somewhat similar to the situation in China.

Within India's national government, the Ministry of New and Renewable Energy (MNRE) has primary responsibility over renewable energy. The agency is responsible for broad areas including solar, wind, biomass, and other new sources of energy that tend towards the replacement of coal. Renewable energy is only expected to account for around 5-6% of the primary commercial energy mix of India by 2032, but renewable energy is still seen as fulfilling a number of national goals, including poverty alleviation and development.

India's national Planning Commission constructs five year plans to direct development. A Working Group under the chairmanship of the Secretary of the MNRE was convened in April 2006 to help formulate proposals for non-conventional energy sources, including renewable energy, to be included in the national 11th Five Year Plan, 2007-2012. To assist the Working Group in its task, four sub-groups were created in June 2006: i) Renewable Power; ii) Renewables for Urban, Industrial and Commercial Applications; iii) Renewables for Rural Power; and iv) Research & Development in Renewable Energy. The Planning Commission also established an expert group to recommend integrated energy policy proposals, impacting both supply and demand, and many of the recommendations of the 2005 Draft Report of the Expert Committee on Integrated Energy Policy either have been or are being implemented.

This specific case study contains two elements. First, it discusses the guidance and action taken at the national level, including the 11th National Five-Year Plan, in establishing national renewable energy targets and incentive policies, as well as the national requirements issued from the Central Electricity Regulatory Commission (CERC) to provinces that require provincial-level targets, RPS policies, and standardized tariffs. Second, it covers the corresponding incentives and policies to implement the 11th Plan in the province of Tamil Nadu, as outlined in the Tamil Nadu Energy Agency's (TEDA) Policy Note for the Year 2008-2009, and the Tamil Nadu Electricity Regulatory Commission's (TNERC) implementation of national requirements to design tariffs and the provincial RPS. A particular focus is placed on the interaction between the national and provincial levels, in addition to methods and data used in the planning process. It also deserves note that stakeholders have been engaged throughout the national and provincial planning processes described below. Lawmaking in India requires that the public be notified and a comment period be observed prior to the enactment of policies, laws, and regulations. Energy planning is therefore subject to public meetings, notifications in the paper and on the internet, publishing of draft regulations, working and expert group input, and incorporation of received comments. In Tamil Nadu, this formal process was used in the establishment of the state's RPS.

This case is included in this report primarily because the jurisdictional split between national and state governments in India resembles, to a degree, the situation in China. India's national 11th Plan explicitly aims to strengthen state capability and to engage local self-governing institutions such as municipalities and towns. In this model, national goals, such as the promotion of a domestic PV market for grid-tied power generation, become state goals. In implementing the national program, Tamil Nadu has undertaken a renewables program—including assessment, funding schemes, policies, and regulations—that has seen some early success. The planning efforts at the national level first empowered the state government and now are looking to empower municipalities as well. Moreover, unlike many of the other cases in our sample, this case includes not just utility-scale renewable energy applications, but also planning for the use of renewable energy in rural applications.

As context, India's population is currently estimated to be just under 1.148 billion. The Gross Domestic Product (per capita purchasing power parity) was estimated at $2,700 in 2007. Over 62.4 million people officially lived in Tamil Nadu in 2001, with 44% of this population living in urban areas. Tamil Nadu is the most urbanized state in India and the fifth largest contributor to India's overall GDP. While over half of India is still without basic energy services, Tamil Nadu has already achieved total electrification of villages. Renewable electricity contributes 8% of grid capacity at the national level. Despite two decades of effort, however, renewable energy systems meet less than 1% of the rural energy needs. According to TEDA, renewable electricity capacity in Tamil Nadu reached 4,115 MW by the end of February 2008, representing over 27% of the state's grid capacity; 281 MW were added in 2007. Wind stood at 3,711 MW (one-half of the country's capacity), bagasse co-generation at 213 MW, biomass power at 99 MW, and small hydro (up to 25 MW) at 87 MW. Renewable electricity contributed 10% of total electricity consumption in Tamil Nadu in 2006-2007, and Tamil Nadu is ahead of other states when it comes to renewable energy sector development.

