## Practice Summaries

# An Optimization Model to Support Renewable Energy Investment Decisions

### Srinivas Bollapragada
General Electric Global Research Center, Niskayuna, New York 12309,
bollapragada@research.ge.com

### Brandon Owens
General Electric Energy, Arvada, Colorado 80007,
brandon.owens@ge.com

### Steve Taub
General Electric Energy Financial Services, Boston, Massachusetts 02111,
steven.taub@ge.com

A majority of states in the United States have instituted Renewable Portfolio Standards (RPS), which require electric service providers to meet a portion of their demand using renewable energy resources. These requirements, along with state and federal incentives, are the main drivers for the construction of utility-scale renewable energy plants in the United States. In order to help understand the implications of the state RPS system for future renewable energy investments, we developed an analytical tool that General Electric Company uses to better price its renewable energy deals and forecast market demand for its renewable energy products.

*Key words*: suboptimal algorithms; forecasting; energy policies: government; decision support systems: information systems; energy: natural resources.
*History*: Published online in *Articles in Advance*.

General Electric (GE) Company has a large renewable energy business. GE Energy, which was the second-largest manufacturer of wind turbines in the world in 2009, also has a growing solar business. In addition, GE Capital's Energy Financial Services (GE EFS) business annually invests billions of dollars in renewable energy power plants. To help it make investment decisions, GE Energy needed a decision support and analysis tool to forecast the demand and supply of renewable energy over the next decade. GE EFS also needed a tool to enable it to project its renewable energy plants' financial performance and thus support investment decisions. To meet these needs, GE Global Research Center (GRC) developed an analytical tool that employs an innovative mathematical model to estimate the financial performance of renewable energy plants and forecast new renewable energy capacity and generation by technology over a 10-year

horizon. Both GE Energy and GE EFS currently use the tool to make better investment decisions around the renewable energy space in the United States.

Because building renewable energy power plants is more expensive than building conventional ones, the main drivers for building them in the United States are government incentives and mandates. The mandates, which are called renewable portfolio standards (RPS), require utilities to meet a certain percentage of demand from renewable energy sources. Utilities that cannot meet these standards can either purchase renewable energy credits (RECs) from entities generating excess renewable energy, or they can pay an alternative compliance payment. We formulated the problem of determining the renewable energy plants that are expected to be built across the United States as the following mathematical program, which minimizes the cost of meeting the RPS requirements.

Minimize

Cost of meeting RPS requirements over the
next decade
= (Energy production cost from new plants
+ Energy transportation costs
+ Penalties paid for noncompliance),

subject to the following constraints

1. meet RPS demand requirements by program and year;
2. meet transmission capacity constraints;
3. meet renewable resource availability constraints;
4. build capacity constraints by technology and year; and
5. meet energy generation constraints.

The decision variables are

• renewable energy plants built by technology, resource, and year over the time horizon,

• renewable energy transported across states by year over the time horizon, and

• penalties paid to state RPS programs for not meeting RPS requirements by year over the time horizon.

The model requires data on a number of factors. Renewable energy generation costs vary based on factors such as technology, availability of resources to locate power plants, proximity of the plants to transmission lines, government incentives and policies, and availability of financing. The factors that influence the revenue generated by renewable energy plants are energy prices and REC prices resulting from government policies and production incentives. We collected data on these factors from a number of sources, both internal and external to GE, and then transformed the raw data into a form that the model can use.

The mathematical program formulation is very large and difficult to solve. Moreover, because many GE divisions will use the decision support tool, it had to be highly portable. Therefore, we developed a greedy heuristic algorithm that does not depend on third-party mathematical program solvers. The greedy algorithm builds plants in the increasing order of cost per megawatt of power generation capacity to satisfy RPS requirements while meeting all other constraints. The heuristic algorithm runs extremely fast (within a few seconds) and generates near-optimal solutions without relying on commercial solvers. In addition to forecasting the plants to be built by state and renewable technology, the algorithm also computes long-term average REC prices using marginal cost analysis.

We implemented our decision support tool as a Microsoft Access database application written in Visual Basic for Applications. The application has an easy-to-use interface that enables users to import the required data, modify the data as needed, run models, view results, and perform scenario analysis. The entire application is approximately 12 megabytes (MB) in size (less than 3 MB when compressed) and can easily be shared across different businesses within GE. Since April 2009, GE has used it for estimating REC prices to be used in renewable energy project deal evaluations, forecasting renewable energy demand to better manage manufacturing capacity, evaluating the effectiveness of government policies, and advocating for effective policies.

*Note to Future Authors*: The goal of "Practice Summaries" is to present short descriptions of successful applications of operations research methodology, with measurable impact in practice, to a wide range of industrial applications. For information on submitting your manuscript, please see http://www.informs.org/Pubs/Interfaces/NEWS/Call-for-Practice-Summaries.