Quantifying State-Policy Incentives for the Renewable Energy Investor

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***Abstract* -- In this paper, we describe an approach to quantify state-level renewable energy policies for a decision maker/investor. We describe the construction of a computational module - a rule-based system - to evaluate state incentives and their impacts on renewable energy investment. We aim to quantify the policy bias of states towards renewable technologies and identify profitable markets for investment, both long- and short-term. We also present how the ability to estimate the expected return from tax credits and incentives for a proposed project can be included while strategizing investment in large renewable energy generation projects.**

***Index Terms*-- renewable energy incentives, state policy incentives, computational policy.**

I. Introduction

Let us suppose Mr. Green Jobs, a rich venture capitalist, is looking to invest $50 million in the renewable energy business sector. He understands that land cost for installing equipment (windmills, solar panels, etc.) is cheaper in some states compared to others and that some states have a higher energy demand and a more profitable market. Using publicly available information on the distribution of renewable resources like wind, solar, and geothermal potential, he also knows that some states are more capable and thereby more efficient in green energy production. Interpreted in business terms, this means that the same capital investment on equipment in two different states would produce different returns. He is also aware that states with high energy demand and environmentally responsible mandates are encouraging investments in renewable energy. After some preliminary investigation, he also finds out that states that may not have abundant renewable resource potential provide lucrative incentives compensating for the vagaries of the resource within the state to meet their increasing energy needs.

How would Mr. Green Jobs make his investment? How would he choose his sites: One large solar farm in one state? Several small wind farms in the same state? Several solar and wind farms across several states? Which states would he use for quick return on investment? In which states will he invest for long-term gains on his investment? Should he even consider available incentives before deciding to site a wind or solar farm? Will such an investment-return based strategy be counter-productive to maximizing the country's renewable resource-potential?

Mr. Green Jobs can find answers to these questions only by optimizing over the energy-strategy space requiring expertise in the following domains: (a) Power systems – for developing cost models for new infrastructure installation, deployment, transmission and grid-integration; (b) Environment impacts – for quantifying benefits of carbon reduction; (c) Geo-spatial search – for segmenting out suitable regions for solar, wind and hydro, and geo-thermal installations; (d) Market analysis – for modeling resource inter-dependencies, population growth, and energy demand; and (e) Government policy studies - for quantifying rules, regulations, and incentives.

Without ignoring any of these domains in his business plan, we assume that Mr. Green Jobs has the expertise or is able to access tools listed by Connolly et al. [1] to include resource availability, land cost, market demand, and power-system related costs. The contribution that we make as an addition to the existing suite of domain-specific tools is a software module that quantifies government policies to assist an investor like Mr. Green Jobs. To the best of our knowledge, we are among the first to implement a computational module for the evaluation of the renewable energy policies on *what-if* investment scenarios over different states within the country. We showcase the module's ability to present facts and comparison charts as an interactive overlay within a web-based Google Earth geographic visualization platform and apply the functionality of this module to study hypothetical, but relevant scenarios of interest to investors.

II. Background

Over the last three decades, we have witnessed the desire to include renewable sources into the energy portfolio as a global trend [2-4]. Some countries have attributed climate-change concerns as the driving factor behind their clean-energy ambitions while other countries have expressed the shift to renewable sources as a futuristic defense strategy [5]. Irrespective of the motivation, achieving these ambitions has been a challenge because technology related to renewable energy can be both expensive and risky investments. Social and infrastructural inertia [6-8] has also acted detrimental to realizing the renewable energy vision.

In the United States, the government's effort to counter the inertia and encourage renewable energy investments, have surfaced in the form several friendly policies and incentives

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[9]. Significant efforts have gone into documenting success stories of such policies. The lessons learned from the policy implementations have helped evolve strategic energy roadmaps [10]. In fact, the case studies on government policies conducted over the last two decades have provided important insights to developing a growing field of literature on policy design practices [11-13]. State-level policymakers rely on estimates of the market potential for renewable energy along with the findings of case-studies (both feasibility [14] and policy success [13]) to develop ideas that can help accelerate the progress towards producing more renewable energy. Our observation is that these case studies are step-by-step guides that assist policy makers create programs to meet clean-energy and energy-security goals, but not necessarily friendly to an investor with business interests.