Methods and Data

Building renewable energy infrastructure requires detailed assessment, often achieved through a combination of analysis and mapping, of the renewable resource base. In India, responsibility for such assessments is split among the national and state governments, as well as other stakeholders. The national 11th Plan, for example, provides information on renewable energy resource potential in India as a whole, and that assessment helped formulate the national renewable energy targets. Some of the renewable resource information provided therein was developed by the government itself, but other studies have come from outside groups and experts. More generally, India's national government continues its effort to conduct more rigorous assessments through geographic information systems (GIS) mapping, and classification and rating of potential site locations continues.

Tamil Nadu, meanwhile, has conducted a number of renewable resource assessments, using provincial and national funding. In terms of wind potential, for example, 5,500 MW has been identified according to wind assessment studies carried out by TEDA with funding assistance from the national government. The potential for biomass is estimated at 487 MW in the District-Level Study carried out by Anna University with MNRE funding. Another 450 MW is estimated to be available from bagasse co-generation in sugar mills. Tamil Nadu has also conducted micro-level site assessments by surveying wind resources around select potential stations, using both MNRE and state funding.

As noted earlier, to help achieve India's national renewable energy targets, national policy requires that state electricity commissions establish a minimum RPS, taking into account renewable resource availability and the impact of renewable energy development on electricity tariffs. Renewable electricity purchases required by these RPS policies are to occur at preferential tariffs set by the state commissions.

Tamil Nadu's resulting renewable energy targets are not based on sophisticated modeling tools and analyses. Instead, they are based on the previously mentioned resource assessments, as well as the state's experience with renewable energy technologies and development. In particular, Tamil Nadu's 10% RPS was established based on an assessment of resource potential, and based on stakeholder comments. The following factors were considered in establishing the percentage: total quantity of energy required; total resource potential for renewable energy generation in the state; quantity of renewable energy currently being generated; power purchase tariffs for renewable energy; and commercial impact of renewable purchases on retail electricity tariffs.

The power purchase tariffs for renewable energy were set in Tamil Nadu by following guidance provided by the national government. The tariff setting process included the consideration of a number of papers, written stakeholder comments, consultations with the State Advisory Committee, a public hearing, and views of experts expressed in a roundtable conference. Both the results of previous competitive bidding processes for renewable energy and cost plus calculation methods were used to help establish tariff levels for different renewable technologies. In some cases where limited cost information was available, such as with grid-connected solar, a provisional tariff was established, after reviewing guidelines from the Commission, equivalent to the highest tariff rate for non-conventional energy sources in the province.

Results and Policy Implications

The national 11^{th} Plan and relevant background documents include a review of performance during the 10^{th} Plan and an assessment of renewable energy resource potential. Importantly, during the 10^{th} Plan, the creation of State Electricity Regulatory Commissions (SERCs) became mandatory. In compliance with the Electricity Act of 2003, the National Electricity Policy was issued in 2005 and National Tariff Policy was issued in 2006. Additionally, in 2006, the Rural Electrification Policy was issued. Based on this background and on the resource potential estimates, national renewable energy targets and investment costs for the 11^{th} Plan are summarized in the "Proposals for Non-Conventional Energy Sources—New and Renewable Energy" working group document and broken down according to the following chapters: Grid-Interactive and Distributed Renewable Power, Renewable Energy for Rural Applications, Renewable Energy for Urban, Industrial & Commercial Applications, Research, Design & Development in Renewable Energy, and Supporting Programs. Towards the end of the document, a “Perspective Plan 2022,” or future energy scenario, is included. The annexes include information pertaining to the working groups and the resource assessment activities.

At the state level in Tamil Nadu, in addition to the RPS and tariff policies, discussed earlier, the “Policy Note for the Year 2008-2009” outlines activities in: 1) Grid Interactive Power Generation, 2) Stand Alone Renewable Energy Systems, 3) Other Schemes, and 4) New Schemes Under Part 2 for 2008-2009. The New Stand Alone Renewable Energy Systems Schemes include: solar powered vaccine refrigerators for medical centers, solar home lights for group homes, solar water heating systems for government hospitals and hostels, the purchase of testing equipment for renewable energy devices and a training program; the Policy Note therefore provides for additional policies and incentives, beyond the state’s RPS and tariff policy.