Our efforts in this paper are directed towards helping such an investor/decision-maker by quantifying state-level policy incentives mandated since 2008. We draw inspiration from the idea of *computation law* presented by Love and Genesereth [15] to develop a self-help tool that empowers investors with the knowledge of attractive policies that can maximize return on their investments. We implement a rule-based architecture recommended for computational law systems in [16] as the processing engine between a web user-interface and a policy database.

III. OUR APPROACH

Figure 1 is a snapshot of the software module illustrating the policy landscape for renewable energy capturing the incentives and regulations as of May 2010. We have included production incentives, grants, rebates, corporate and personal tax credits, sales, and property tax credits for each state. A user can sift through the policy incentives with relative ease using most web browsers that support Google Earth rendering capability.

A. *Components of the software module*

Our software module consists of three components: (1) the policy database, (2) the user-interface for visualization and manipulation, and (3) computational scripts that take inputs from the user, fetch relevant rules from the database, and return the results after applying the rules to the user inputs. We used publicly available software development toolkits to design the Google Earth visualization interface. The policy database is a concise and processed form of the information published in the excellently compiled Database of State Incentives for Renewable Energy [17]. We store and represent this data archive of state incentives as computable/programmable code that can be executed on demand.

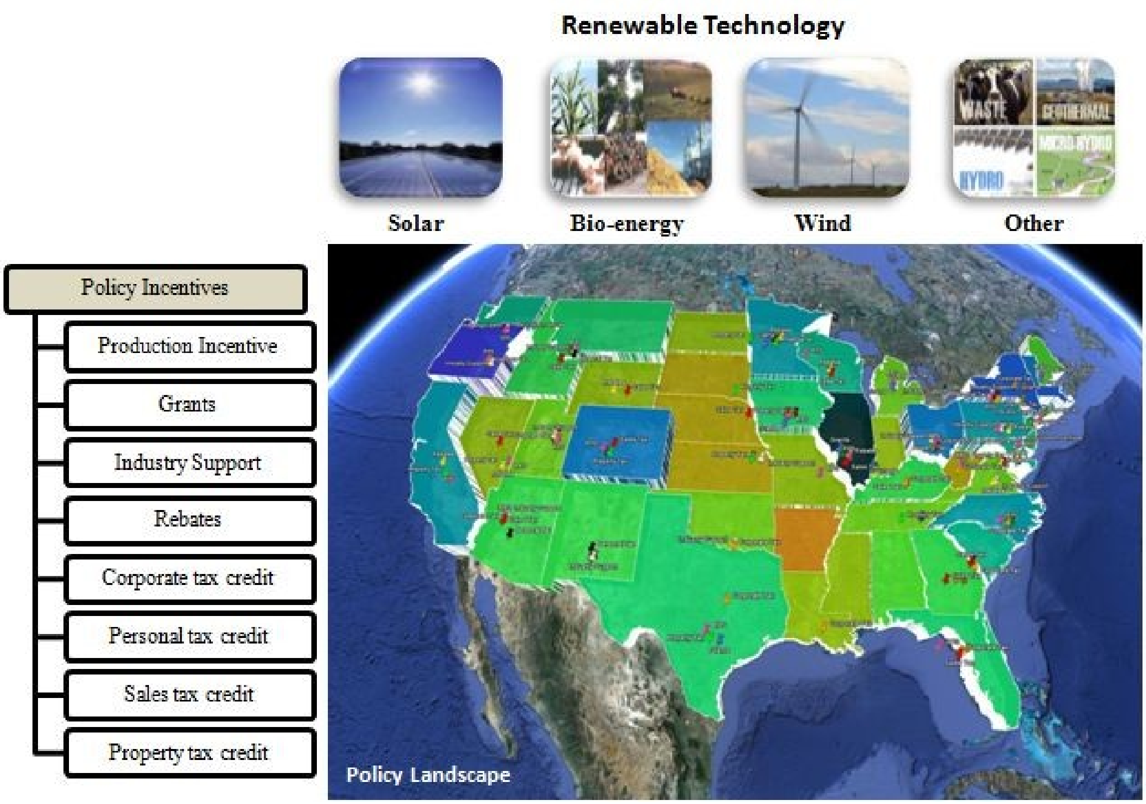


Fig. 1. Our software module presents the state-level policy landscape using the Google Earth visualization platform. This screen shot displays the number of policies (encoded as height and color of the bar on each state) that an investor may be eligible for in each state. Using this interface, the investor can query the policy database and peruse details of how much and for how long states offer incentives before making an investment decision.