The 11th Plan adopts, almost in their entirety, the working group proposals for renewable energy. The goal for additional grid-connected power capacity from renewables is set at 15,000 MW on a national level, or about 20% of the total 70,000 MW of generation capacity planned from 2008-2012. This total includes resource-specific targets for wind (10,500 MW), small hydro (1,400 MW), and co-generation (1,200 MW), as well as smaller contributions from biomass power, urban waste-to-energy, industrial waste-to-energy, and grid-interactive solar. The investment requirement for setting up this renewable power capacity is estimated at US $13.6 billion. MNRE has included a subsidy support system of approximately US $1 billion to support many of these technologies, with subsidy levels specified and focused on production-based rewards rather than capital-based subsidies. Performance testing is required for projects supported by subsidy. Emphasis is also placed on harmonizing national standards with international standards for equipment to maintain trade competitiveness. The MNRE recognizes the need for the integration of its deployment programs with those of other ministries. Electricity sales policies, for example, including RPS and purchase tariffs, fall under a different ministry. The working group proposals also highlight targets and programs for rural renewable energy use as well as renewable energy use in urban, industrial, and commercial applications, and incentive levels and budgets for each of those programs. Biofuels are also addressed in the 11th Plan.

The MNRE previously withdrew subsidies for grid-tied solar power because of cost concerns. Recently, however, this sector has seen a number of technological developments and growth in local manufacturing capacity. New state initiatives for feed-in tariffs, tax rebates, and low-interest loans have helped to persuade the national government to provide generation-based incentives for grid-interactive solar power generation. As a result, a maximum incentive amount of US $0.27/kWh (PV) and US $0.22/kWh (solar thermal electric) for 10 years is available for certain grid-tied solar installations built after December 31, 2009. Each state is allowed up to 10 MW under this program. TEDA has submitted a proposal under this program to accept letters of interest from potential project developers. Furthermore, Tamil Nadu officials are participating in a study-trip abroad to learn about recent developments in the field. The state hopes to engage in discussions about joint ventures to set up solar power generation projects in Tamil Nadu. To further encourage the development of these technologies, the electricity purchase tariff established in Tamil Nadu for solar thermal and solar photovoltaic generation plants was set at around US$ 0.069/kWh; this is the highest tariff for renewables in the province.[6]

The 11th Plan also identifies RD&D as critical to sector development. A subsidy of 100% of project costs in government institutions and 50% in the private sector is being offered for selected RD&D activities. The 11th Plan specifies the areas of RD&D that are in most need of support, focusing on product-development oriented RD&D—even basic and fundamental research is to aim for this goal—to bolster the domestic industry and reduce excessive reliance on imports. TEDA, meanwhile, has taken up three R&D projects jointly with Anna University, with costs shared equally by the state government and the university.

The national focus on local manufacturing has translated into the state of Tamil Nadu setting up a Special Economic Zone for the manufacture of renewable energy devices. In 2007, a memorandum of understanding was signed by the state and private promoters and is now awaiting national approval. The Special Economic Zone is expected to attract 40 manufacturers, with 5,000 people projected to receive direct employment from these facilities and another 10,000 employed indirectly.

The 11th Plan also seeks to provide a structure by which local (below state) governments implement national renewable energy goals and programs. For example, District Advisory Committees on Renewable Energy are being constituted in every district to oversee the implementation of renewable energy programs in the district. Over 409 of these Committees have been set up across the country. Each has 14 members from heads of various departments and two representatives of Members of Parliament. Funds are also provided for town and city level renewable energy planning; this includes developing local information infrastructure through local awareness, urban design, laws and process development.

Advantages and Disadvantages

India's provinces have been directed to set RPS policies for electricity distributors and to set preferential rates for the purchase of renewable energy. Subsidies provided by the national government are used to support these regional efforts. Tamil Nadu undertook an open, deliberative process in establishing its RPS and its tariffs. Stakeholder input and expert consultation served as guideposts throughout.

India's 11th Plan and related developments in Tamil Nadu did not involve extensive modeling effort. Instead, these plans and related developments primarily resulted from government consultation, as informed by quantitative renewable resource assessments and simple spreadsheet analysis of investment needs and other factors. The goal was to develop policies and programs to support government goals.

[6] Detailed tariff calculations are enclosed as annexes to the TNERC Order Number 3 dated 15-5-2006 setting forth the rates for renewables (excluding solar, which is set forth in the later Order Number 6 dated 11-7-2008). Electricity purchase tariffs are currently as follows: US $0.06/kWh for wind commissioned prior to the tariff-setting and US$ 0.063/kWh for wind commissioned after the tariff-setting; and US$ 0.069/kWh for biomass and bagasse, as well as for solar.

Despite the lack of detailed modeling, several aspects of these efforts may be relevant for China:

- The relationships between national goals and provincial renewable energy programs as described in this case are somewhat similar to the Chinese circumstance.

- The case demonstrates how the national government can help support and leverage state funds and programs for R&D, special economic zones for manufacturing, deployment programs, and capacity building.

- Coordination between national and state resource assessment activities to generate renewable resource data is an essential pre-condition for effective renewable energy planning, with India's national government serving in an ongoing capacity as a clearing-house of renewable energy information—such as resource assessment, site classification, etc.

- Developing district-level committees to address renewable energy barriers and to raise awareness at the local level.

References

The "XIth Plan Proposals for New and Renewable Energy", as well as other background and related documents, can be found at the Ministry of New and Renewable Energy website at http://mnes.nic.in/

The "Policy Note for the Year 2008-2009" provides an overview of implementation efforts underway in Tamil Nadu and can be found on the Tamil Nadu Energy Development Agency website at http://www.teda.gov.in

Decisions of the Tamil Nadu Electricity Regulatory Commission, including tariff-setting decisions, are available online at http://tnerc.tn.nic.in/

6. Lessons and Recommendations

Renewable energy planning can have multiple motives, take many forms, rely on varying data sources, utilize different models, and rely upon different levels of stakeholder involvement. International experience reflects those variations, and no single "template" has emerged as a best practice renewable energy planning approach. Indeed, we have not identified planning process examples internationally that replicate what is required in China vis-à-vis nationally-required local renewable energy plans. Similarly, no single "best" modeling approach has been developed internationally. Instead, a variety of diverse and typically disconnected planning efforts have occurred, making it difficult to identify strong lessons and recommendations.

Nonetheless, below we identify a number of general lessons and recommendations that have emerged from our review of the international planning case studies presented earlier. Those observations are split into four subsections: (1) objectives, principles and scope; (2) selection and use of planning tools; (3) data input needs; and (4) process recommendations. To the extent feasible, we have tried to target these observations to the context of China's provincial planning efforts. Those efforts are still not fully defined, but will operate within the context of data limitations as well as limits to the ability of provincial stakeholders to fully engage in complicated modeling efforts. As a result, a number of the approaches used internationally are not appropriate for application in China, though elements of those efforts may still offer important insights. Given that context, we also note that some of our recommendations may not be able to be immediately implemented, but may instead take some years to achieve.

6.1 Objectives, Principles, and Scope

- **Clarity of Objectives and Scope Is Essential:** As discussed earlier, renewable energy planning efforts can have multiple purposes—they can be used to help set renewable energy targets, implement those targets, conduct land-use and spatial planning, or provide input to transmission development. Some international renewable energy planning efforts seek to meet all of these objectives, but most are more limited in scope. Some are focused exclusively on renewable energy, while others embed renewable energy planning into broader energy planning processes. Within the renewable energy sector itself, some planning efforts focus exclusively on the electricity sector, while others also include heating and transport; some include only commercial energy options, while others also include rural energy use. There is no "best practice" on the objectives and scope of renewable energy planning efforts, but it is essential that those objectives and scope be clear from the start.

- **Provinces Must Have Direction on their Planning Responsibilities:** Related to the first observation, above, China's central government should provide clear direction to provincial planners on the objectives and scope of their efforts. Of particular importance is direction on whether provincial renewable energy planning is to focus primarily on the implementation of provincial renewable energy targets that are established by the central government, or whether provincial planning is intended to establish provincial renewable energy targets.

Our understanding of China's *Renewable Energy Law* is that China's national government, cooperating with provincial, autonomous region, and municipal governments, is to establish mid- and long-term targets for renewable energy development and utilization within each of these smaller administrative regions. To ensure that the subsequent renewable energy targets are achieved, each relevant provincial, autonomous region, and municipal government is required to establish and implement a renewable energy development and utilization plan. To our knowledge, provincial renewable energy targets have not been developed by China's national government, and it is therefore unclear whether the provinces' energy planning responsibilities are to focus on the renewable energy development and utilization plan, or whether that are also intended establish renewable energy targets; if the latter, then the relationship between the provincial and national target-setting responsibilities is similarly unclear. These matters should be clarified, as should the general scope and structure of the required provincial plans.