B. Why a rule-based system?

In Table 1, we present samples of the data archived in the policy database. The typical incentives listed in the table suggest that policy-based incentives can apply to different aspects of installation and deployment including but not limited to feasibility demonstrations, equipment for generating renewable power, and tax breaks on the property that houses the equipment. The challenge in realizing these policy incentives within a computational framework arises when we observe that states have unique ways of encouraging and rewarding renewable energy investment.

For example, Vermont provides $0.125/kWh of generated wind energy and $0.30/kWh for solar energy. Ohio provides a sales tax waiver on eligible equipment and installation costs for both solar and wind, while Maine provides the sale tax waiver only for wind equipment excluding the installation costs and solar-energy related technologies from the incentive. With some other incentive types, a percentage of installation cost (limited by a maximum amount) or fixed amount of return after installation over a period of time (like say 5 or 10 years) for every unit of power generated is a common reward mechanism. Different schemes for the same policy incentive-type in different states for different timelines guided us towards the rule-based architecture for the software implementation.

C. The rule-based system

Assuming that all policy aspects have been properly quantified, our rule-based system is designed to answer a query like: If Mr. Green Jobs is ready to invest $X in a state to generate *s* KWh of solar, *w* KWh of wind energy and *r* KWh of other renewable energy, how much encouragement (in the form of incentives) from each state can he expect for that renewable energy investment? When submitted through the user interface, such a query initiates a workflow similar to the one illustrated in Table II. We iterate over all the states, identifying eligible incentives for the respective renewable type in each state to approximate the amount of credits and incentives.

For example, if an investor is building a 50 MW solar farm, the rule-based system would evaluate the eligible incentives at each state for the 'solar' renewable type and execute sub-queries similar to the one specified as an example in Table II. By design, the policy database returns code snippets that when executed with the relevant user inputs for variables like equipment cost, installation cost, etc. will provide an estimate of the state-incentive. We also allow the user to specify a time-period he is willing to wait before assessing his return on investment to enable long-term and short-term analysis of returns. The policy landscape after executing such a query recommends the top candidate-states for his investments.

TABLE I

DIFFERENT INCENTIVE TYPES FOR RENEWABLE ENERGY OFFERED BY DIFFERENT STATE GOVERNMENTS WITH EXAMPLES OF TYPICAL INCENTIVES

Incentive Type	Description
Rebates	Promote the installation of renewable energy systems and energy efficiency measures. *Typical Incentives:0.39/kWh for 5 years, 35% of equipment cost*
Grants	Designed to pay down the cost of eligible systems or equipment, research and development, and project commercialization. *Typical Incentive:30% of cost on equipment up to 250000.*
Production incentives	Cash payments based on the number of kilowatt-hours (kWh) generated by a renewable energy system - a performance reward. *Typical Incentive: $0.15/kWh up to $5,000/year.*
Industry support	Financial incentives to recruit or cultivate the manufacturing and development of renewable energy systems and equipment. *Typical Incentives:$5000 per job created, 35% tax credit, 50% tax abatement.*
Corporate tax credit	Corporate tax credit for purchase and installation of green energy technology. *Typical Incentive:30% of equipment cost up to $3500.*
Personal tax credit	Multi-year tax credits for purchase of renewable energy systems for personal use. *Typical Incentive: 1.5¢/kWh for 10 years after facility begins producing energy more than 759KW.*
Sales tax	Exemption from the state sales tax (or sales and use tax) for the purchase of a renewable energy system. *Typical Incentive:100% of sales tax on equipment and installation costs.*
Property tax	Exemptions, exclusions and abatements for renewable energy equipment on property. *Typical Incentives: Equipment valued at 20% depreciated cost, 100% of equipment value.*

TABLE II

THE PSEUDO CODE BEHIND THE COMPUTATIONAL POLICY MODULE

Input : Investment, Expected Energy Production Portfolio, Installation costs based on portfolio.

```
For each State in the U.S {Alabama, Alaska, Arkansas, etc.)
    For each renewable resource {solar, wind, geo-thermal, etc.)
        For each incentive type {Production, Coporate Tax, etc.}
         Incentive+=ComputeIncentive(Power,State,IncentiveType,...)
        end
    end
end

function ComputeIncentive(Power, State, Incentive, RenewableType, PropertyCost, InstallationCost,.....)
    Construct Rule from PolicyDatabase
    Execute Rule
end
```