- **Planning Should Reflect Provincial Policy Options and Influence:** A number of the international case studies reflect a tension between regional and national governments. Though regional governments often wish to lead in renewable resource development, those governments often find that their ability to do so is limited because national renewable energy policy takes precedence, leaving regional governments with a more-limited range of possible policy instruments. Especially if provincial renewable energy plans are to focus on the implementation of targets, it may be useful for the central government to provide the provincial governments with a clear policy "toolkit" that identifies the range of policy options that provincial governments have the authority to use to support renewable energy, in all three sectors (electricity, heating, and transport) and in both rural and non-rural applications. Such a toolkit could identify the policy options that might be used at the provincial level, and provide examples of their use.

- **Target Implementation Options Should Go Beyond Economic Incentive Policy:** International experiences show that a variety of institutional barriers can hamper the development of renewable energy, e.g., access to transmission, siting and permitting, grid interconnection standards, lack of financing options, land use competition, building requirements, work force constraints, lack of equipment suppliers, etc. Many of these barriers are "local" in nature, and therefore might best be addressed on a provincial basis. In fact, these local barriers are major points of emphasis in a number of the international case studies presented earlier. As a result, it would be helpful to not only clarify the possible provincial use of economic incentive policies of various forms (e.g., grants, electricity pricing, tax policy), but also the authorities of the provincial governments in these other areas. The scope of the provincial renewable energy plans should, if possible, be inclusive of these institutional barriers, and include both a discussion of critical institutional barriers and provincial plans to address them.

6.2 Selection and Use of Planning Tools

- **Models Should Be Consistent with Objectives and Scope:** No single "best" modeling approach has been developed internationally. In fact, it is rare to find two renewable energy planning efforts that have even used the same model: instead, a variety of tools have been developed and used, with little cross-over among planning efforts. In a number of cases, new tools were developed specifically for the planning exercise, and in many instances multiple tools were used, each with a specific purpose. In still other cases, modeling tools were not even used, because the objectives of the planning process did not require them. Some of this variety simply reflects institutional context, for example, the Green-X model sometimes used in Europe (and adapted for use in Morocco) was initially developed using European data sets, and is therefore not used in the United States. In other cases, however, the varying modeling approaches reflect the very different objectives and scope of the planning processes. Models used to evaluate electricity sector scenarios are not the same as those that cover the transportation sector, for example, while optimization and scenario-based models also serve different purposes. Similarly, some models are used to predict the cost implications of increased renewable energy development, whereas others focus on the benefits of renewable energy, the transmission infrastructure needs, or the operational grid integration challenges. Said more directly, modeling tools are typically developed for specific purposes, and it is impossible to identify the best approaches for the Chinese context without more information on the objectives and scope of the provincial planning responsibilities. Once those objectives are identified it will become more obvious whether a modeling tool is even required and, if so, what specific modeling functions are needed.

- **Models Should Be Consistent with Capabilities and Data Availability:** Quite obviously, modeling tools must also be consistent with the capabilities and resources available. This is another reason that we see considerable variety among the ten international case studies presented earlier—in some cases, regional planners have relied on a multitude of sophisticated modeling tools, while others have not used any modeling tool per se but have instead sought to synthesize available information in a more qualitative fashion. Additionally, it must be recognized that modeling tools are only as good as the data inputs that go into them: it does little good to input low-quality, low-resolution data into a highly-sophisticated high-resolution energy planning model. The development of high-quality data inputs should therefore precede the use of complicated energy sector models at the provincial level. Indeed, even with high-quality data, extraordinarily complicated models are unlikely to be of much use for provincial application in China. Fortunately, several of the international case studies provide examples of what is possible with less-sophisticated tools, some of which may be appropriate (with modification) for application in China.

- **Sensitivity and Scenario Analysis Should Be Conducted:** The energy sector is exposed to considerable risk and uncertainty, and an underlying theme of most energy-sector forecasts is just how inaccurate they have been. As a result, many of the international energy planning processes described earlier explored the sensitivity of model results to various inherent uncertainties, e.g., different fuel prices, future renewable energy costs. In fact, one of the key objectives of modeling should be to build an understanding of the sensitivity of the results to varying input parameters. While the absolute results of any model are bound to be incorrect, the process of sensitivity and scenario analysis can help to identify the critical factors that will determine the ultimate results of any policy or deployment effort.

- **Transparent Supply-Curve Models Should Be Considered for Provincial Application:** As already noted, a range of models have been used internationally, none of which are immediately appropriate for provincial application in China. Nonetheless, supply-curve models of the nature used in the Pennsylvania case (as well as in one of the UK studies, among others) may be most suitable for China's provinces. A provincial supply-curve model may be relatively easy to adapt from an existing supply-curve models used internationally, or may be constructed from scratch. Such models can be implemented in Excel, and therefore do not strictly require a more complicated modeling platform. Alternatively, more sophisticated supply-curve models such as Green-X may be able to be adapted for the Chinese context, if adequate data and modeling capabilities exist. Such models can be focused exclusively on the electricity sector (e.g., the Pennsylvania case), or can also include heating and transport (Green-X used in Europe and Morocco). Additionally, such models are typically far more transparent than are integrated energy sector models, allowing users to easily view and alter key assumptions. Supply-curve models allow for a relatively simple economic assessment of different renewable energy deployment scenarios, but by virtue of their simplicity, cannot take into consideration all of the various feed-back effects that other models can handle. Such models are also not able to comprehensively forecast the various co-benefits of renewable energy (e.g., employment, environment, etc.), which require different tools. As with all modeling tools, supply-curve models require adequate data inputs on the cost and potential for various renewable energy options, and on the cost of alternative conventional energy technologies. Similarly, though relatively easy to construct, a variety of pitfalls can be encountered in application. As such, if such tools are pursued, China's central government may wish to first collect the required data input and then construct a version of the tool that provincial planners could then modify and use as they see fit.

- **Allocation of Renewable Energy Targets in the EU May Be Instructive:** It is our understanding that China's *Renewable Energy Law* requires that China's national government, cooperating with provincial, autonomous region, and municipal governments, establish mid- and long-term targets for renewable energy development and utilization within each of these smaller administrative regions, and that those targets are to be consistent with the national targets, but are also to consider the economic context and resource potential at the local/regional level. If that is the case, experiences in the EU in the allocation of the proposed EU-wide renewable targets among Member States may be relevant. As shown by that experience, no single target allocation approach is ideal, but such allocations may wish to account for a variety of factors, including: renewable resource potential, equal allocation of responsibility, variations in wealth, and the early actions of certain regions. In allocating targets to provinces in China, whether this is accomplished at the provincial or central level, similar factors might be considered, and the central government may wish to compile relevant datasets to allow stakeholders to consider different target allocation approaches.

6.3 Data Input Needs

- **Energy Planning Requires Access to Quality Data:** Whether or not a modeling tool is used, energy planning requires access to high-quality data. For renewable energy planning, such data include information on the location, cost, and performance of potential renewable energy projects, and may also require information on the cost and characteristics of the conventional energy sources that are competing with renewable energy options. International renewable energy planning efforts often rely on existing data sets that have been compiled previously, sometimes updated for the specific study in question; increasingly, GIS tools are being used to obtain a better understanding of the geographic scope of renewable resource options and costs. The collection and compilation of renewable resource and cost data is often one of the most significant activities in international renewable energy planning efforts. Comprehensive and up-to-date renewable energy resource and cost data for China are still not available in many instances. The *Renewable Energy Law* does require the preparation of national renewable energy resource surveys. Those surveys might ideally be designed with provincial use in mind and, once complete, may offer a critical input to provincial planning efforts.

- **China's National Government Should Consider Developing an Appropriate Dataset:** It may be too much to ask for every province to develop its own unique datasets. Even internationally, most local energy planning processes have relied heavily on pre-existing data. As such, China's central government may wish to develop a comprehensive database of relevant input data for renewable energy planning processes. Such a dataset would certainly need to contain provincial-level information on renewable resource potential, cost, and perhaps location, by renewable energy technology. Over time, it may be beneficial to put the data in GIS form, to facilitate further analysis. Additionally, such a dataset might include provincial-level information on expected load growth, and on the cost and availability of conventional energy sources. As noted earlier, it may also be useful to input these data into a supply-curve model, developed at the central level for use within the provinces. Many provinces might choose to rely exclusively on the dataset provided by the central government. Others, however, may feel that they have access to more-detailed, and higher-quality local data, and may therefore choose to make limited use of the nationally provided data. The development of a national dataset of this type would be a significant undertaking, and would require ongoing dedicated staff and resources.

- **Coordinate National and Provincial Resource Assessment:** Though a nationally provided, central dataset could be immensely valuable for provincial planning, that dataset will necessarily be somewhat coarse, and unable to account for all of the local factors that will influence the location and cost of potential renewable energy deployment. As a result, in other countries, local governments have often supported local resource assessment activities to supplement national efforts. These efforts, as in India, have sometimes been co-funded by the national government, with results then fed-back into the national datasets. China may wish to explore providing financial assistance and other resources to provincial governments to execute similar responsibilities.