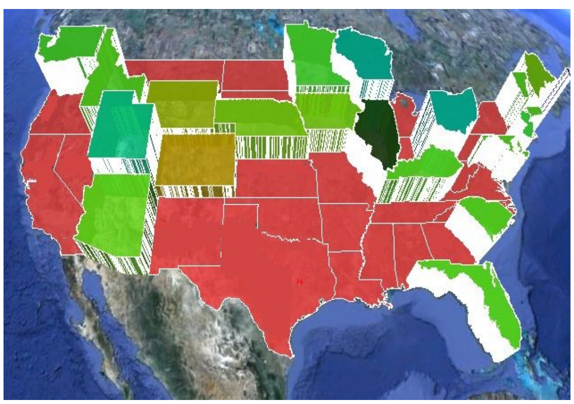
Example : *Executing Rule "select Rule from PolicyDatabase where State like 'SC', RenewableType like 'solar', Incentive Type like 'PersonalTax' and Power = 50 MW"* returns *min(65000, 0.25*InstallationCost)*.

IV. Policy Landscape in Hypothetical Scenarios

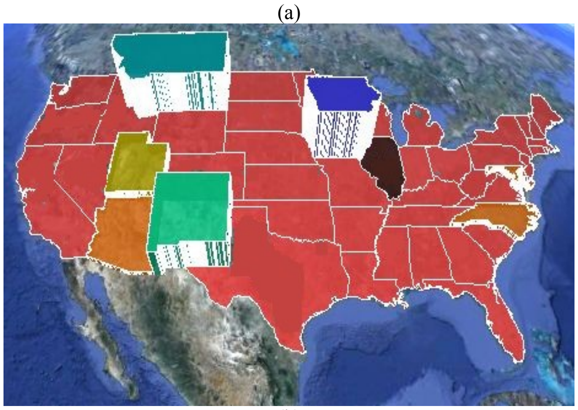
Although state-incentives can be an important consideration for investors, each investor may have his/her own concerns and investment goals. In this section of the paper, we showcase the different functions built into our software module to address such user-specific concerns and present the policy landscape results for hypothetical scenarios of interest.

Case #1 : An investor would want to explore states that provide the best sales tax incentive for renewable energy equipment. Considering different sales tax rates from state to state, we illustrate the net sales tax incentive landscape for $1 million of investment in Figure 2a. The height and color in the policy landscape encode the amount of incentives. Taller state boundaries represent larger incentives and states filled in red color indicate states with little or no incentives. We will follow this height and color scheme throughout this paper.

Case #2 : Another investor may be more interested in reducing his tax load while also investing in renewable energy. He would want to find out which state gives him the best rebate on personal tax credit incentives. The results in Figure 2b is a rendering of the personal tax credit landscape for an investment of $1 million.



(a)



(b)

Fig. 2. State-wise incentive landscape visualization. (a) The sales tax incentive landscape. (b) The personal tax credit landscape.

Case #3 : Let us assume that wind related technologies currently cost $2 million per MW and solar technologies cost $5 million per MW (50% of these costs are spent on equipment and the rest on installation, taxes, licensing etc.). An investor like Mr. Green Jobs, is ready to invest $50 million in several small farms, and wants to identify states that would provide the maximum incentives on his investment short-term.

Our module is designed specifically to answer different forms of such *what-if* cases while considering siting projects across different states. Without considering factors like resource availability and land cost, Figure 3 is a snap shot of the policy landscape from the computational module suggesting that states of Montana, Maine, Vermont, and North Carolina provide the maximum incentives for a 1-year time window. Although just the policy incentive values may not drive the investor to choose one of these states, these estimates help back-up the risk quantified in the cost analysis of his renewable energy business plan.

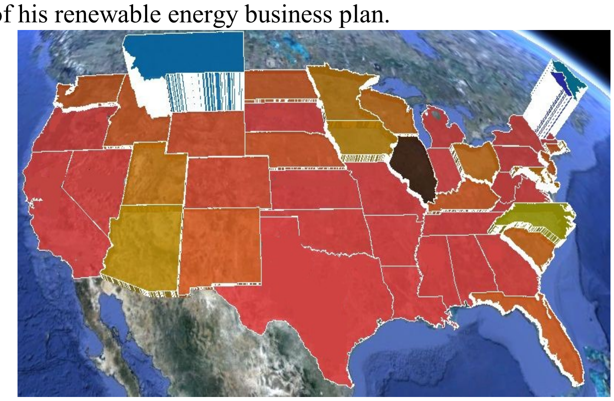
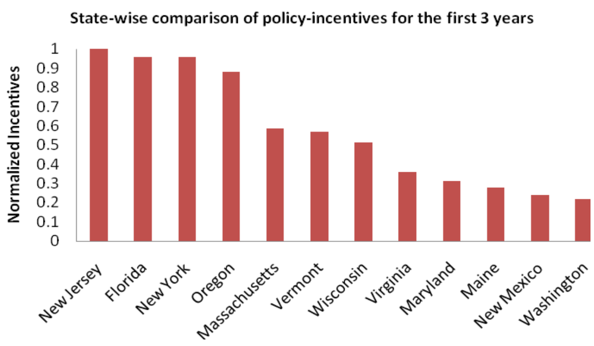
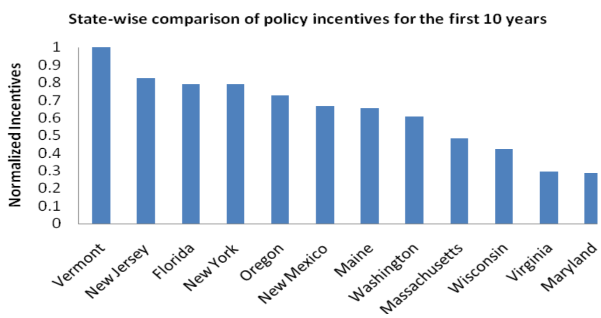


Fig. 3. Given that an investor is ready to invest $50 million towards generating 25 MW of new electricity, some states (extruded as long bars) can provide incentives close to 10% of his investment.

Case #4 : We consider a hypothetical case of one large 500 MW capacity solar-power installation to study the short-term and long term returns from the state incentives. We were unable to include state-wide differences in labor and equipment costs for this analysis although such costs may be substantial. We present the results of our investigation in Figure 4. We picked the top 12 incentive-friendly states for a 500 MW generation farm and computed eligible incentives over a three year period and a ten year period. We have normalized the scores for interpretation in Figure 4a and 4b with respect to the maximum incentive from the state. From the graphs, it appears that most state-incentives are rewarding long-term investments while only a few states have considered short-term risk mitigation benefits to the investor. An interesting observation that captures attention in these graphs is the incentives from the state of Vermont. We observe that although Vermont does not appear to be a great destination for short-term incentive gains on large farm installations, it could be the best option while considering a 10-year investment term.



(a)



(b)

Fig. 4. A state-wise comparison of renewable energy incentives for one large solar farm in each state. (a) Returns from incentives in the first 3 years. (b) Returns from incentives in the first 10 years.

V. Summary

We proposed a rule-based approach to quantify the policy incentives and mandates offered by each state to help renewable energy investors. We note that there are very few efforts documenting a computational policy framework of incentives (and regulations) amenable to an investor's optimization goals in the current literature and claim the following contributions with our module:

- To the best of our knowledge, we are among the first to have implemented a computational module that quantifies the state-level renewable energy policy incentives as a business decision-support tool for investors.
- The results from the computational policy module can feed in as a cost layer input for visualization and analysis into existing geospatial "site search" optimizers [18, 19] that consider factors like land cost, renewable resource potential, proximity to infrastructure, etc.
- The state-level comparisons and analysis that can be done using our policy module provide feedback to government agencies for attracting new investments while also providing key insight to commercial investors by advising them of expected returns.

In general, investment plans depend on additional factors such as existing cost structures, expected future cash flows from parallel investments, size of initial capital, and so forth. We have not been able to include such parameters in the current version of the policy module. In the future, we would like to include investor-specific variables such as current tax load, discount rate, finance rates on loans, etc. to make the computational policy module more valuable, realistic, and user-friendly.

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