6.4 Process Recommendations

- **Development of a Provincial Planning Template Should Be Considered:** To ensure some level of consistency among provincial renewable energy plans, a basic planning template might be considered. Such a template could identify the required content and structure of the provincial renewable energy plans, and could be informed by the objectives and scope of the required planning efforts as well as by some of the "lessons learned" described here. The content and structure of some of the international renewable energy plans discussed previously may help to guide the development of the template. Along with the template, as described above, we also recommend that the central government provide: (1) a policy "toolkit" that identifies the range of possible policy options that are at the provinces' disposal to support the attainment of the provincial renewable energy targets; (2) a publicly available database of relevant input data that might be used in provincial planning; and (3) possibly a supply-curve model that might be used at the provincial level.

- **Modeling - If Used - Should Inform, Not Dictate, Provincial Renewable Energy Plans:** Modeling can be and often is used to inform international renewable energy planning processes. In no instance, however, do the modeling results dictate the exact form and content of the resulting plan. The energy sector is too complex and uncertain, and the engineering, economic, and policy issues too intertwined, to think that a model can provide a single "correct" solution to renewable energy planning. Indeed, some of the renewable energy plans summarized earlier did not rely upon new modeling at all; instead, they relied upon earlier analysis and/or on expert judgment.

- **Stakeholder Engagement Is Essential:** International experience shows that stakeholder involvement in energy planning processes is widespread. Though the exact nature of this engagement varies, the heavy involvement of interested parties can help ensure that energy planning results and recommendations are substantively sound and widely supported. It is often the case that outside stakeholders are aware of data sources or renewable energy developments that can provide critical input into planning processes. China's *Renewable Energy Law* specifies that renewable energy plans are generally to be released to the public, except for those elements that require confidentiality. The *Renewable Energy Law* also specifies that in creating renewable energy development and utilization plans, opinions from relevant units, experts, and the public are to be collected. China's central government may wish to provide further details on the minimum requirements for stakeholder involvement in the provincial plans, and to include in the planning template a section that will allow provincial planners the opportunity to describe how stakeholder input was solicited and used.

- **Analysis Functions Can Be Outsourced to Reflect Agency Staffing Limitation:** There may be a tendency to believe that provincial renewable energy planning efforts must be entirely conducted by provincial governmental agencies and staff, leading to concerns about the ability of such personnel to fulfill their responsibilities adequately. The fact of the matter is that local government officials and staff, in China and elsewhere, are rarely "modelers" and will rarely be able to perform planning responsibilities, without support. The international planning efforts summarized earlier, for example, were often led by relevant governmental agencies, but the analysis itself was more-often-than-not conducted by outside consultants. This outsourcing of analysis functions is common internationally, and should be considered in China as well. China's national government may even wish to designate, fund, and train one or more consulting firms to help perform those functions. Local provincial officials would still be required to oversee this work, and ensure that adequate stakeholder involvement is sought, but should not be required to perform the analysis in-house.

- **Provincial Planning Should Consider City and County Government Actions:** Several of the case studies reported earlier, including those in South Africa and India, recognized the need to involve local government actions at the city and country levels. In India, for example, district-level committees have been created to address renewable energy barriers and to raise awareness at the local level. In South Africa, many of the policy recommendations provided in the West Cape energy plan were targeted at actions required at the municipal level, and close engagement with municipal and local governments has occurred. As China develops its template for provincial level renewable energy planning, it may wish to consider a dedicated section on actions needed at the city and county levels.

- **Create an Implementation Plan and Monitor Progress**: Historically, a number of renewable energy planning processes have resulted in documentations and reports, but little action. Many of the cases presented earlier, however, have been accompanied with specific plans for implementation, with clearly identified responsibilities and timelines. The best-practice cases also include regularly updated reports that monitor progress towards the plan, in both quantitative (e.g., are the renewable targets being achieved) and qualitative (e.g., was the provincial policy developed as indicated in the plan) terms. International experience therefore suggests that provincial renewable energy plans include a clear implementation plan, with responsibilities and timelines clearly identified. It may also be useful to require the provinces to regularly report back to the central government on their progress in implementing their plans, though an annual report or otherwise.